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STEM: The Push to Improve Science, Technology, Engineering, and Mathematics

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States Heeding Calls to Strengthen STEM

Equipping students to succeed in science, technology, engineering, and math holds economic appeal.

By Sean Cavanagh

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Unnerved by job losses, weak test scores, and competition from an increasingly skilled foreign workforce, state officials have launched a variety of efforts to improve mathematics, science, and technology education, in an attempt to gird against whatever economic challenges may come.

Those initiatives are being filed under an increasingly recognizable identifier: STEM, or science, technology, engineering, and math education. The term has become popular shorthand among policymakers convinced that schools must do a better job preparing students for an economy that will require different and more technically sophisticated skills.

Some of the state-level activity can be traced to the 1980s and 1990s, when states first hatched plans to raise academic standards and require testing across subjects—efforts that have evolved and expanded since then, particularly under the federal No Child Left Behind Act.

Last year, national policymakers also took up the cause, when Congress approved legislation that authorizes the creation of numerous STEM-related federal programs, such as those focused on teacher training and recruitment, as well as the expansion of existing ones. At the same time, some federal leaders, including officials of the Bush administration, have called for more effective measures of what works in STEM education, given the federal government's estimated $3 billion annual investment in those areas.

But the idea of bolstering the economy through improved STEM education has especially strong appeal in the states, particularly those hard hit by job losses in manufacturing and other areas, says Meghan Groome, a senior policy analyst at the National Governors Association. That Washington-based organization of the states' chief executives has tried to spotlight promising efforts in math and science education.

Technology has played a strong role in state and local efforts to improve student achievement in recent years, as education officials have sought to mine data to improve instruction and use technology for purposes such as teacher professional development and online courses for students. States and districts have also tried to boost students' overall technological literacy, in part by expanding access to laptop computers and other equipment, and by attempting to integrate the use of digital tools across the curriculum, such as with special projects.

Elected officials are trying "to think about what the 21st-century economy is going to look like in

their states, and how the K-12 systems in their states can contribute to that economy," Groome says. "STEM education is really about building a positive future [with] high-wage, highly skilled jobs."

Some Skeptical of Campaign

Last year, the governors' association hired Frank Luntz, a prominent pollster and consultant based in Alexandria, Va., to conduct a national public-opinion study on a range of economic and educational issues.

He found that a majority of Americans believe that states, more so than the federal government, should take a strong role in attempting to encourage innovation—which they saw as closely tied to technological innovation—in K-12 schools and the workforce. That support comes from both Democrats and Republicans, the survey found.

But the public's appetite for higher math and science standards is not universal.

A survey released last year found that just 25 percent of parents in Kansas and Missouri think that their children should be studying more math and science, and that 70 percent believe that things "are fine as they are now." The survey was conducted by Public Agenda, a New York City-based opinion-research organization.

Data Table Download

Math Achievement on NAEP	**PDF**
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Progress on NAEP Math and Science	**PDF**

Some have questioned the rhetoric used by the business leaders and elected officials who see STEM education as a way of fortifying the U.S. economy long term. B. Lindsay Lowell, the director of policy studies at Georgetown University's Institute for the Study of International Migration, co-authored a 2007 paper arguing that the educational pipeline in math and science "is not as dysfunctional as believed," noting the increases in state math and science academic standards and test scores, by some measures, in recent years.

The K-12 and college education systems are producing plenty of students with the science and engineering skills and enthusiasm needed to meet workforce demands, the paper found. The problem, the authors argued, is with science- and engineering-oriented firms failing to attract and retain those graduates.

"Training people in math and science is not the same as creating a math or science job in the economy," Lowell says. While he applauds efforts to improve math and science education—and notes the broad discrepancies in individual states' performance in those areas—too many policymakers, he says, "are confusing supply and demand."

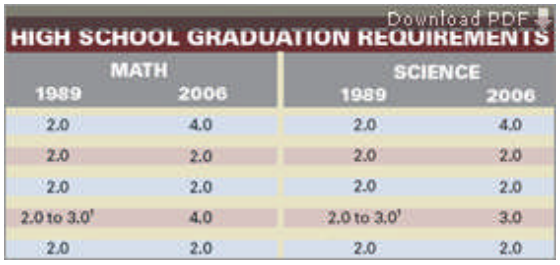
Yet economic concerns have been a driving force behind many state STEM efforts, in which K-12, higher education, and business leaders have worked together to identify workforce needs and determine how schools and colleges could help meet them.

Some states are trying to lead more students into STEM studies and careers through monetary incentives, as the case in Washington state. The state, with private backing, is offering scholarships to students who score well in those subjects on state or college-entrance exams, and who agree to study the subjects in college and stay in the state to work in STEM-related fields after graduation.

Requiring More

States increased the number of mathematics and science credits needed for a high school diploma from an average of 2.2 years of math and 2.0 years of science in 1989 to 3.0 years of math and 2.7 of science in 2006.

Others are tackling student motivation. Utah, for instance, sponsors math and science camps for students in grades 7-12.



SOURCE: Council of Chief State School Officers, 1989 and 2006

And many states have supported math and science "academies," specialized public schools tailored to students with talents in those subjects. The **National Consortium for Specialized Secondary Schools of Mathematics, Science, and Technology**, which supports the academies, had just 15 member institutions when it was founded in 1988; it has more than 100 today, serving 37,000 students nationwide.

Many STEM-focused schools, as one might expect, have a long tradition of providing students with access to up-to-date computer technology, says Cheryl A. Lindeman, the executive director of the consortium, in Lynchburg, Va. But today, she says, those schools tend to regard technology as a skill that should be emphasized across subjects, and as a focal point for independent student projects.

"Twenty years ago, the M, S, and T were separate," says Lindeman, referring to STEM. "Now they are really [thought of] as interdisciplinary."

Requirements Rising

But perhaps the most common state STEM strategy is one that targets the entire student population: increased graduation requirements in math and science.

Between 1989 and 2006, states increased the number of credits needed for a high school diploma from an average of 2.2 years of math and 2.0 years of science to 3.0 years of math and 2.7 years of science.

As recently as a decade ago, according to the **Education Commission of the States**, just 19 states, plus the District of Columbia, set a minimum of at least three years of math to graduate with a regular high school diploma. And at that point, only 13 states, plus the District, mandated three years of science.

Today, in the 2007-08 school year, 38 states require at least three years of math or are phasing in that standard, according to the ECS, a Denver-based policy and research organization. And 35 states require at least three years of science before graduation, or will add that mandate soon.

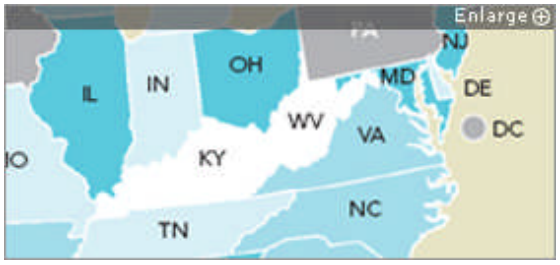
In addition, 48 states now have standards for what students should know and be able to do with technology, according to the Editorial Projects in Education Research Center's survey for *Technology Coutns 2008*. Thirty-two states have those standards in stand-alone documents, with six of those also embedding the standards in those for other subjects. In 16 states, the standards are only found embedded in other academic-content areas.

Increased STEM mandates have met resistance from some educators, parents, and others, who fear they will encourage students to drop out of school. Critics also ask where school districts will find the teachers to lead those courses, and whether schools will have to cut back on electives to make room for the new requirements.

Those objections surfaced in Colorado last year, when

Poverty: The Gap in Science

In 31 states, a gap of more than 20 scale-score points existed in the average scores of low-income 8th graders and their nonpoor peers on the 2005 National Assessment of Educational Progress in science. States' average poverty gap was 28.1 points.



SOURCE: EPE Research Center, 2008

state lawmakers, countering the nationwide trend, rejected a proposal to require four years of math and three years of science before graduation. But Jennifer Dounay, a policy analyst at the ECS, says students seem to benefit when more is demanded of them. She cites a 2003 University of Michigan study that found that schools that offer more challenging math courses, such as calculus, have fewer dropouts. Federal research has shown that students who take advanced math and science courses in high school are more likely to complete college, she notes.

"The level of curriculum matters, especially in graduation rates," Dounay says. States and districts that do not set high standards in math and science, she adds, "are creating a pathway to fall behind."

But as states raise standards in math and science, the impact of their efforts so far remains unclear.

On the one hand, student scores on the National Assessment of Educational Progress, known as **"the nation's report card,"** have improved in math in the 4th and 8th grades since 1990, on tests measuring both state-by-state and national trends in that subject. Moreover, those gains have occurred among students across achievement levels. NAEP reading scores, by contrast, have been more stagnant over that time.

"There's no question we're making more progress in math than anything else," says Kati Haycock, the president of the Education Trust, a Washington-based research and advocacy group that supports efforts to raise academic achievement, particularly among students from disadvantaged backgrounds. Haycock points out that minority students have made steady gains in math on the national assessment in recent testing cycles.

But math scores among older students have stagnated; 17-year-olds' performance in that subject has remained almost flat on NAEP since the early 1970s. And in science, NAEP results have been similiarly mixed. Fourth graders' science scores have risen over the past decade, but 8th graders' performance has stayed the same, and high school seniors' marks have actually fallen since 1996.

Structure and Instruction

Some experts say those results suggest a need to introduce students to challenging math and science in different ways.

Schools have, for example, made increasing use of interactive technology in math classes—systems that provide teachers with instant feedback on whether individual students are grasping the material, as those lessons unfold.

Science teachers at all grade levels are relying on online lessons and experiments as a way to stir students' enthusiasm for the subject. Teachers also use Web sites from scientific organizations for reliable, up-to-date information on scientific issues of the day, such as climate change and bioethics, that they believe textbooks are not covering in depth.

And while critics have complained about the academic quality of vocational education programs, those courses, if taught well, can offer a valuable path into challenging math and science, argues James R. Stone III, the director

Trends in the Science Gap

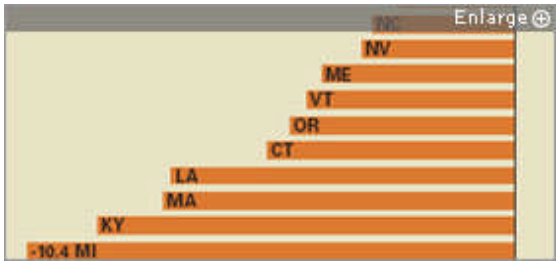
Nationally, the 8th grade poverty gap on the National Assessment of Educational Progress

of the National Research Center for Career and Technical Education, at the University of Louisville, in Kentucky.

Stone and others at the center, formerly based at the University of Minnesota-Twin Cities, have devised an instructional model that trains vocational education teachers to identify and build upon math topics that occur naturally within career-oriented classes—from agriculture to nursing to automotive technology—rather than trying to force math into such courses out of context.

A federally funded 2006 study found that the instructional approach increased the math scores of students taught that way. About a dozen states and school districts are now seeking help from the center to develop teacher training based on the math-in-career-education model.

in science narrowed only slightly, by 3.5 scale-score points, between 2000 and 2005. Among the 36 states that participated in both assessments, gaps narrowed in 26 states but grew in 10. The states that narrowed their gaps between low-income and nonpoor students the most were Kentucky, Louisiana, Massachusetts, and Michigan.



SOURCE: National Assessment of Educational Progress, National Center for Education Statistics, U.S. Department of Education, 2000 and 2005.

"There's a growing recognition that simply piling on the regular math classes, taught in the regular way, doesn't seem to be working," Stone says. Enthusiasm for math and science rises, he says, when students are given the opportunity to apply those skills—and "for many kids, that's career and tech ed."

For many states, the road to improved math and science achievement runs through more specialized, and in some cases smaller, high schools.

In 2003, for example, North Carolina officials launched the North Carolina New Schools Project, supported by Gov. Michael F. Easley and an $11 million grant from the Seattle-based Bill & Melinda Gates Foundation. The project seeks to redesign 100 high schools across the state as small schools with academic themes.

Eighty-six schools are now being created from scratch or redesigned as part of the project. Thirty-four of the schools have a specific STEM focus.

Students who attend the redesigned schools will be expected to follow a demanding curriculum in math, science, and other core academic areas, says Tony Habit, the president of the North Carolina project.

The state has seen many of its major industries, such as textiles, furniture, and farming, wither away over the past two decades, though other sectors of the economy, in white-collar fields such as technology, have taken hold. Many of the redesigned schools are opening in cities and towns affected by job losses and others with businesses requiring skilled workers, Habit says.

"The economy is in transition," he says. "We've seen communities that have been been significantly impacted. … [We] need to grow a new workforce so we can grow jobs in sectors of the economy that hold promise for the future."

North Carolina was one of the first states, in the 1990s, to establish technology standards for students. It also has a statewide 8th grade technology assessment, which measures not only students' technological skills but also their ability to use the Internet appropriately.

The New Schools Project will continue that tradition, Habit says. Sixteen of the schools being planned by the project will have a 1-to-1 student-to-computer ratio, and a heavy emphasis on integrating

technology into curricula through independent projects and other means.

As states move to raise student achievement in math and science, some are addressing a crucial related need: the quality of their teaching corps.

According to a 2007 report from the Washington-based Council of Chief State School Officers, only 61 percent of the nation's math teachers in grades 7-12 have a major in that subject, a lower percentage than for science. In some states, the percentage of math teachers with a college major in math or science is much lower than it is nationwide.

Several states are seeking to shore up the educator workforce with help from the private sector. The National Math and Science Initiative, a Dallas-based nonprofit organization, has awarded grants of as much as $2.4 million each to 12 universities in nine states so far to replicate U Teach, a widely praised program for training math and science teachers at the University of Texas at Austin.

That effort, which aims to spawn 50 such teacher-training programs, is being underwritten with $125 million from the ExxonMobil Corp. In an effort to ensure that the university efforts will last, the program requires that the schools show support from the governors' offices in their states when applying for funding.

Some state efforts, meanwhile, focus on improving the skills of math and science teachers who are already in the classroom.

Alabama officials since 2002 have run a statewide professional-development program called the Alabama Math, Science, and Technology Initiative, or AMSTI, which was created at the recommendation of business and public officials. Schools that apply for the program must agree to send all of their math and science teachers, directors of instruction, and administrators to two-week summer workshops for two consecutive summers. The workshops emphasize grade- and subject-specific teaching techniques in math and science, strategies that AMSTI officials believe research has shown to be effective.

Participating schools receive help throughout the year from roving AMSTI instructors. Schools designate lead teachers in math and science; allow time for teachers to work on math and science lessons as teams; and form partnerships with local business organizations.

They are also asked to incorporate technology into their math and science lessons. Schools are expected to use graphing calculators in middle school math, and they receive access to science-related technology for labs at the middle and high school levels. Teachers are trained to use that technology, says Steve Ricks, state coordinator for AMSTI.

Schools that take part in the state program, funded at $38 million in fiscal 2008, are recognized as "AMSTI Schools," a title that they typically display on their school grounds. About 365 schools at all grade levels—roughly one-quarter of the state's total—have received that designation so far.

Students at AMSTI schools outperformed those from nonparticipating schools with similar demographics on Alabama's standardized tests in reading and math and the state's graduation exam, according to an independent evaluation in 2005.

"We realized, if you want to bring high-quality, high-paying jobs to Alabama, you have to look at math and science," Ricks says. "We've seen tremendous changes in attitudes from students; … we've seen changes in teachers' attitudes."

States have also sought to make sure that teachers are prepared to use technology wisely. Virginia has required school boards to ensure that they have two full-time technology staff members per 1,000 students: one to provide technology support, the other an "instructional-technology resource teacher" to help teachers integrate those resources in the classroom.

Many other states have tapped federal aid to pay for professional development that helps teachers use interactive classroom technology and assessment tools to guide lessons, says Mary Ann Wolf, the executive director of the State Educational Technology Directors Association, which tracks that state activity.

"States are beginning to see, if you want to transform education, technology [should] play a key role," Wolf says. "Technology can be an accelerator for change."

New Roads Into STEM

As they try to meet the needs of employers, states are also launching STEM efforts that will appeal to a broad range of students, not just high achievers.

For instance, Virginia, with the help of a $500,000 grant from the NGA and the Gates and Intel foundations, is planning to launch six "governor's schools," or academies, with a focus on both career and technical education and the STEM subjects.

The career-oriented academies are a twist on the governor's schools—state-supported schools with demanding academic curricula—that have been a fixture in Virginia since the early 1970s. The new academies, which are supported by Gov. Tim Kaine, will be regional centers or programs within schools that promote technical trades but also adhere to high state-approved standards in math and science.

While Virginia "has excelled at developing programs for gifted and talented students" through governor's schools and other means, state officials wrote in their application to the NGA, it has "fallen short in developing critical 21st-century skills in the general student population."

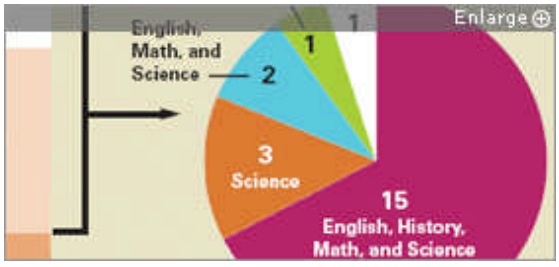
"We will not be able to meet the needs of Virginia's current and emerging industries without raising the educational achievement and attainment of this middle majority," wrote state officials.

The academies will emphasize "the application side" of math and science, says Linda Wallinger, the assistant superintendent for instruction for the Virginia Department of Education. The target population is students with a strong interest in technical fields, who will be exposed to increasingly stronger math and science.

In the years ahead, the success of state STEM efforts will depend partly on policymakers' ability to tailor those programs more specifically to workforce needs, says Groome of the NGA.

Integrating Tech Standards

While 26 states have technology standards that are distinct, stand-alone documents, 16 states integrate technology standards for students within the standards for other subjects. Six states have both types of standards, while three have none at all. Of the states that embed their technology standards, 15 weave them into the standards of the four core subjects of English, history, math, and science.



SOURCE: EPE Research Center, 2008

State leaders already have acquired a keener sense of how important interpersonal, or "soft," skills in

addition to core academic lessons, are to employers, she says. They also need to become attuned to the demands of the job market.

For instance, some business and science leaders in recent years have spoken of the need to boost the number of students focusing on the physical sciences—rather than biologic sciences— because of future shortages in physical science-related fields.

Some labor experts, meanwhile, say policymakers need to do a better job of informing students of career opportunities in economic sectors that are projected to grow in the years ahead, such as health care and other professional and technical services, and that require competency in math, literacy, and other areas. "It's really about [creating] more of a dialogue, a 'fluency' between education people and workforce-development people," Groome says. "We need to look specifically at what our workforce demands are."

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