




Growing Opportunity

A Two-Year Update on *The Opportunity Equation:
Transforming Mathematics and Science Education
for Citizenship and the Global Economy*



SEPTEMBER 2011



Opportunity Equation is a partnership between Carnegie Corporation of New York and the Institute for Advanced Study. Over the past two years, the initiative has worked to advance the recommendations of the Carnegie Corporation of New York-Institute for Advanced Study Commission on Mathematics and Science Education in its 2009 report, *The Opportunity Equation*.

The release of the *Opportunity Equation* report in June 2009 heralded a turning point in the nation's understanding of STEM education.

The report presented Americans with a vision for excellent, equitable science, technology, engineering, and math (STEM) learning that would reach all U.S. students and prepare them for full participation as citizens and as workers in an increasingly global economy. For the United States, the report explained, the challenge must be to graduate all young people to be “STEM-capable,” equipped for adult life with a broad foundation of STEM knowledge and a set of crucial skills that come from rigorous STEM learning.

To achieve that vision, the report argued, schools and school systems must change fundamentally: STEM learning must become exciting, accessible, and challenging for all students, not just those who attend certain schools or who aspire to work in STEM-related jobs or earn advanced STEM degrees. Further, STEM learning must be infused across the whole curriculum, not reserved solely for science and math classes. STEM teaching must change, too, requiring changes in the way teachers are prepared and the supports they get to keep their skills sharp.

The *Opportunity Equation* report resonated powerfully with many constituencies: educators, professionals in the STEM fields, and government leaders, as well as concerned citizens in business, philanthropy, and other sectors. Many people recognized the justice of its findings and the wisdom of its recommendations. Many noted, as well, that the report represented a breakthrough from earlier reports: rather than looking at math and science education in isolation, the Commission argued that improving STEM education would depend on “doing school differently” through broader transformation of the American educational system.

The OpportunityEquation.org website offers the latest news on developments in STEM education, case studies of innovative programs, research, and more.

In the two years since its release, the *Opportunity Equation* has served as a call to action, a unifying framework, and a mission statement. It has inspired a wide range of specific actions and has lent momentum and credibility to a growing movement. Our nation has not yet achieved the goal of excellent, equitable STEM education for all students, but we are measurably closer than we were two years ago.

This brief update covers some of the major developments in each of the four areas emphasized in the *Opportunity Equation* report. It concludes by looking back at the Commission's original recommendations, noting signs of change, and highlighting questions and priorities for the future.

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ABOUT OPPORTUNITY EQUATION

The Opportunity Equation initiative promotes equity and excellence in mathematics and science education. A partnership between Carnegie Corporation of New York and the Institute of Advanced Study, the initiative was created to carry out the recommendations of the Carnegie Corporation of New York-Institute for Advanced Study Commission on Mathematics and Science Education in its 2009 report, *The Opportunity Equation: Transforming Mathematics and Science Education for Citizenship and the Global Economy*.

Opportunity Equation is co-chaired by Michele Cahill, vice president for National Programs at Carnegie Corporation of New York, and Phillip Griffiths, past director and professor emeritus of mathematics at the Institute for Advanced Study. Its staff works to advance the recommendations of the report—and thereby to transform American education through the dynamism of high-quality science, technology, engineering, and math learning.



Excellence and Equity

Mobilizing for Math and Science Learning

To frame its recommendations, the Carnegie-IAS Commission crafted a comprehensive plan for transforming American STEM education. The plan included specific recommended actions in four areas:

THE PLAN

Excellence and equity

mobilizing for math and science learning

Standards and assessments

focusing on essential skills and knowledge

Teaching and leadership

supporting effective teachers and leaders

School and system design

transforming classrooms, schools, and systems

Significant progress has been made in each area—enough to suggest that a movement has started that will produce real improvements in STEM education in the United States.

Building Commitment

STEM education is for all American students—and many people and organizations will need to join in to make that vision a reality. Here are a few recent signs that the nation's commitment to STEM learning is on the rise:

FEDERAL LEADERSHIP



The U.S. Department of Education made STEM the sole competitive priority in the first two rounds of the Race to the Top competition and included it as an absolute priority for the second round of i3 grants. President Obama is highlighting STEM nationally through his Educate to Innovate campaign. Citing lackluster performance by the U.S. on international measures of science and math, the President has called for moving American students “from the middle of the pack to the top in the next decade.”

CORPORATE INVOLVEMENT



Several ambitious public-private partnerships have come together to move the agenda. One, Change the Equation, has recruited a network of more than 100 corporate CEOs to invest strategically and advocate for improved STEM education. Through projects such as its state-by-state *Vital Signs* reports, CTEq hopes to “arm both business leaders and state leaders with the information they need to make the case for truly high expectations for our nation's students.”

Voices for STEM Excellence and Equity

Other influential reports have echoed the key findings of the *Opportunity Equation* report. Over the past two years, even more leaders in science, engineering, education, and public policy have added their voices to the call for improving STEM education for all American students. For example:

The **President's Council of Advisors on Science and Technology (PCAST)** issued recommendations on improving STEM education in a September 2010 report, *K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future*. The report's authors contend that the United States must both "prepare students so they have a strong foundation in STEM subjects and are able to use this knowledge in their personal and professional lives" and "inspire students so that all are motivated to study STEM subjects in school and many are excited about the prospect of having careers in STEM fields." The report lays out a five-part strategy for achieving those priorities.

A June 2011 report by the **National Research Council**, *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*, responds to a Congressional request for information on effective STEM programs around the country. In assessing program quality, the NRC committee considered the dual goals of excellence and equity, highlighting programs that have been shown to do a good job of preparing all students—including but not limited to the most motivated—with the science and math knowledge they need for productive futures.

STATE MOBILIZATION



NONPROFIT INNOVATION



States are mobilizing key constituencies—including business and higher education—to improve STEM learning. To cite just two examples, Massachusetts recently announced a collaborative plan for STEM excellence, and Texas continues to develop a network of regional STEM collaboratives to support schools around the state. Ohio and North Carolina are among the many states that have formed multi-sector coalitions with support from the Teaching Institute for Excellence in STEM (TIES).

Leading education nonprofits, in concert with forward-looking schools and districts, have intensified their focus on STEM; at the same time, prominent science organizations have stepped up their involvement with school improvement. Groups from NewSchools Venture Fund to the American Museum of Natural History are innovating and collaborating to boost STEM learning. They recognize that, although the gains will be hard won, the payoff in students' STEM skills and knowledge will be very great.

These are encouraging developments, but more needs to be done to ensure that the importance of STEM learning is clear to all Americans, especially students and parents. And new ways need to be found to build the thrill and relevance of STEM learning into the education of every American student.



Standards and Assessments

Focusing on Essential Knowledge and Skills

In June 2009, when the *Opportunity Equation* recommendations were issued, math and science standards that set common expectations for all American students seemed attainable—but a long way off. The Common Core State Standards Initiative was already underway, and 49 states and territories were involved in developing the new standards in mathematics and English language arts. Yet the standards themselves had not yet been written, and no one knew how many states would actually sign on to implement the standards in their schools and classrooms. The process of creating new standards for science education had not yet begun.

Since then, the shift toward common K-12 standards has been rapid and decisive, with more advances to come over the next few years.

SHARED STANDARDS

The Promise for States

COMMON CORE STANDARDS IN MATHEMATICS AND ENGLISH LANGUAGE ARTS

The Common Core State Standards Initiative, coordinated jointly by the Council of Chief State School Officers (CCSSO) and the National Governors Association (NGA), is a state-led effort to establish a shared set of clear educational standards that states can voluntarily adopt.

HIGH-QUALITY ASSESSMENTS ALIGNED WITH THE COMMON CORE STANDARDS

Two multi-state consortia, the Partnership for Assessment of Readiness for College and Careers (PARCC) and the SMARTER Balanced Assessment Consortium (SBAC), are designing high-quality assessments that will help teachers, schools, and districts implement the Common Core standards and chart improvements in student performance.

2009

SCIENCE STANDARDS THAT REFLECT THE BEST THINKING OF SCIENTISTS AND EDUCATORS

To lay the groundwork for new science standards, the National Research Council (NRC) convened an independent panel of experts from across the science fields to prepare a conceptual framework. A coalition of interested states and organizations are drawing on the NRC framework to draft next generation science standards, for voluntary adoption by states.

2010

June 2009

Process for drafting common standards announced, with 49 states participating

November 2009

Writing begins on common K-12 standards in mathematics and English language arts

June 2009

24 states form PARCC consortium to develop new Common Core-aligned assessments

December 2009

29 states form SBAC consortium to develop new Common Core-aligned assessments

January 2010

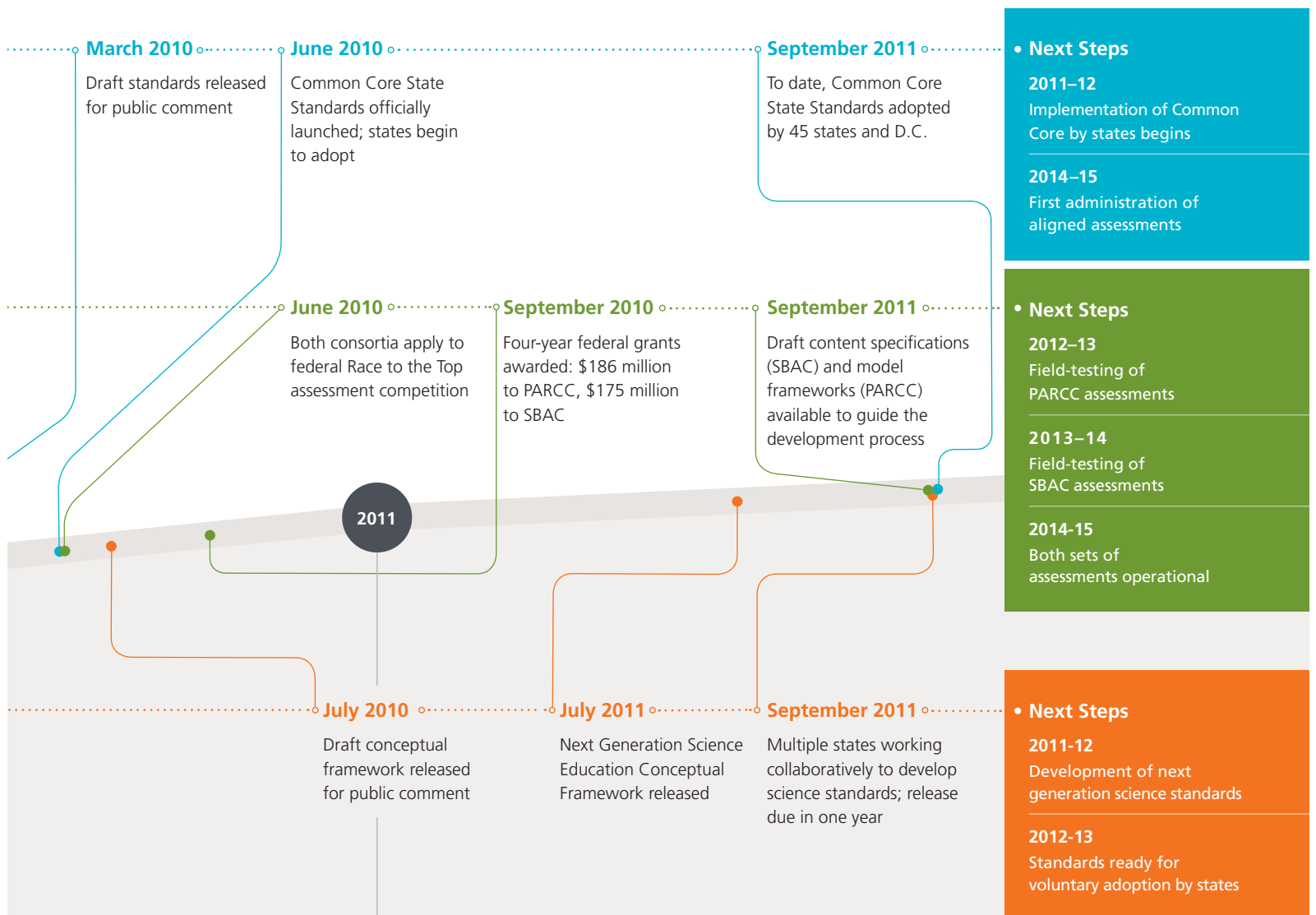
NRC expert panel convenes, begins work on conceptual framework for science standards

The move to shared standards for all American students is aspirational, even idealistic—yet it is also solidly pragmatic. Standards that are shared across states will be a resource for teachers and enable educators and state policymakers to view the strengths and weaknesses of the educational system, assess what needs to be done to improve schools, and prioritize the immediate and long-term needs of students and teachers.

There will be other benefits, as well. Shared standards, including both Common Core math standards and next generation science standards, will significantly enlarge the market for high-quality curricular materials and innovative technologies—which in turn will help teachers personalize learning for every student. For the first time, the nation will have clear benchmarks for assessing the quality of teacher

training and professional development programs, based on how well their graduates perform in terms of student learning.

Shared standards will also save money for states: for example, rather than pay for their own duplicative assessment systems, states will be able to pool their resources for more sophisticated tests and measurements of student performance. Having recognized the potential of shared standards, many state leaders have taken important steps forward by adopting Common Core standards in math and English language arts, joining multi-state assessment consortia, and signing on to help develop next generation science standards.





Teaching and Leadership

Supporting Effective Teachers and Leaders

Excellent teaching must be at the heart of any successful effort to improve math and science education in the United States. But no single approach will meet the nation's needs.

As the Carnegie-IAS Commission made clear, ensuring that all American students have teachers who engage them in rich math and science learning will require concerted, complementary initiatives to increase the supply of talented teachers, give them the best possible preparation, and encourage the most effective teachers to stay in the profession and hone their skills. Success will also depend on upgrading human capital management in the nation's schools and districts.

Over the past two years, multiple new efforts to improve STEM teaching have emerged and existing STEM teaching initiatives—by organizations such as Math for America and the National Science Teachers Association—have expanded. Equally important, the field is looking at the challenge from new angles, generating new ways to stimulate innovation, surface and share ideas, and improve on existing models. There's more to be done, but there's also real and impressive evidence that meaningful change is underway.

Motivating Coordinated Action

100K_{IN}10 INITIATIVE

100K_{IN}10 is a multi-sector network of organizations committed to meeting the nation's need for STEM teachers by increasing supply, retaining excellence, and building a movement. The partners include school districts, colleges, teacher residency programs, federal and state agencies, education nonprofits and museums, corporations, and foundations—all unified by a single, ambitious goal: to ensure that every American student has high-quality STEM teachers, in every school and at every grade level.

The initiative got its start in early 2011, when a small group of partners convened to discuss what could be done to meet President Obama's call for 100,000 new, excellent STEM teachers in 10 years. Solutions would need to come from many quarters and would need to be both innovative and highly practical. And, although the solutions would not be managed centrally, they would need to align well enough to add up to measurable change.

The 100K_{IN}10 partners are playing a variety of roles, from providing funding and building public support to testing new ideas and expanding successful programs. A collaborative research and development platform will enable continuous improvement.

100K_{IN}10

ANSWERING THE NATION'S STEM CHALLENGE

Adding a STEM Focus

Many organizations are increasing their emphasis on STEM, recognizing that raising the bar on STEM means raising the bar on learning overall.

SOME EXAMPLES

Citizen Schools

Recruiting STEM volunteers for extended learning time programs in turnaround schools

New Teacher Center

Developing a STEM professional mentoring network

New Visions for Public Schools

Preparing STEM teachers through an intensive clinical residency

Prompting New Ideas and Resources

ASHOKA'S CHANGEMAKERS COMPETITION

Despite the hard work of our nation's best teachers and principals, most schools are ill-equipped to educate all of our young people to higher levels of understanding in the STEM fields. Could valuable community assets—found today in American companies, nonprofits, and other organizations—be tapped or expanded to reach all American students and enrich the knowledge of teachers? Could existing programs be improved systematically to help students and teachers even more?

Believing the answer was yes, Ashoka's Changemakers launched an online, collaborative competition, Partnering for Excellence: Innovations in Science + Technology + Engineering + Math (STEM) Education. The competition sought out models that bring STEM resources into public schools, thereby using private and nonprofit assets in new ways to further student learning. The particular challenge was to design models that bring people with STEM expertise into engagement with schools on a "long term, part time" basis.

Between May and August 2011, a total of 265 ideas were submitted. Judging by an expert panel and interested community members will take place this fall; prizes will be awarded in November to help winning ideas move forward.

LONG TERM, PART TIME STEM TALENT FOR SCHOOLS

	FULL TIME	PART TIME
SHORT TERM	Teaching as service (placements in full time teaching positions for non-career teachers)	Supplementary learning resources (career days, one-day field trips)
LONG TERM	Traditional teachers (most of the teachers who taught you when you were in school)	YOUR SOLUTION HERE

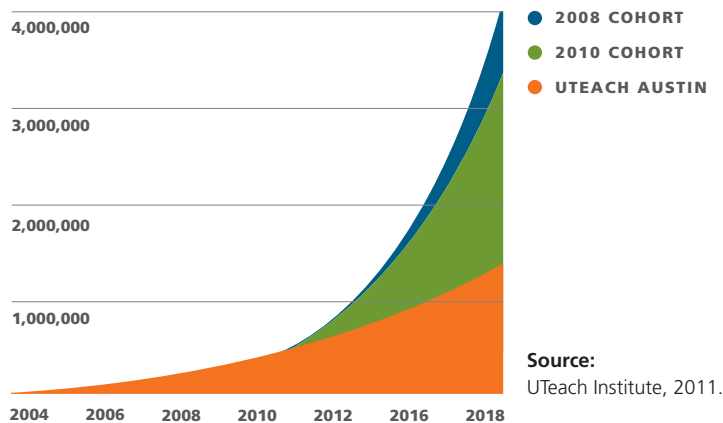
Scaling Up Success

UTEACH/NATIONAL MATH AND SCIENCE INITIATIVE

The UTeach model, pioneered in 1997 at University of Texas Austin, cleverly solves many of the classic problems of recruiting well-prepared STEM graduates to the teaching profession. Aimed at undergraduate STEM majors, UTeach gives talented science and math students a chance to complete their regular degree programs, gain clinical classroom experience, and earn a teaching credential—all at the same time, at little or no additional cost to the candidate. Overall, more than 90 percent of UTeach graduates actually become math and science teachers, and more than 80 percent of them are still teaching five years later.

Since 2006, UTeach has gotten assistance from the National Math and Science Initiative (NMSI), founded in that year as a response to *Rising Above the Gathering Storm*, a report by the National Academies that warned of a coming crisis in STEM teaching. Believing in scaling up proven models, NMSI worked with UTeach to document their approach and fund a series of replications. A first round of competitive grants were awarded to 13 universities in 2008, and an additional 8 universities began implementation in 2010. In 2011–12, a third replication cohort will start UTeach programs at 6–7 universities.

PROJECTED NUMBER OF STUDENTS TAUGHT BY UTEACH GRADUATES NATIONALLY



Providence After School Alliance

Building a STEM learning community among local nonprofits

Teach for America

Creating new incentives that help retain strong STEM teachers in the profession

University of Washington College of Education

Producing video tools for new STEM teachers

Urban Teacher Residencies United

Increasing the supply of STEM teachers in urban public schools

Washington, D.C., Public Schools

Building partnerships to bring STEM resources to schools



School and System Design

Transforming Classrooms, Schools, and Systems

The Commission argued that every element of a school's design, including its use of time, money, talent, and technology, should be viewed as a potential asset to improve instruction and foster student resiliency and achievement. Like factories and corporate workplaces, the American educational system needs to be redesigned for a global economy, one that demands far higher levels of knowledge and skills in every area, particularly in math and science, and far greater ability to apply them to analyze problems, generate solutions, and work collaboratively. To a very considerable extent, the future of American young people depends on our ability to transform our schools.

Yet redesigning American education is an exceptionally daunting challenge. The system is not well structured to promote innovation, test new ideas, or bring the best approaches to scale. Another impediment is the siloed nature of the system, which makes it hard to design approaches that reach across academic subjects, modes of learning, levels of schooling, or geographic regions.

Fortunately, some innovators are addressing key design challenges head on, with integrated solutions to systemic problems.

Integrated Solutions for Excellence and Equity

Current U.S. Educational System



THE PROBLEM

Conventional schools don't make the best use of resources to maximize student potential.

DESIGN CHALLENGE:**PERSONALIZE
LEARNING**

A growing cohort of schools are pushing ahead with personalized, next generation learning that's built right into the school model. **DSST Public Schools** (named for the charter network's original school, the Denver School of Science and Technology) is a prime example. DSST combines traditional and inquiry-based approaches, using technology to support students' individual learning, transform classroom teaching, and enable a schoolwide assessment system. DSST currently operates five open-enrollment STEM schools for approximately 1,500 Denver students in grades 6-12.

DESIGN CHALLENGE:**LEVERAGE
TECHNOLOGY**

To prepare students to succeed in the new economy, schools need to help students leverage technological resources, understand and use information from various sources and media, and apply their knowledge. The **New Tech High School** model integrates technology and instruction, using project-based learning as the vehicle by which students learn, collaborate, and demonstrate mastery. The **New Tech Network** is working with 40 district and charter public high schools across nine states to support them in implementing this distinctive approach.

DESIGN CHALLENGE:**REINVENT
COLLEGE MATH**

Roughly half of community college students need developmental math before they can even qualify for a required, credit-bearing math course, and up to 70 percent never complete the sequence—putting a diploma completely beyond their reach. **Statway**, a project of the Carnegie Foundation for the Advancement of Teaching and the Charles A. Dana Center at the University of Texas, is reinventing college math by combining developmental and college-level work, offering rigorous, relevant statistics content, and emphasizing strong teaching. Sixteen community colleges are Statway partners.

DESIGN CHALLENGE:**ENABLE
INVENTION**

In a new alliance coordinated by the Council of Chief State School Officers, nine states have joined forces to create the **Shared Learning Collaborative** (SLC), an open-source technology system that will support implementation of the Common Core. The SLC will enable teachers to create rich, personalized learning experiences for students, track student progress, and diagnose learning needs. It will also foster a vibrant community of curriculum and tool developers. The SLC will ultimately be available to all states and districts.

Transformed U.S. Educational System

THE GOAL

New designs use and combine resources creatively to help all students learn.



Renewing the Call

Two years after the release of the *Opportunity Equation* report, the outlines of a movement to improve STEM learning are clear. Without a doubt, important gains have been made in key areas. Yet it's also true that the path ahead holds many uncertainties. Questions for the nation—and, more pointedly, for specific constituencies—are as urgent as they were in 2009.



Excellence and Equity

Mobilizing for Math and Science Learning

2009 RECOMMENDATIONS

- 1 Mobilize the nation to improve math and science education for all students
- 2 Place mathematics and science at the center of school innovation, improvement, and accountability efforts

WHERE WE STAND

With the recession reshaping our economy in both short-term and permanent ways, good-paying jobs requiring only a high school education continue to dwindle. Analysis by Georgetown University researcher Anthony Carnevale suggests that, by 2018, 63 percent of all jobs in the United States will demand at least some college education—up from 28 percent in 1973 and 59 percent in 2007. The fundamental cause is “skill-biased technology change,” a process by which employers cut costs by eliminating positions that can be done more cheaply by computer. In every sector, including manufacturing, the jobs that remain require skilled workers with at least some postsecondary training. College was once the preferred route to economic success; today, for most young people, it is the only route. And STEM skills and knowledge are essential for college success.

As states continue to cope with the effects of the economic recession, there's a danger that their determination to improve STEM education will wane. That would be a short-sighted mistake, with negative economic consequences for the country and American young people.

WHAT'S AHEAD

We must find ways to make the case for excellence and equity in STEM education even more powerfully, especially to parents and students. It is also essential that we continue to invest in transforming STEM education in all American schools, at every grade level. Exciting, motivating STEM learning must reach many more students through new approaches and the expansion of successful ones. The nation can't afford not to capitalize on the advances made so far.

How can we maintain and accelerate progress toward the goal of excellence and equity in STEM learning for all American students?

What can be done to increase understanding of the problem and potential solutions among the public, educators, and others?

How can the weight of our efforts be put behind the most important and promising developments?

In this final section, we revisit the Commission's 2009 recommendations and take stock of how the picture has changed. We then suggest what can be done within today's context to consolidate the most important advances and prioritize the work that still needs to be done.



Standards and Assessments

Focusing on Essential Skills and Knowledge

2009 RECOMMENDATIONS

- 1 Establish common math and science standards that are fewer, clearer, and higher and that stimulate and guide instructional improvement and galvanize the nation to pursue meaningful math and science learning for all Americans
- 2 Develop sophisticated assessments and accountability mechanisms that, along with common standards, stimulate and guide instructional improvement and innovation in mathematics and science

WHERE WE STAND

Most states have signed onto the Common Core K-12 standards and joined in the development of aligned assessments, but the toughest challenges lie ahead. The expectations of the Common Core represent a huge leap over current practice in many states, requiring implementation strategies that give schools and teachers strong support. Although difficult, the effort will be worth it in terms of college- and career-readiness.

Next generation science standards, currently under development, will be an important complement to Common Core standards in math and English language arts. The development process is a promising one, with strong participation from states, scientists, and educators.

WHAT'S AHEAD

Over the next few years, the Common Core standards, aligned assessments, and science standards will provide a foundation for transforming STEM education, while also enabling state leaders and educators to set goals and measure progress. We must ensure that teachers have the resources they need to implement the Common Core and put its new, higher expectations to work in their classrooms. In particular, tools are needed that deepen teachers' STEM knowledge and help them deliver personalized, rigorous STEM learning to all students.



Teaching and Leadership

Supporting Effective Teachers and Leaders

2009 RECOMMENDATIONS

- 1 Increase the supply of well-prepared mathematics and science teachers at all grade levels by improving teacher preparation and recruitment
- 2 Improve professional learning for all teachers, with an eye toward revolutionizing math and science teaching
- 3 Upgrade human capital management throughout U.S. schools and school systems toward ensuring an effective teacher for every student, regardless of socio-economic background

WHERE WE STAND

State budget shortfalls and resulting teacher layoffs in some districts have obscured the fact that excellent STEM teachers continue to be in high demand nationally. The tightening of the teacher workforce makes it all the more important to attract talented, well-prepared STEM grads to the teaching profession, deploy them well in schools where they are most needed, retain and reward them for excellence, and support their professional learning.

Fortunately, leaders from many sectors—including government, education, business, and philanthropy—have acknowledged that the nation needs many more excellent STEM teachers, and that coordinated action will be needed to recruit and retain them. The nation has also witnessed the growth and refinement of some highly promising approaches to teacher preparation, including teacher residencies and university-based programs that combine strong STEM academics with rich clinical experiences.

WHAT'S AHEAD

Teacher preparation programs—both alternative and university-based—must continue to innovate if they are to attract the most talented candidates and prepare them to succeed in the classroom. This is especially important in the STEM fields, where graduates have many attractive alternatives to teaching.

We also need to do more to strengthen the links between our nation's teachers and resources in other sectors that can enrich and enliven STEM learning for all American students. Corporations, science institutions, and other nonprofits are stepping up to provide learning experiences for students, while also enabling teachers to refresh their STEM knowledge. Efforts like these—many of them coordinated through state or local STEM coalitions—should be continued and expanded.



School and System Design

Transforming Classrooms, Schools, and Systems

2009 RECOMMENDATIONS

- 1 Build high expectations for student achievement in mathematics and science into school and classroom culture and operations as a pathway to college and careers
- 2 Enhance systemic capacity to support strong schools and act strategically to turn around or replace ineffective schools
- 3 Tap a wider array of resources to increase educational assets and expand research and development capacity

WHERE WE STAND

Despite the signs of progress noted in this report, STEM learning has not yet changed appreciably for most American students. The United States has taken important steps toward articulating higher expectations for all students, but we have not reached agreement about how our schools can best help students reach these new, higher levels of learning, especially in STEM.

The need for systemic capacity to improve schools, support teachers, and open pathways for all American students remains great. As a nation, we must move away from the industrial model of schooling that served us in the past and adopt a more flexible and accountable approach, one that gives schools and teachers the tools to solve problems, customize, and address individual students' needs. We need to do a better job of deploying resources strategically toward excellence and equity.

WHAT'S AHEAD

It is essential that we invest in data systems that help guide student learning and provide meaningful information about the effectiveness of schools. That information will be crucial as we continue to retool and redesign our education system for even higher performance. Teachers must be fully engaged in the design of data systems, to ensure that data are useful to them and to avoid the "teach-to-the-test" mentality that has marred the effectiveness of current accountability systems.

As a nation, we need to encourage innovation and scale up effective designs that "do school differently." Attaining that goal will require that schools tap into a wide array of approaches, technologies, people, and resources to meet students' needs and allow all young people to become STEM-capable.

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NEW YORK | STUDY

Commission on Mathematics
and Science Education

As a society, we must commit ourselves to the proposition that all students can achieve at high levels in math and science, that we need them to do so for their own futures and for the future of the country, and that we owe it to them to structure and staff our educational system accordingly.

THE OPPORTUNITY EQUATION, 2009