Laboratories of Reform:
Initiatives in Midwestern States to Improve Math and Science Education

A Report of The Council of State Governments’ Midwestern Legislative Conference
Laboratories of Reform:
Initiatives in Midwestern States to Improve Math and Science Education

A Report of
The Council of State Governments’
Midwestern Legislative Conference

Midwestern Legislative Conference
Executive Committee Officers

Chair
Senator Jay Scott Emmer
Kansas

First Vice Chair
Senator Stephen Buehrer
Ohio

Second Vice Chair
Representative Scott Reske
Indiana

Immediate Past Chair
Senator Tom Dempster
Assistant Majority Leader, South Dakota

For more information or to order copies, contact:
The Council of State Governments
701 E. 22nd Street, Suite 110
Lombard, IL 60148
630/925-1922
630/925-1930 (fax)
www.csgmidwest.org
E-mail: csgm@csg.org

August 2009
LABORATORIES OF REFORM: INITIATIVES IN MIDWESTERN STATES TO IMPROVE MATH AND SCIENCE EDUCATION
Foreword

The United States’ continued prosperity depends on our ability to educate future generations in a way that keeps them competitive in the ever-changing global economy.

Here in the Midwest, it is more important than ever that we prepare young people to succeed in the areas of math and science. The jobs of yesterday are giving way to a new frontier of opportunities in the STEM (science, technology, engineering and mathematics) fields.

As state policymakers, it is imperative that we work to better equip our students for careers in the sectors that will drive our economies such as energy, bioscience, agriculture and medicine.

In this report, the Midwestern Legislative Conference looks at a number of strategies being used by state policymakers to strengthen math and science education.

The information in this report comes from interviews with state officials, educators, legislators, policy experts and representatives of nonprofit organizations, such as teachers’ associations.

In this era of limited resources and difficult economic conditions, states can work toward ensuring a bright future by investing in an asset that is sure to yield excellent dividends: our young people.

Jay Scott Emmer
Kansas State Senator
2009 Chair of the Midwestern Legislative Conference
LABORATORIES OF REFORM: INITIATIVES IN MIDWESTERN STATES TO IMPROVE MATH AND SCIENCE EDUCATION
# Table of Contents

**INTRODUCTION** .................................................. 7

**SECTION I**  
**NATIONAL CONCERN, STATE RESPONSIBILITY:**  
Lawmakers seek to improve K-12 math and science education, better engage young people .......................... 8

**SECTION II**  
**FOUNDATIONS OF LEARNING:**  
High-quality teachers are critical to student success in math and science, and concerns about shortages are spurring state actions .......................... 14

**SECTION III**  
**PUSH FOR STRONGER GRADUATION REQUIREMENTS:**  
With changes in state laws, legislators are asking more of students, K-12 systems ............................................. 20

**SECTION IV**  
**THE CASE FOR QUALITY ACADEMIC STANDARDS:**  
International data reveal why standards are a building block for world-class math, science education — and how states can improve ............................................. 26

**SECTION V**  
**VALUABLE CONNECTION:**  
STEM education offers the chance to provide students with the adaptable, analytical skills they need in a “knowledge economy” ............................................. 32

**APPENDIX**  
**THE PROVINCIAL PERSPECTIVE:**  
The Canadian provinces are working to increase student and teacher engagement in mathematics and the sciences ............................................. 36
The state of math and science education: Room for improvement in instruction, student achievement

In late 2008, the release of Minnesota students’ test scores in math and science proficiency made big news in the state. The positive results, education and business leaders said, were good reason for pride and celebration.

This wasn’t a high-stakes test in the sense that results would determine whether a student could get into college or whether a school would face sanctions.

Instead, the Trends in International Mathematics and Science Study assessed Minnesota fourth- and eighth-graders’ performance in these two subject areas compared to counterparts around the world. How these students measure up, state leaders say, is an indicator of how Minnesota is doing in a high-stakes global competition for success in today’s economy, one that is increasingly driven by technological innovation, that demands a skilled workforce, and that puts a premium on math and science aptitude.

Recognizing this economic reality, Minnesota and other Midwestern states have made improving K-12 math and science education a top policy priority. The importance of this issue is also what led Kansas Sen. Jay Scott Emelr to choose it as the focus of his 2009 Midwestern Legislative Conference chair’s initiative.

Why the focus on math and science?

States are increasingly focusing on improvements to math and science education because of concerns about student performance, as well as the economic consequences of inadequate achievement levels in these subject areas.

Among the 30 industrialized countries participating in a 2006 assessment of 15-year-olds’ math and science literacy, the United States ranked 21st in science and 25th in math. According to the American Society for Engineering Education, fewer than 15 percent of high school graduates have a strong enough math or science foundation to pursue science or technology degrees.

At risk, government and business leaders say, is the nation’s long-held standing as a world leader in science, technology and innovation a position that has contributed mightily to U.S. economic prosperity.

Four years ago, in the landmark report “Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,” The National Academies said improvements to K-12 mathematics and science education were critical to shoring up “the foundations of America’s competitiveness” in the global economy.

The need to strengthen K-12 math and science education is a national concern, but many of the policy solutions must come from the states.

Organization of the report

This report “Laboratories of Reform: Initiatives in Midwestern States to Improve Math and Science Education” was completed as part of Sen. Emelr’s 2009 MLC chair’s initiative.

The goals of this report are to provide members of the MLC with a perspective on the importance of math and science education, share some of the new and long-standing initiatives in place in the Midwest, and highlight the policy steps that states and provinces can take to improve student achievement.

“Laboratories of Reform” includes five main sections, some of which were written by the staff of the CSG Midwestern Office (which provides secretariat services to the MLC) and some of which were written by experts in math and science education.

For example, a section on the importance of quality academic standards was co-written by William Schmidt, the distinguished professor at Michigan State University who led efforts to improve math standards in Minnesota. His work has been credited with helping improve Minnesota’s math scores on the international assessment.

Another section which examines the importance of delivering quality STEM (science, technology, engineering and mathematics) education to students was written by Brad Mitchell, director of STEM education and economic development engagement for the Battelle Memorial Institute and The Ohio State University.

Writing in the sections done by CSG Midwest staff was informed by state-by-state research as well as interviews with legislators, K-12 education experts, university leaders and state agency officials. These sections examine state efforts to:

- enhance student interest and achievement in math and science (Section I);
- increase the number and quality of K-12 math and science teachers (Section II); and
- establish more-stringent high school graduation requirements (Section III).

Within each section, various policy reforms and education strategies are highlighted. The report also includes an appendix highlighting initiatives in three Canadian provinces: Manitoba, Ontario and Saskatchewan.
States are seeking new ways to spark student interest — and raise student achievement — in science, technology, engineering and mathematics. One state in this region, Ohio, has launched one of the most notable and comprehensive STEM initiatives in the country. In this section, the Ohio initiative, as well as other student-centered approaches in the Midwest, is explored. This article was co-written by Jennifer Ginn, policy analyst for CSG, and Kate Tormey, assistant editor/policy analyst for CSG Midwest.

Lawmakers seek to improve K-12 math and science education, better engage young people
Two years ago, the Ohio General Assembly placed a big bet on the future of the state’s children with STEM education.

The idea behind the education reform plan was to bring in new partners to help design schools that stress “STEM” subjects: science, technology, engineering and math.

In 2007, the legislature passed and the governor signed HB 119, which dedicated more than $200 million in the biennial budget for a STEM education initiative.

The funding was divided into several areas: establishing STEM schools (grades 6-12) and Programs of Excellence (grades K-8); providing scholarships for students to attend Ohio colleges and universities; offering professional development for teachers; and increasing the supply of STEM/foreign-language teachers at the secondary level.

The scope of the initiative and the level of the funding commitment make Ohio’s new emphasis on STEM education unique.

But it also is emblematic of a trend being seen around the country, as state and federal lawmakers and local educators strive to improve student performance in math and science education.

“If we want to have high-paying jobs for more people in this state, it’s a simple equation,” says Ohio Sen. Jon Husted, one of the primary supporters of HB 119.

“We have to be better educated,” says the Republican from Kettering. “The skills most in demand are STEM skills.”

Two years before Ohio launched its initiative, The National Academies warned about the erosion of a vital, long-standing competitive advantage that the United States has enjoyed in the global economy: its status as a leader in science and technology innovation.

To reverse this trend, the Academies said, K-12 math and science education has to be “vastly improved.”

The responsibility for making these improvements lies in large part with the states.

Ohio’s STEM initiative is just one example of how states in the Midwest are trying to foster student interest and success in math and science.

**STEM takes root in Ohio**

Ohio has five STEM “hub sites” that serve low-income and minority students in Akron, Cincinnati, Cleveland, Columbus and Dayton. So far, only Columbus and Cleveland have new STEM schools up and running. A second school in Columbus and schools in Cincinnati and Dayton are scheduled to open in the fall of 2009.

In order to establish a STEM school, the site must have three

---

**State programs encourage teens to study math, science**

States in the Midwest, either through stand-alone initiatives or through the work of their public universities, have many programs in place encouraging high-school-age students to study — and succeed in — math and science. Here are some examples from the region.

- Each year, two Indiana students receive the Mr./Miss Math or Science Award. The prize, which got its name from the long tradition of extending Mr. and Miss Basketball awards to the state’s best players, was created by Gov. Mitch Daniels in 2008 to recognize high achievers in math and science. Winners receive a $2,000 scholarship from McGraw-Hill Education.

- The South Dakota State Scholars program encourages high school students to take a rigorous course load that includes math and science. The program also brings local businesspeople into the classroom to talk with students about the importance of math and science in the workplace.

- In Ohio, the state Department of Education funds Summer Honors Institutes, which are open to gifted ninth- and 10th-graders and offer a focus on math and science.

- The North Dakota Governor’s School, funded by the state, offers a six-week, tuition-free summer enrichment program for high school students. Admission is competitive, and students can choose from a variety of subjects to focus on, including mathematics and laboratory science.

- Some states offer scholarships, loans or grants to students who study math and science, often with the requirement that the graduate remain in an in-state job for a period of time.

This year in North Dakota, legislators agreed to establish and fund STEM grants, a merit-based financial-assistance program for students in the fields of science, technology, engineering and math.

*Article written by Kate Tormey, assistant editor/policy analyst for CSG Midwest*
essential elements: interest from public schools, involvement of a college or university, and a business or industry committed to working on the project. The hub brings all the partners together, each of which are heavily involved in setting up how the school will operate.

State funding helps establish the school, along with donations from foundations and private partners, while the Ohio STEM Learning Network provides resources and shares best practices.

“We’re asking the business partner to be an active, engaged player in the game,” says David Burns, director of sustainability for the network, “not somebody who’s donating something.”

STEM schools are urged to talk about education as an economic development issue, an idea that business leaders have embraced.

“It’s one of the most important tools for economic growth in this state,” says Sean Yoder, executive director of the Ohio Business Alliance for Higher Education and the Economy. “If we’re not able to grow and develop and attract talent, then we know we’re not going to be able to compete.”

Ohio’s first STEM school, the Metro Early College High School in Columbus, began accepting students in the fall of 2006. It is a partnership between Columbus-based Battelle—the world’s largest independent research and development firm—and The Ohio State University. The school, which receives funding from the Bill and Melinda Gates Foundation, has almost 300 students enrolled, 43 percent of whom are eligible for free or reduced-price meals.

“If a student exits high school with Algebra 2 as the last math class they took, [he or she is] at that time remedial in college,” says Marcy Raymond, principal of the Metro School.

“The high school barrier keeps kids from being able to access college….We’re trying to remove barriers to choosing engineering, to choosing chemistry.”

Ohio’s latest STEM school is the MC² STEM High School in Cleveland, which is located on a General Electric campus. The school started in August 2008 with a class of 93 ninth-graders, all of whom are eligible for free or reduced-price meals. Each year, the school will add one more grade level. GE employees serve as mentors for the students, who can also complete internships at the plant.

At both the Cleveland and Columbus schools, students complete classes not when they spend a certain amount of time in the classroom, but when they can demonstrate they’ve learned the skills. For some students, one class may take 16 weeks; for others, it may take 20. Students at both schools also can take college classes while still in high school and earn credits that will transfer to any Ohio college or university. At the Metro School, students can graduate with up to 90 college credits.

For it to be effective, Husted says, Ohio’s new initiative will have to impact not only the students attending the new STEM schools, but the state’s entire K-12 system. That transformation will take time.

“It’s about changing the culture of education,” he says. “It’s about changing the culture of how we think about the economy. Then we have something that can be meaningful and sustainable.”

Different approaches used in other states

When Illinois Math and Science Academy (IMSA) President Max McGee took a group of students on a recent trip to Singapore, he was well aware of that country’s reputation for having top-notch math and science education.

So he was thrilled when the IMSA students held their own in conversations with some of the most distinguished scientists in the world.

McGee chalks up the students’ abilities to the academic approach at the IMSA, a residential program for academically talented students in grades 10 through 12. The school has been producing scientists, mathematicians and engineers for more than two decades. Created by the Illinois legislature in 1985, the academy currently educates 650 students in a rigorous hands-on STEM-focused curriculum. Admission is highly competitive.

The state-supported school does not charge tuition, room or board, but does levy activity fees on a sliding scale, making the cost similar to attending a traditional public high school, McGee says.

But the school isn’t part of the state’s K-12 education system—it’s part of the state’s higher education system, which McGee says is key to achieving the school’s mission.

“If we want to have high-paying jobs for more people in this state, it’s a simple equation. We have to be better educated. The skills most in demand are STEM skills.”

bio Sen. Jon Husted

=OHIO S E N T E N C E I
National concern, state responsibility: Lawmakers seek to improve K-12 math and science education, better engage young people

At both the Cleveland and Columbus schools, students complete classes not when they spend a certain amount of time in the classroom, but when they can demonstrate they’ve learned the skills. For some students, one class may take 16 weeks; for others, it may take 20. Students at both schools also can take college classes while still in high school and earn credits that will transfer to any Ohio college or university. At the Metro School, students can graduate with up to 90 college credits.

For it to be effective, Husted says, Ohio’s new initiative will have to impact not only the students attending the new STEM schools, but the state’s entire K-12 system. That transformation will take time.

“It’s about changing the culture of education,” he says. “It’s about changing the culture of how we think about the economy. Then we have something that can be meaningful and sustainable.”

Different approaches used in other states

When Illinois Math and Science Academy (IMSA) President Max McGee took a group of students on a recent trip to Singapore, he was well aware of that country’s reputation for having top-notch math and science education.

So he was thrilled when the IMSA students held their own in conversations with some of the most distinguished scientists in the world.

McGee chalks up the students’ abilities to the academic approach at the IMSA, a residential program for academically talented students in grades 10 through 12. The school has been producing scientists, mathematicians and engineers for more than two decades. Created by the Illinois legislature in 1985, the academy currently educates 650 students in a rigorous hands-on, STEM-focused curriculum. Admission is highly competitive.

The state-supported school does not charge tuition, room or board, but does levy activity fees on a sliding scale, making the cost similar to attending a traditional public high school, McGee says.

But the school isn’t part of the state’s K-12 education system—it’s part of the state’s higher education system, which McGee says is key to achieving the school’s mission.

“If we want to have high-paying jobs for more people in this state, it’s a simple equation. We have to be better educated. The skills most in demand are STEM skills.”

bio Sen. Jon Husted

=OHIO S E N T E N C E I
National concern, state responsibility: Lawmakers seek to improve K-12 math and science education, better engage young people

At both the Cleveland and Columbus schools, students complete classes not when they spend a certain amount of time in the classroom, but when they can demonstrate they’ve learned the skills. For some students, one class may take 16 weeks; for others, it may take 20. Students at both schools also can take college classes while still in high school and earn credits that will transfer to any Ohio college or university. At the Metro School, students can graduate with up to 90 college credits.

For it to be effective, Husted says, Ohio’s new initiative will have to impact not only the students attending the new STEM schools, but the state’s entire K-12 system. That transformation will take time.

“It’s about changing the culture of education,” he says. “It’s about changing the culture of how we think about the economy. Then we have something that can be meaningful and sustainable.”

Different approaches used in other states

When Illinois Math and Science Academy (IMSA) President Max McGee took a group of students on a recent trip to Singapore, he was well aware of that country’s reputation for having top-notch math and science education.

So he was thrilled when the IMSA students held their own in conversations with some of the most distinguished scientists in the world.

McGee chalks up the students’ abilities to the academic approach at the IMSA, a residential program for academically talented students in grades 10 through 12. The school has been producing scientists, mathematicians and engineers for more than two decades. Created by the Illinois legislature in 1985, the academy currently educates 650 students in a rigorous hands-on, STEM-focused curriculum. Admission is highly competitive.

The state-supported school does not charge tuition, room or board, but does levy activity fees on a sliding scale, making the cost similar to attending a traditional public high school, McGee says.

But the school isn’t part of the state’s K-12 education system—it’s part of the state’s higher education system, which McGee says is key to achieving the school’s mission.

“If we want to have high-paying jobs for more people in this state, it’s a simple equation. We have to be better educated. The skills most in demand are STEM skills.”

bio Sen. Jon Husted
people who are at the top of their professions and have an enormous amount of expertise they can bring to our students,” McGee says.

The other advantage is that the school can adopt class schedules more in line with those offered at universities. On Wednesdays, for example, juniors and seniors conduct independent research with mentors at off-campus laboratories and universities.

McGee says many people wrongly assume that the IMSA’s highly talented graduates leave Illinois for academic powerhouses such as MIT or Cal Tech. In fact, about half of them go on to attend in-state universities—a key factor in keeping talented young people in Illinois upon college graduation.

The academy’s mission to promote excellence in science and math education isn’t limited to students on its campus. Each summer, the IMSA staff conducts summer camps throughout the state for students of all ages, in hopes of sparking interest in STEM fields. The school also offers a number of professional development programs that train teachers in hands-on instructional techniques designed to inspire young minds.

Indiana, too, has had a residential school for gifted students for more than 20 years. The Indiana Academy for Science, Math, and Humanities serves about 300 juniors and seniors from across the state.

Each summer, the academy (located at Ball State University) also hosts a wide range of courses for teachers from around the state to update their skills in areas such as calculus, computer science and chemistry.

One of McGee’s hopes is that more math and science academies such as those offered in Illinois and Indiana will grow and flourish in the Midwest and eventually form a network.

“There is not a better time for this initiative,” he says.

Kansas academy up and running

Policymakers in another Midwestern state, Kansas, answered this call to action, creating a residential math and science school based in part on the IMSA model.

In the fall of 2009, 26 Kansas students will form the first class of the Kansas Academy of Mathematics and Science (KAMS), an academically rigorous program for students interested in math and science.

The academy was created in 2006 by the Legislature, in response to a growing concern that Kansas was falling behind other states and the rest of the world in producing engineers and scientists.

Housed at Fort Hays State University, the two-year high school program is available to students after completion of their sophomore year. Students will receive instruction from university faculty

Closing the gap: Student populations underrepresented in STEM fields

In 2000-01, 13 percent of the bachelor’s degrees awarded to African-Americans and Hispanics were in STEM fields, compared with 31 percent for Asian-Americans and 16 percent for whites, according to the American Council on Education.

This disparity has fueled state efforts to encourage racial minorities and women, who are typically underrepresented in STEM fields, to consider careers in these areas.

Iowa’s Science Bound program, housed at Iowa State University, seeks to promote diversity in STEM fields by identifying gifted minority seventh-graders in three Iowa cities. Participants meet regularly with math and science teachers for mentoring and academic support, and also attend summer programs that offer hands-on learning opportunities.

Successful students are then invited to take part at the high school level, and become eligible upon graduation for full scholarships to Iowa State University if they pursue a degree in math or science. Science Bound is sponsored by the university, government agencies such as NASA and the U.S. Department of Energy, and private companies. Since the program began in 1990, more than 200 minority students have been offered scholarships.

Women are also underrepresented in many STEM fields. In 2008, for example, 27 percent of computer scientists were female; 1 percent were female and Hispanic.

Iowa, Illinois, Minnesota and Wisconsin are among seven states participating in the STEM Equity Pipeline project, an initiative aimed at closing the gender gap in STEM education.

The project’s goal is to provide opportunities for women in STEM fields by training educators to mentor females, provide them with academic support, and expose them to majors such as engineering and health sciences. Teams of educators also assess educational equity in their states’ schools and universities, and identify ways to increase the participation of students traditionally underrepresented in STEM fields.

The project was created by the National Alliance for Partnerships in Equity Education Foundation and is funded by the National Science Foundation.

Article written by Kate Tormey, assistant editor/policy analyst for CSG Midwest
alongside college students and will graduate with 68 college credits. They also will be exposed to some of the state’s growing industries, such as wind energy and biological and plant sciences.

Kansas Sen. Laura Kelly, who supported the legislation (HB 139) creating the academy, says the school is far from a “panacea” to addressing one continuing concern in her state: the “brain drain,” or loss of talented young people to other states.

However, she believes it is a step in the right direction.

“We need to really reshape our educational structure to meet the demands of today’s world,” Kelly says.

Ron Keller, director of Kansas’ new academy, says the school is already having an impact on the future plans of young people.

“Some students remarked to us that they will strongly consider staying here to complete their [higher] education,” he says. “And an awful lot of them have expressed interest in remaining here in the state [after college].”

**Uneartbing math, science talent**

These new or long-standing initiatives in states such as Kansas, Indiana, Illinois and Ohio all share a common emphasis on delivering quality math and science education to young people. Where they sometimes differ, though, is in the scope of the programs and type of students being served.

At the Illinois academy, for example, students tend to be extraordinarily gifted, and the school aims to promote a rigorous education among students who have an underlying interest in STEM subjects.

Ohio’s network of STEM schools, in contrast, targets a broader student population.

Both approaches – challenging interested and talented young math and science students on the one hand, and better engaging and teaching all students on the other – should be part of state reform efforts, says Christopher Kolar, coordinator of research and evaluation at the Illinois academy.
“There is talent throughout a population,” and it benefits the state “to find these people, wherever they are, and develop them along,” says Kolar, who serves on the board of directors of the National Consortium for Specialized Secondary Schools of Mathematics, Science and Technology. “It’s important that we look a little deeper for that talent so that it doesn’t get missed.”

Another policy approach, then, is for states to establish new math and science programs within existing K-12 schools.

In Wisconsin, for example, the state offers schools grant funding to develop instructional programs designed to improve the achievement levels of students in STEM subjects. Grants are awarded on a competitive basis, and school districts are encouraged to use the funds to support student populations (women, low-income, minority and disabled) that have been traditionally underrepresented in STEM fields.

The Michigan Mathematics and Science Centers Network serves teachers and students in local school districts throughout the state, with programming, academic support and professional development in math and science. The network also includes seven accelerated high school programs that belong to the aforementioned national consortium.

According to education policy experts, efforts to promote math and science in young people should start as early in the education system as possible.

“We’re losing a whole lot of kids at the elementary level,” says Francis Eberle, executive director of the National Science Teachers Association. “It’s a huge problem.”

“This really starts in the K through 5 grade levels; that is the time you want to get them with an ‘aha’ moment,” he adds.

That moment often never comes, though, in part because of the teaching methods being used.

“Unfortunately, far too many elementary schools and teachers still do rote memorization of facts [and] worksheets,” Eberle says, rather than engage students in “hands-on, problem-based learning.”

State-funded and -led professional development for elementary-school teachers can help improve the instructional strategies being used.

But Eberle also points out that many schools don’t have the laboratory equipment needed to support a more “hands-on” curriculum, and that instruction time is often shifted away from science as educators prepare students for standardized testing in other subject areas.

He says an early exposure to engaging math and science coursework lays the foundation for student interest and success in these subject areas. Conversely, an inadequate elementary-level curriculum can lead to deficiencies in middle school, high school and beyond.

A head start: The value of quality math, science instruction in the early grades

According to education policy experts, efforts to promote math and science in young people should start as early in the education system as possible.

“We’re losing a whole lot of kids at the elementary level,” says Francis Eberle, executive director of the National Science Teachers Association. “It’s a huge problem.”

“This really starts in the K through 5 grade levels; that is the time you want to get them with an ‘aha’ moment,” he adds.

That moment often never comes, though, in part because of the teaching methods being used.

“Unfortunately, far too many elementary schools and teachers still do rote memorization of facts [and] worksheets,” Eberle says, rather than engage students in “hands-on, problem-based learning.”

State-funded and -led professional development for elementary-school teachers can help improve the instructional strategies being used.

But Eberle also points out that many schools don’t have the laboratory equipment needed to support a more “hands-on” curriculum, and that instruction time is often shifted away from science as educators prepare students for standardized testing in other subject areas.

He says an early exposure to engaging math and science coursework lays the foundation for student interest and success in these subject areas. Conversely, an inadequate elementary-level curriculum can lead to deficiencies in middle school, high school and beyond.

Article written by Kate Tormey, assistant editor/policy analyst for CSG Midwest
In order to improve math and science education, states and local school districts must first and foremost ensure that qualified, effective teachers are instructing students in these subject areas. In this section, Mike McCabe, CSG Midwest director, provides an overview of some of the trends in state policy designed to attract, retain and train K-12 math and science instructors. The article also examines whether the teacher shortages being reported by different school districts across the region are the result of problems with teacher recruitment, or with the retention of those who have entered the profession.
“Besides parents, the quality of teachers is the most important factor in determining whether students will be successful at school.”

Those were the words of Minnesota Gov. Tim Pawlenty in fall 2008, when he unveiled a series of education reforms with teacher preparation, recruitment and training as its centerpiece.

The proposals were new; the governor’s message about the value of good teachers certainly was not.

However, in recent years, a series of factors has placed an even greater emphasis on the need to recruit, educate and retain qualified teachers particularly in the fields of math and science.

In parts of the Midwest, school districts have struggled to hire qualified teachers in these hard-to-fill subject areas.

Nationally, recent studies and policy initiatives have linked the need for more high-quality teachers in STEM (science, technology, engineering and mathematics) fields to the ability of the United States and its workers to compete in the global economy.

“We are beginning to lose our unrivaled edge in mathematics, science and innovation to competitor nations,” the American Association of Colleges for Teacher Education cautions in a June 2007 report.

Improved STEM education at the pre-college level, the report concludes, “must receive our highest priority as a nation.”

In answering this call, advocates and policymakers at every level have come to realize that the key to improved student performance in math and science is excellence in teaching.

As Francis Eberle, executive director of the National Science Teachers Association, notes, “Student interest in STEM … begins with the classroom teacher.”

Not surprisingly, teacher-centered initiatives have been at the heart of state efforts to improve math and science education. Some of these efforts have shown signs of success, even as new data are beginning to call into question the conventional wisdom about teacher supply and demand.

Teacher recruitment and retention

With qualified math and science teachers in short supply in many places, and with studies showing student progress being impeded by a lack of quality instruction, reform-minded policymakers have zeroed in on teacher recruitment as a key focal point in the effort to improve STEM education. And one way to attract new teachers to the field is by providing targeted financial assistance in the form of scholarships and loan-forgiveness programs.

MATH, SCIENCE TEACHER SCHOLARSHIPS

The Teacher Service Scholarship program in Kansas is typical of state efforts across the Midwest to meet the demand for qualified math and science teachers by offering scholarships in exchange for student commitments to teach in high-need areas or hard to fill subjects for a specified period of time. Under the Kansas program, aspiring teachers are eligible to receive annual scholarships of up to $5,100 for four years (or five years for a course of instruction requiring graduate work).

In return, scholarship recipients must work in one of several “hard-to-fill” disciplines (math and science are among them) or in an underserved area of the state. They must teach on a full-time basis for a period at least as long as the course of study for which the scholarship was awarded.

Similarly, the Dakota Corps Scholarship program targets South Dakota education students who are willing to teach in high-need areas (currently including math and science) for periods that are at least a year longer than the duration of their scholarships. The awards cover full tuition at state institutions of higher education, but if a student fails to complete the required service commitment, the scholarship converts to a low-interest loan.

The Illinois Future Teacher Corps Program provides annual scholarships of up to $5,000 to college juniors and seniors who agree to teach for five years in either a shortage subject area including reading, science and early childhood or a geographic area experiencing a teacher shortage (or both, in which case recipients are eligible for $10,000 scholarships).

LOAN FORGIVENESS FOR TEACHERS

Like scholarships, loan-forgiveness programs are offered in a number of states in hopes of attracting new teachers to work in underserved geographic areas and targeted content fields. In Iowa, for example, teachers who work for more than a year in a designated shortage field (including math and science at the secondary level) can apply to have their student loans paid by the state. The Iowa Teacher Loan Forgiveness Program provides eligible teachers with loan repayment assistance of up to 20 percent of qualifying loan balances per year for five years. Additional loan forgiveness is also available for special-education and math and science teachers who are considered “highly qualified” (meaning they have an endorsement in their field).

In North Dakota, the University Teacher Shortage Loan Forgiveness Program reduces loan indebtedness for individuals teaching in grade levels or content fields designated as shortage areas by the state superintendent of public instruction. Subject to the availability of appropriated funds, eligible teachers may receive up to $1,000 per year for three years in loan forgiveness; lender institutions are reimbursed by the state-owned Bank of North Dakota.
A loan-forgiveness program was also part of a comprehensive, five-year teacher-capacity plan launched in Ohio in 2006. The program provides up to $20,000 in loan forgiveness over a five-year period to high school math, science and foreign-language teachers.

At least two other Midwestern states considered legislation in 2009 to provide loan-forgiveness incentives to teachers in high-needs fields. In Illinois, a proposal to create the STEM Teacher’s Loan Repayment Program (HB 738) was pending as of late June. The measure would encourage talented students to teach science, technology, engineering and math in Illinois schools.

Meanwhile, in Nebraska, lawmakers approved LB 547, which revised the state’s Attracting Excellence to Teaching Program (now called the Excellence in Teaching Act). The bill increases to $3,000 per year (for up to five years) the amount of loan forgiveness for two groups of college students: undergraduates working on education degrees in designated shortage areas, and certified teachers seeking additional endorsements. Loan recipients are required to work as teachers in Nebraska for two years after graduation before the forgiveness begins.

In addition to programs like these, several states have experimented with other forms of financial incentives. Ohio offers qualified teachers of math, science and foreign language a $20,000 “signing bonus” (to be paid over five years while the teacher is still teaching) as an alternative to loan forgiveness of a similar amount. And the “I-Teach” project in Iowa — part of the broader Iowa Mathematics and Science Education Partnership recently established by the state Board of Regents and funded by the legislature — seeks to attract more talented and diverse candidates to math and science education by offering tuition-waived courses in teaching and paid internships in educational settings.

“Student interest in STEM...begins with the classroom teacher.”

Francis Eberle, executive director of the National Science Teachers Association

Keeping teachers, expanding the pool

Scholarships, loan forgiveness and signing bonuses can help attract individuals to the teaching profession. But teachers’ groups say there is another bottom line policymakers must consider: how much math and science instructors are getting paid for their work.

“Competitive salaries positively influence the labor supply by attracting talented individuals to the profession, while minimizing costly attrition rates,” the American Federation of Teachers notes in a 2008 survey of salaries for K-12 instructors.

Teacher-pay issues continue to receive considerable attention in many Midwestern states, some of which rank at or near the bottom in the AFT survey.

Policymakers, too, have experimented with more-targeted teacher-pay initiatives.

TARGETED PAY INCREASES

In South Dakota, for example, lawmakers in 2007 approved the Teacher Compensation Assistance Program to help schools keep good teachers in high-need subject areas by increasing their salaries. The state contributed $4 million to the program, which also required a $1 million match from local districts.

Two years earlier, Minnesota established the Q Comp program, a performance-based merit pay system. As of January, 44 school districts and 28 charter schools across the state were participating in the voluntary initiative, which includes a career ladder with advancement options for teachers, job-embedded professional development opportunities, and teacher observation and evaluation protocols, as well as performance-based pay and an alternative salary structure.

Though touted by advocates as an effective incentive for teachers to improve their skills, the program remains controversial, and lawmakers opted not to enact Gov. Tim Pawlenty’s recent proposal to mandate statewide participation in Q Comp.

REACHING OUT TO MID-CAREER PROFESSIONALS

Pawlenty’s proposal to expand Q Comp was part of a larger package of reforms that the governor unveiled in the fall of 2008. Another key element of his “Teaching Transformation Act” was a plan to recruit mid-career professionals to teach in high-need subject areas such as math and science by providing them with an alternative route to teacher certification. The so-called SMART program failed to win legislative approval, but similar initiatives designed to grow the pool of qualified instructors by reaching out to non-teachers in mid-career have already been launched in several other states.

In Ohio, a wide-ranging 2006 effort to recruit, train and retrain teachers in high-need subject areas included funds for the training and licensure of mid-career professionals. It also included support for alternative teacher-licensure programs developed by the state’s Educational Service Centers in partnership with institutions of higher education. The initiative yielded immediate results, as more than 370 mid-career professionals and current
The role of higher education: Universities look to strengthen programs for math, science teachers

Institutions of higher learning have the responsibility to prepare, and provide continuing education to, the nation’s math and science teachers.

And under a new national initiative, many public universities and state university systems have pledged to make this responsibility more of an “institutional priority,” says Howard Gobstein, co-director of the Science and Mathematics Teacher Imperative, a recently established project of the Association of Public and Land-grant Universities.

While there are many capable math and science teachers in K-12 classrooms, Gobstein says, most states, on the whole, have shortages, both in terms of pure numbers and quality. He cites several reasons why, including the stature of the teaching profession in U.S. society and a corresponding lack of appropriate compensation.

Another problem, Gobstein believes, is that school systems and faculty advisors don’t do enough to encourage those pursuing math- and science-related degrees to consider teaching.

The association has called the nation’s shortage of highly qualified math and science instructors a crisis in education.

In response, it has brought together more than 110 higher-education institutions to participate in the Science and Mathematics Teacher Imperative.

“One are committing to doubling and tripling” the number of math and science teachers that they produce, Gobstein says.

The association is developing two tools (funded by the National Science Foundation) to help universities in this effort.

One tool will help leaders determine the strengths and weaknesses of their math and science teacher-preparation programs, in part by detailing the attributes of model programs around the country. This tool also will help participating institutions share with one another best practices in teacher preparation.

Secondly, a supply-and-demand assessment tool will be developed to determine state needs for science and math teachers.

“For some [public universities and systems], this has not been an institutional priority,” Gobstein says.

“Some may not have a complete program, so it’s not easy for a student to figure out the path [to becoming a teacher]. Others haven’t made this a sufficient priority, so perhaps [they] don’t have a scholarship fund or other support in place.”

Examples of math, science programs already in place

In the Midwest, meanwhile, several new or long-standing state-level initiatives are being used to improve training for current and/or future K-12 math and science teachers.

Below are some examples of higher-education efforts in the region.

- **Indiana’s I-STEM Resource Network** began as a collaboration between 15 institutions of higher education in the state, and has since become a public-private partnership. The network supports teachers in STEM fields (science, technology, engineering and mathematics) by providing ongoing continuing education and resources; it particularly targets help for teachers instructing at-risk students.

- **The Iowa Mathematics and Science Education Partnership** is a project of the Board of Regents and a collaboration among the state’s three public universities. First funded by the legislature in 2008, the goal of this new partnership is to address the shortage of math and science teachers in Iowa. Along with programs that aim to enhance teacher retention and student learning in math and science, the partnership provides competitive grant money to the three universities. The grants fund professional development programs for math and science instructors. Under one initiative of this Iowa partnership, current math and science teachers are offered summer-long paid internships in business and industry that emphasize the practical applications of STEM education.

- **The Center for Science and Mathematics Education at North Dakota State University** has been in existence since 1998. In collaboration with other higher-education institutions, the center implements a statewide plan for improving undergraduate teacher preparation as well as graduate-level professional development training for science and math teachers.

- **Black Hills State University in South Dakota** is offering programs of study (at the master’s degree level) that encourage teachers to become “math or science specialists.”

- **Kansas State University** runs a summer training program that provides content and pedagogical training geared toward state math and science standards. The program typically emphasizes the needs of underrepresented and underserved students.

Article written by Laura Kliewer, a senior policy analyst at CSG Midwest
teachers were either trained or retrained to teach math, science or foreign language within months of the program’s inception.

Many other Midwestern states, too, offer “fast track” programs and other alternative paths to teacher certification for mid-career professionals, though these programs often are not specific to math and science education.

Teacher training, professional development

While the recruitment and retention of new teachers is critical to any effort to improve math and science education, so too is the quality of instruction provided by those educators. States are employing a variety of strategies to equip teachers with the knowledge, tools and resources that they need to improve student achievement.

Minnesota has been a leader in this policy area.

In 2007, lawmakers appropriated $3 million (matched by a $500,000 grant from the National Governors Association) for the establishment of the Minnesota Math and Science Teacher Academy. The academy — actually a network of nine regional centers — employs a “train-the-trainer” approach to providing high-quality professional development. Each summer, local districts send teams of teachers to the appropriate regional centers, where they receive extensive training on the implementation of Minnesota’s new content standards and requirements. Participants are exposed to a variety of instructional techniques and eventually become certified trainers themselves, which enables them to share what they’ve learned with colleagues in their districts.

The regional centers also serve as ongoing sources of training and professional growth by linking K-12 schools with participating higher-education institutions. At least one such institution partners with each regional center.

Last year alone, more than 1,000 Minnesota teachers attended summer training provided through the state academy.

Another example of a statewide effort to improve teacher training is Michigan’s Math and Science Centers Network. It links 33 regional centers across the state in an effort to provide curriculum support, professional development opportunities and student services to teachers in local districts. Supported in part by federal Math Science Partnership grant funds, the network strives to assist teachers in implementing the state’s new math and science graduation requirements. It also provides training on teaching in high-needs schools, and offers a Math and Science Leadership Academy for teachers across the state.

In addition, several university-led teacher-training programs are in place in the Midwest (see sidebar story for examples).

Is it time to reassess?

Without question, skilled teachers are critical to the success of state efforts to improve student performance in STEM education. But as policymakers continue working to grow and support the pool of qualified teachers, questions about the true nature of the supply problem are beginning to emerge.

According to a recent Consortium for Policy Research in Education report (“The Mathematics and Science Teacher Shortage: Fact and Myth”), it may be time for policymakers to re-think the conventional wisdom about teacher supply and demand.

Even in the fields of math and science, the report found, the annual supply of newly qualified teachers is about 2½ times the number of expected retirements for the same period.

“We’re producing more than enough teachers, but we’re not keeping them, and they’re not evenly distributed,” says University of Pennsylvania professor Richard Ingersoll, co-author of the report.

Ingersoll acknowledges that many schools are in desperate need of qualified math and science instructors. But this shortage is not a “supply problem,” as much as it is a “quitting problem.”

“Pre-retirement teacher turnover far outpaces losses due to retirement; as a result, most of the nation’s newly minted teachers are filling mid-career vacancies.

Ingersoll says the problem with a conventional “shortage” diagnosis is that it leads to a misplaced emphasis on producing more teachers instead of addressing the issues that cause individuals to leave the profession.

The report suggests that teacher retention, rather than recruitment, should be the focus of efforts to improve math and science instruction. Factors likely to curb attrition rates, the study’s authors say, include “more support for new teachers, more generous salary schedules, fewer student discipline problems, more adequate resources and classroom supplies, more effective leadership, and enhanced faculty input into school decision-making.”
Groups offer states ideas to improve quality, quantity of math and science teachers

State laws and regulations can either “help or hinder” the ability of K-12 school districts to hire effective math and science instructors, according to the National Council on Teacher Equality and the National Math and Science Initiative.

In a 2009 policy brief, the two organizations offer five steps that policymakers can take in order to help.

1) **Raise standards for getting into a teacher-preparation school** — Ideas include requiring aspiring teachers to demonstrate a solid knowledge of math skills (at least Algebra II for future elementary instructors and pre-calculus for secondary teachers) and admitting only students in the top half of their graduating high school class.

2) **Improve the quality of undergraduate education** — The organizations propose that prospective elementary school teachers take a “3/1” course sequence, which would provide a more solid mathematics background and get rid of “muddled regulations” in state codes. Prospective instructors, the organizations say, should study three separate teaching topics (such as those related to math foundations, algebra and geometry, and statistics) and one methods course for teaching mathematics. They also recommend that states develop model science-course requirements for aspiring elementary teachers.

3) **Expand the pool of potential teachers** — Ideas include encouraging school districts to offer “flexible compensation packages”; waiving tuition, forgiving loans and offering signing bonuses; and ensuring that alternative-certification programs are flexible enough to attract individuals with “deep subject-matter knowledge” into the teaching profession.

4) **Send quality math and science teachers to the schools that most need them** — Offering incentives for K-12 instructors to work in high-needs schools could help improve student performance and close achievement gaps in subjects such as math and science, the organizations say.

5) **Re-evaluate curriculum standards and graduation requirements** — Future math and science teachers are the product of states’ K-12 systems. With that in mind, the organizations say, academic rigor in these systems must be improved.

Two Midwestern states are mentioned in the policy brief: **Kansas** and **Minnesota**.

Kansas was cited for the participation of one of its public universities in UTeach, which allows students to earn a degree in their major and a teaching license in four years. In Minnesota, regional Math and Science Teacher Academies are used to update current educators on instructional strategies. One goal of the academies is to prepare teachers to help students meet Minnesota’s more-stringent math requirements, which call for young people to take Algebra I in eighth grade and Algebra II in high school.

Push for stronger graduation requirements:
With changes in state laws, legislators are asking more of students, K-12 systems

One trend in state education policy has been to strengthen high school curriculum requirements, including in math and science, with the goal of making sure students graduate with the academic background and skills they need to succeed in college or to compete in the job market. In this section, Tim Anderson, publications manager for CSG Midwest, examines this trend, with a particular emphasis on changes made in two Midwestern states: Michigan and North Dakota. The article also touches on some of the concerns and education issues raised with enactment of these tougher requirements.
Up until a few years ago, Michigan had just one state-level curriculum requirement for graduating high school students—complete a semester of civics education.

North Dakota, not so long ago, had no requirements at all; decisions on the courses to be taken and passed were left to local school districts.

But much has changed in those states, reflecting a broader regional and national trend in which legislative and education leaders have decided that new, and more-stringent, state-level graduation requirements should be part of reform efforts designed to ensure academic rigor in the K-12 system.

Requiring more of students in the subjects of math and science is a fundamental part of the changes being made by legislatures.

“States have made a lot of progress,” says Matt Gandal, vice president of Achieve Inc., an organization that advocates for stronger graduation requirements and works with states to implement them.

“In 2005, only a few had requirements at a level we deemed consistent with what colleges and employers needed; we’re now at 20 [including Indiana, Michigan, Minnesota, Ohio and South Dakota in the Midwest].” Some of these states have an “opt-out” provision and offer an alternative path to a diploma.

Indiana, in particular, has been a national trendsetter.

In that state, Gandal says, policymakers thoughtfully and methodically rolled out the Core 40 curriculum: they tied high school and end-of-course assessments to it, linked the subjects taught in high school to college admission requirements, developed a statewide public awareness campaign about the tougher graduation requirements, and gradually made the Core 40 the “default” curriculum for students.

Indiana has since been used as a model by other states.

But the graduation requirements that ultimately are established can vary considerably from state to state (see table in this section).

In Illinois, for example, one year of science must be taken, while in Ohio, a student must complete three years of science, with courses that expose him or her to an “inquiry-based laboratory experience.” (This new science requirement is part of the Ohio Core curriculum, SB 311, which was signed into law in early 2007.)

Case studies from the Midwest: North Dakota and Michigan

Recent changes to Michigan’s requirements (the result of legislation, SB 1124 and HB 5606, signed into law in 2006) are among the most extensive in the nation.

The state has gone from having a single curriculum requirement for high school graduation to what has been called the most comprehensive set of requirements among the 50 states. As part of the new law, students must complete three years of science and four years of math, including Algebra II.

North Dakota’s new requirements are not as stringent. However, as part of several education reforms enacted by the legislature in 2009 under HB 1400, a student who decides to take a more rigorous set of courses (including in math and science) will receive an incentive with a certain grade-point average and college-admission test score, he or she will be in line for a state-funded scholarship of $6,000.

Lt. Gov. Jack Dalrymple expects up to one-third of the state’s high school graduates to be eligible for the scholarship.

“We think there has been a problem [in the past] with kids not seeing enough of a direct reward for their hard work,” says Dalrymple, who served as chair of a state commission that helped develop the scholarship proposal, the new high school curriculum requirements, and the multi-tier path for graduation.

In Michigan, North Dakota and other states, the idea behind setting new and tougher requirements is fairly straightforward: ensure that students graduate with the skills they need for success in the workforce or in a postsecondary institution.

“In this globally competitive world we now live in, all our students need to learn higher-level concepts,” Mike Flanagan, Michigan’s superintendent of public instruction, wrote in an editorial last year defending his state’s new graduation requirements (known as the Michigan Merit Curriculum) and challenging proposals to change them.

“Anyone who claims otherwise is setting up our students and our state for failure now and into the future.”

For Flanagan and others, then, requiring courses that introduce and teach these higher-level concepts becomes a fundamental part of efforts to equip young people with the skills they will need.
Math instruction is a prime example.

According to Gandal, college-level algebra is a proven “defining gatekeeper of success in college.”

“No matter what degree you are pursuing, you are going to have to take a college algebra class,” he notes. “If that becomes your barrier, it might become your barrier to getting credentialed.”

In turn, some type of postsecondary degree is increasingly a “gatekeeper of success” in the workforce.

Ideally, then, tougher graduation requirements at the high school level improve student outcomes once a young person moves on to college, or to a job that demands certain high-level skills.

More rigor, more questions for policymakers

But several issues have arisen with the revamping and strengthening of high school graduation requirements.

For starters, there is the question of state vs. local control. Many states in the Midwest have traditionally deferred decisions about curriculum and education policy to local school districts. Nebraska, in fact, still has no state-level graduation requirements.

A mix of factors, though, has led states to become more active in setting education policy, including the fact that many are paying a higher percentage of total K-12 costs than in years and decades past.

In North Dakota, for example, as recently as four years ago, the state was providing just over 40 percent of the non-federal dollars for K-12 education. With recent legislative changes, the state’s share is now 70 percent.

With the additional state funding came tougher graduation requirements.

“This was an opportunity to say we want to see improvements in academic rigor,” Dalrymple says.

But there are also questions for state policymakers beyond financing and local sovereignty.

• Are all or most students academically capable of meeting the more-rigorous requirements, particularly in a subject such as math? Just as advanced algebra is a common barrier to college success, it is a stumbling block for K-12 students—a fact that has led some states not to include it as a requirement or as part of their “default” high school curriculum.

• Are states and local districts providing enough resources to the students who may struggle in a class like Algebra II?

• Are states and local districts ensuring that advanced classes are being taught by highly qualified and effective teachers? The presence of highly qualified teachers in all schools, many education-reform advocates say, is essential to making tougher graduation requirements workable and doable for students.

As Gandal notes, stronger requirements alone cannot be counted on to improve student outcomes.

“You can’t just shove the students into higher-level courses and expect that they will be successful; there have to be more strategic supports put in place, and that is an area where a lot more time and energy need to be spent,” Gandal says.

Some lawmakers call for curriculum flexibility

Without these supports in place, or without enough curriculum flexibility for students, can these requirements do more harm than good?

Michigan Rep. Joel Sheltrown worries that this will be the case in his state, and believes that one consequence of the Algebra II requirement (the course is required or part of the default curriculum in Indiana, Minnesota, Ohio and South Dakota) will be higher dropout rates.

He has introduced legislation this year (HB 4410) that would offer another graduation option—a “career training education” pathway—for students. For example, a student could graduate with more vocational-skills courses but without taking an Algebra II course.

“We need to be more nimble in education, not throw everybody in the same box,” Sheltrown believes.

“We should be elevating career training in our schools,” he adds. “There are plenty of good jobs out there that don’t require a four-year degree and that cannot be outsourced.”
Michigan education officials say local schools have the flexibility to work career-training courses into the new graduation requirements.

And they add that the new requirements not only reflect skills that students should have, but expectations that they can meet.

“Students can learn this and be successful if you have consistent expectations and enough supports in place,” says Jan Ellis, a spokeswoman for the Michigan Department of Education.

Ellis says school districts in her state are emerging as models for others on how to help students handle the increased academic rigor. Strategies include offering more individual assistance for students, establishing separate “support classes” for students who need help in a particular course (for example, offering an Algebra II support class and allowing it to count toward the state requirement), and giving individuals more time to graduate.

She notes, too, that Michigan’s new grade-level content standards for elementary and middle schools will help better prepare students for the Michigan Merit Curriculum.

Ellis also disputes the claim that tougher high school graduation requirements will result in higher dropout rates.

“Most early-warning signs of dropping out begin to show in second grade, and the dropout rates peak in around the ninth grade, before students begin taking the classes under the requirements.”

**Rigor and reward: North Dakota’s graduation paths**

North Dakota’s new graduation requirements do not go as far as Michigan’s. The state’s default curriculum, for example, does not require students to take Algebra II.

However, for those students wanting a more rigorous curriculum, North Dakota schools will provide it to them.

A “diploma with academic honors” or a “diploma with technical honors” will be awarded to students who complete higher-level courses, graduate with a grade-point average of at least 3.0, and score at least 24 on the ACT. The technical-honors diploma requires students to take additional career-training courses and to show proficiency on a job-skills assessment exam. If these “diploma with honors” students attend a post-secondary school in the state, each will be eligible for a $6,000 scholarship.

A fourth type of diploma will be offered to students who opt out of North Dakota’s “default” requirements.

This optional diploma was included to help ensure that dropout rates don’t rise as the result of stronger graduation standards. However, the state also wanted to make it clear that most students are expected to complete the tougher requirements, Dalrymple says.

---

<table>
<thead>
<tr>
<th>State</th>
<th>Math</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>3 years (Algebra I, 1 year; geometry, 1 year)</td>
<td>1 year</td>
</tr>
<tr>
<td>Indiana</td>
<td>3 years (Algebra I, Algebra II and geometry or Integrated Mathematics I, II and III)</td>
<td>3 years (biology, 1 year; chemistry or physics or integrated chemistry-physics, 1 year)</td>
</tr>
<tr>
<td>Iowa</td>
<td>3 years</td>
<td>3 years</td>
</tr>
<tr>
<td>Kansas</td>
<td>3 years (“algebraic and geometric concepts”)</td>
<td>3 years (“physical, biological, and earth and space science concepts”)</td>
</tr>
<tr>
<td>Michigan</td>
<td>4 years (Algebra I, Algebra II, geometry)</td>
<td>3 years (biology and physics or chemistry)</td>
</tr>
<tr>
<td>Minnesota</td>
<td>4 years (geometry, Algebra II, probability/statistics and Algebra I in 8th grade)</td>
<td>3 years (biology and chemistry or physics)</td>
</tr>
<tr>
<td>Nebraska</td>
<td>Set at local level</td>
<td>Set at local level</td>
</tr>
<tr>
<td>North Dakota</td>
<td>3 years</td>
<td>2 years (biology)</td>
</tr>
<tr>
<td>Ohio</td>
<td>4 years (Algebra II or its equivalent)</td>
<td>3 years (physical science, biology and 1 unit of “advance study”; 3 units of “inquiry-based” lab experience)</td>
</tr>
<tr>
<td>South Dakota</td>
<td>3 years (Algebra I, Algebra II and geometry)</td>
<td>3 years (biology and chemistry or physics)</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>2 years (algebra, geometry and statistics)</td>
<td>2 years (“biological and physical sciences”)</td>
</tr>
</tbody>
</table>

* Some states offer an optional diploma that does not require students to meet all of these “default” graduation requirements.

Source: Achieve Inc., Education Commission of the States and CSG Midwest research

As a result, the optional diploma will be made available only to students who, after two years of high school, have failed three semester courses or have a GPA below the 25th percentile of their school class.

Gandal says Achieve Inc. has been “agnostic” on states’ use of these “opt out” provisions.

“The concern some people have is that it could become abused, so the kids we’re really trying to help with the stronger requirements—those who aren’t getting access to a rigorous curriculum—are being encouraged to opt out,” he says.
But in Michigan, Sheltrown believes the “pendulum has swung too far” in the other direction. Not only should a second pathway to a diploma be offered, he says, the state should make it easier for a student to receive a “personalized curriculum.”

One option for state policymakers is to initially offer an opt-out provision to students as part of the transition to tougher graduation requirements, and then eventually eliminate it. Ohio is an example of a state that has done this, Gandal says.

‘Strategic supports’ for students

One area of agreement among many legislators and educators is the need to find ways of better helping students succeed in the classroom.

According to Dalrymple, North Dakota will increase the number of tutors, counselors and career advisors in the schools, while also allowing first-year teachers to take part in a state-funded mentoring program.

Gandal says those types of resources along with having highly qualified and effective teachers in the classroom are essential to making tougher graduation requirements reachable for all students.

“There have to be more strategic supports put in place,” he adds.

In many states, it is too early to gauge the impact of tougher requirements on student achievement and outcomes.

Ellis says future test scores on the Michigan Merit Examination (a statewide assessment of 11th-graders) will be used to determine the impact of the new Merit Curriculum.

If Michigan and other states show signs of student improvement, the trend toward tougher graduation requirements will likely continue across the country.
The case for quality academic standards:
International data reveal why standards are a building block for world-class math, science education — and how states can improve

In this section, Michigan State University distinguished professor William H. Schmidt and senior researcher Leland S. Cogan examine the importance of academic standards as a foundation for high-quality math and science instruction. They look at the issue from both an international and state perspective. On the international level, the authors compare and contrast the standards in different countries, and show the link between these differences to variations in student test results. They then demonstrate why the creation of new math standards in one Midwestern state, Minnesota, has likely contributed to a significant rise in test scores. Dr. Schmidt led the team that helped Minnesota establish rigorous statewide math standards.
Since the publication of “A Nation at Risk” more than two decades ago, there has been an increasing demand for quality public education from many avenues – concerned parents, the business community, academics, economists and politicians – which has provided impetus to the standards-based education movement.

The basic notion informing this movement is that an educational system should be guided by content standards that define what students should be expected to know or to do, which, in turn, should provide guidance to what teachers teach in their classrooms.

Essentially this is the practice in most of the countries that have been participating in the Trends in International Mathematics and Science Study (TIMSS), which compares the mathematics and science achievement levels of fourth- and eighth-grade students in different countries (including the United States).

In the vast majority of these countries, national content standards are in place and disseminated by a national institutional center responsible for curriculum policy.

Most of these countries use content standards as a major policy instrument that defines the vision of what is important for children to learn as a part of their schooling and, consequently, what focus teachers should have in their classroom instruction.

The goal of the standards-based school reform effort in the United States attempts to use content standards in a similar manner: as a policy instrument to shape classroom instruction.

However, as important as common standards may be in supporting outstanding student performance, not all are created equal or can be counted on to meet the goal of improving instruction and outcomes.

This is an especially important point to make in a country such as the United States, which has a plethora of standards defined at different levels of the U.S. system.

Most students attend schools guided by state, if not both district and state, content standards.

No mandatory national standards exist in the United States, only non-binding recommendations. This situation results in a “splintered vision” for what teachers should teach and students should learn at any given grade.

The value of quality standards: An international perspective

One of the most important findings from the 1995 TIMSS is that differences in achievement from country to country are related to what is taught in different countries.

<table>
<thead>
<tr>
<th>Age or grade level/subject</th>
<th>International test</th>
<th>U.S. score (above/below average?)</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th grade/math</td>
<td>TIMSS* (2007)</td>
<td>Above</td>
<td>11th among 36 participating nations</td>
</tr>
<tr>
<td>4th grade/science</td>
<td>TIMSS* (2007)</td>
<td>Above</td>
<td>8th among 36 participating nations</td>
</tr>
<tr>
<td>8th grade/math</td>
<td>TIMSS* (2007)</td>
<td>Above</td>
<td>9th among 48 participating nations</td>
</tr>
<tr>
<td>8th grade/science</td>
<td>TIMSS* (2007)</td>
<td>Above</td>
<td>11th among 48 participating nations</td>
</tr>
</tbody>
</table>

* TIMSS stands for Trends in International Mathematics and Science Study.
** PISA stands for Program for International Assessment.

Source: National Center for Education Statistics

To get a rich picture of math and science instruction in each country, we looked at the “intended” content (what officials intended for teachers to teach) and “enacted” content (what teachers actually reported teaching in their classrooms).

In most countries, the intended content was simply the national curriculum. (In the United States, we examined state and district standards.)

In all of the countries, we determined the enacted content by surveying teachers about what they had covered.

Analysis of this rich curriculum data along with student achievement revealed that student performance is not primarily a function of demographic variables or other variables not greatly affected by schooling, but is significantly related to what is taught in school: schooling does make a difference. Specifically, we can see that the curriculum itself – what is taught – makes a huge difference.

For example, consider the performance of Bulgarian students in science. They were tops in the world in the area of the structure of...
mater, but almost dead last in the area of physical changes—a topic not intended for students in the Bulgarian curriculum.

Consider, too, the remarkable variations in U.S. performance in mathematics. Our eighth-grade students did their very best math work in the area of rounding. Our kids are among the world’s best “rounders.” We obviously teach it thoroughly. But based on the 1995 TIMSS results, we obviously are not doing an adequate job of teaching measurement; perimeter, area and volume; and geometry.

‘Mile wide, inch deep’ standards

If curriculum standards do ultimately impact student achievement, what, then, are the characteristics of quality standards that may promote outstanding student performance? And what improvements could be made to the standards used in the U.S. system?

An examination of U.S. state standards revealed that more topics at each grade level were intended to be taught and learned than in any other nation.

Not too surprisingly, then, U.S. textbooks are first in the world. Our mathematics textbooks are truly encyclopedic; no others in the world have as many pages or cover as many topics.

According to TIMSS data, eighth-grade mathematics textbooks in Japan have around 10 topics, compared to the more than 30 topics in U.S. eighth-grade textbooks. And U.S. teachers cover more topics than instructors in any other country.

One of the reasons that U.S. “intended content” contains so many topics for each grade is that it is highly repetitive. Topics are introduced earlier than in many other countries and then repeated year after year. To make matters worse, very little depth is added each time the topic is addressed because, each year, much of the time is devoted to review.

Thus, intended content in the United States is not very demanding by international standards. This is especially true in the middle-school years, when the relative performance of U.S. students displays a significant gap when compared with that of counterparts in top-performing countries. During these years, the rest of the world shifts its attention from the basics of arithmetic and elementary science to beginning concepts in algebra, geometry, chemistry and physics.

Finally, the intended content in the United States is incoherent. Mathematics, for example, is really a handful of basic ideas; but in the United States, mathematics standards are long laundry lists of seemingly unrelated, separate topics.

This laundry-list approach is often reflected in the U.S. textbooks that provide practical support to teachers. These books cycle through the topics to be taught with little if any explanation that connects or provides conceptual linkages between topics.

This method to teaching mathematics works against the efforts of teachers and students to develop sound understanding upon which further learning must be based, according to the 2005 publication “How Students Learn: History, Mathematics and Science in the Classroom.”

Previous research has described U.S. standards as being “a mile wide and an inch deep.”

Lessons from top-performing countries

The profile of the composite curriculum constructed from the top-performing countries in the 1995 TIMSS provides a stunning contrast, and may function as a pole star to guide future U.S. curriculum and standards-writing efforts.

The curricula in these countries exhibit three characteristics: focus, coherence and rigor.

CHARACTERISTIC NO. 1: FOCUS

At each grade, the curricular content standards focus on a smaller set of topics for teachers to teach and students to learn than was typical.

Because time for learning in school is a finite quantity for any grade, this focus on a small number of topics allows both teachers and students to devote more time to each topic so that all students may grasp what they are expected to learn; they have the time to learn each topic in-depth.
CHARACTERISTIC NO. 2: COHERENCE

In addition, these curricula sequence topics cross grade levels in a coherent manner, reflecting the logic and organization of a discipline like mathematics.

Such coherence is seen not only in the “super-organization” of topics across grades, but in the sequencing and development of topics in each grade’s curriculum materials.

This type of structure further supports the efforts of teachers and students to make connections among mathematical ideas. This, in turn, supports mastery learning among students.

CHARACTERISTIC NO. 3: RIGOR

Finally, the rigor of these curricula emerges from the disciplinary-based sequencing of topics, both within and across grades, proceeding from basic concepts (meaning and operation of whole numbers, for example) to more developed notions (the rational number system and its properties, for example).

Perhaps because sufficient time has been devoted to mastery learning at the early grades, basic concepts actually drop out of what is intended and the curricula move on to focus instead on concepts that are more challenging and demanding.

Case study for quality standards: Minnesota’s rise in math scores

Is this sort of focused, coherent and rigorous curriculum possible in the United States?

The experience of Minnesota over the past 15 years may provide some insight. Minnesota participated in the 1995 TIMSS to obtain an international benchmark for its students. At that time, the state’s students were performing at the level of a typical U.S. student in mathematics, but their science performance was near that of the top-performing countries.

One factor thought to contribute to the students’ outstanding performance in science was Minnesota’s statewide “de facto” curriculum standards in that subject area. This led to the development and revision of official mathematics standards in the state; the 1995 TIMSS curriculum analysis of international standards was used as a guide.

In 2007, Minnesota again participated in the TIMSS.

Little change was evident in students’ science performance, but significant changes were evident in mathematics scores for fourth-grade students and, to a lesser extent, eighth-grade students.

Why did the state improve so dramatically in fourth-grade mathematics?

Room for improvement: U.S. 15-year-olds “below average” in math, science literacy

How does U.S. student performance in math and science compare to the rest of the world? Two international assessments of student performance provide some answers, with results varying considerably depending on the grade levels being tested.

The 2006 Program for International Student Assessment tested math and science literacy among 15-year-old students in different nations, including the 30 member countries of the Organization for Economic Cooperation and Development (OECD).

Compared to the math and science scores in other OECD countries, achievement levels for U.S. 15-year-olds were below average in both subjects. Students placed 21st among the 30 developed countries in science and 25th in math.

A second international assessment — the Trends in International Mathematics and Science Study (TIMSS) — is used to compare the knowledge and skills of fourth- and eighth-graders in different countries over time. Close to 60 countries participated, in some way, in the 2007 TIMSS, results for which were released in late 2008.

In both subject areas, U.S. fourth- and eighth-graders had TIMSS scores that were above average. Those scores, however, did not place the United States among the top-performing countries.

One notable result from the 2007 TIMSS was the progress made by one “mini-nation,” Minnesota. That state participated in the international study in order to compare its student performance on an international scale.

Minnesota’s math scores rose significantly between 1995 and 2007. In fourth-grade math, for example, Minnesota students’ test scores increased by 38 points (as a comparison, the U.S. score rose by 11 points over the same time period). The state’s fourth-graders outperformed counterparts in all but four countries; Minnesota eighth-graders ranked sixth.

Several state-initiated reforms — including new statewide academic standards in math, teacher preparation and professional development, and more instructional time devoted to the subjects tested on the TIMSS — have been cited as reasons for Minnesota’s improvement.

Some of those same efforts, many educators say, could help the United States improve its standing among OECD countries in the areas of math and science literacy among 15-year-olds. Other reform ideas include redesigning schools and curriculum to more effectively engage young people; targeting help for struggling or failing students; and strengthening assessments, coursework and graduation requirements.

Article written by Tim Anderson, publications manager for CSG Midwest
One possibility is that, unlike in 1995, Minnesota now had statewide mathematics standards; they were put in place in 1997 and revised in 2003.

Therefore, on the 2007 TIMSS, all four years of the mathematics learning of Minnesota’s fourth-graders were most likely informed by the 2003 statewide standards. (It should also be noted that the 2007 TIMSS test for fourth-graders aligned well with Minnesota’s 2003 standards for fourth-grade mathematics.)

As a consequence of Minnesota’s new formal state standards for math, instruction time at the elementary level increased from about 30 minutes per day in 1995 to around 60 minutes per day in 2007.

This increased time, as well as trimmed expectations for the number of topics to be covered at the elementary level, brought significant focus to both teachers’ and students’ efforts.

In addition, one of the goals of standards and accountability assessments is to reduce variation from one school to the next in what teachers teach and emphasize and in what students learn. The value of having uniform quality standards is seen in Minnesota’s most recent TIMSS results.

**Standards only part of equation**

As essential as high-quality, coherent content standards may be for an education system to provide all students with a challenging and world-class education, they are not a panacea.

Coherent standards that aim to shape classroom instruction must be accompanied by professional development for teachers that prepares them to bring standards to the classroom in an effective way. This help for teachers was an integral part of Minnesota’s recent effort.

Further insights come from the international arena.

In every top-performing country, there is a single, national curriculum (content standards). This curriculum does not sit on a shelf unread and unused. Nor is it an exceedingly long document that teachers must thumb through on their own, selecting which topics to emphasize and which to merely mention.

The curriculum’s coherence is translated into textbooks, workbooks, diagnostic tests for teacher use and other classroom materials all of which enable instructors to deliver consistent, effective classroom instruction.

In turn, the curriculum serves as an important basis for the nation’s pre-service teacher-education programs and for ongoing professional development, thus helping contribute to consistent, high-quality teaching across classrooms and schools.

Underlying all of this and making it all possible is the fact that the curriculum is common—that is, the same coherent set of topics is intended to be taught in the same grade to virtually every child in the country at least from grades one through eight. Regardless of a student’s school or teacher, the system is designed so that he or she is exposed to the same material in the same grade.

A common, coherent curriculum makes possible a cascade of benefits for students’ education. Net effects include

- positively influencing overall student achievement;
- greatly reducing the differential achievement effects produced by standards and curricula of varying quality and emphasis; and, as a result,
- substantially weakening the relationship between student achievement and socioeconomic status (a link that is quite strong in the United States).
States urged to create “high and common” academic standards in math, science

How does a state go about setting or revising content standards in subjects such as math and science?

By passing new laws, legislatures often start the process, but the work itself is traditionally left to a collaborative group of educators (K-12 teachers and university professors, for example), state agency officials, and other stakeholders with expertise in the subject area.

In recent years, several states in the Midwest have relied on these groups to revamp and strengthen academic benchmarks detailing what students should know at varying grade levels in different subject areas.

Proposals made in 2009 would make additional changes. In Ohio, Gov. Ted Strickland put forward a plan earlier this year calling for the state to better align its standards and accountability system with “21st century skills.” For example, academic standards would be revised every five years not only in core content areas, but for skill sets related to creativity and innovation, critical thinking and problem solving, and communication and collaboration.

States in the region, meanwhile, are also now involved in national efforts designed to bolster standards in various subject areas, including math and science, with a goal of ensuring that students are prepared to graduate from K-12 systems with the knowledge and skills they need to succeed in the workforce, college or postsecondary technical schools.

For example, Illinois is currently participating in Achieve Inc.’s American Diploma Project (ADP).

States in the ADP Network agree to use national benchmarks in developing new high school learning standards. Several states in the Midwest (Indiana, Michigan, Minnesota, Nebraska, Ohio and Wisconsin) also are part of the network.

Illinois is among the first group of states to not only use national benchmarks, but also look at what other countries require of their students.

Achieve’s goal is to ensure K-12 systems in participating states have a rigorous set of standards and assessments in order to eliminate what the organization calls the “expectations gap”: high school graduates lacking the skills and knowledge that postsecondary institutions and businesses expect of them.

In June 2009, the Carnegie Corporation released a report urging a “national mobilization” effort to transform math and science education. One of the study’s main recommendations is to establish “high and common standards” across all states in these subject areas.

The Carnegie report endorses the Common Core Standards Initiative being spearheaded by the National Governors Association and the Council of Chief State School Officers. Forty-nine states, including all in the Midwest, have joined the initiative, a state-led process to develop a common core of standards in English/language arts and mathematics for grades K-12 that will be “research- and evidence-based, internationally benchmarked, aligned with college and work expectations, and include rigorous content and skills.” The initiative also will seek a similar level of standards for science.

Along with these efforts, states are getting a nudge from the federal government. The American Recovery and Reinvestment Act ties emergency education funding to efforts in states to raise academic standards and improve the quality of standardized tests.

Article written by Laura Kliewer, senior policy analyst at CSG Midwest
Valuable connection:

STEM education offers the chance to provide students with the adaptable, analytical skills they need in a “knowledge economy”

In this section, the link between science, technology, engineering and math (STEM) education and economic growth and competitiveness is examined; some important questions for policymakers are raised as well, including this fundamental one: In a world where economic competition is becoming more and more intense, how can states and their schools best prepare students for future success?

This article was written by Brad Mitchell, director of STEM education and economic development engagement for the Battelle Memorial Institute and The Ohio State University. Battelle is managing the state of Ohio’s STEM Learning Network.
STEM education is a highly relevant and fairly controversial issue at a time of amazing economic, social and political upheaval.

As states face severe economic challenges and related social tensions, there are different views about the importance of science, technology, engineering and math (STEM) education and about who pays for it, how much, and for what.

STEM education itself, in fact, remains a bit of a mystery. It has no clear and shared definition. There is a wide variety of perspectives on exactly what science, technology, engineering and math education is and should be, and what should inform a state’s STEM education strategy.

For policymakers, too, it can be difficult to discern rhetoric from reality in the promises made about the value of STEM education for local, state and national prosperity and security.

Indeed, the promise of STEM education has sometimes been oversold. For example, technology-based economic development has become a standard blueprint for city, regional and state economic development. While sometimes spectacular, the return on investment has generally been mixed. On the education side, requiring more high school credits in math and science to produce “21st-century learners” has become a popular educational reform. However, many states simply do not have the financial or human-capital resources to fully offer high-quality math and science education to all learners in all settings.

The uncertainty and confusion surrounding STEM education require many questions to be asked and answered about its role in future education policy and its potential to contribute to economic growth. We raise some of these questions below.

There is at least one other fundamental and compelling question that should be raised: What new minds and skills are needed for the future?

This, rather than searching for a universally shared definition of STEM education, will help underscore the need for public policies and innovations that improve how subjects such as math and science are taught and learned.

**STEM and U.S. competitiveness: Links and questions to consider**

As a country, we have covered this ground before.

From the launch of Sputnik to The National Academies’ publication of “Rising Above the Gathering Storm,” policymakers at all levels of government have wrestled with how science, technology, engineering and mathematics education relates to four key aspects of American competitiveness: economic development, educational attainment, social equity and technological ingenuity.

**THE ECONOMIC EQUATION**

First, there is the relentless drive for a competitive edge in the global economy. How much does our economic future depend on our ability to create, attract and retain STEM-based industries and occupations? For example, do we have enough “home-grown” engineers, and are the growing numbers of engineers produced in places such as China and India truly an economic threat?

What STEM-oriented jobs can and will be outsourced in a global economy? The U.S. Department of Labor projects that by 2014, 15 of the 20 fastest-growing jobs in the United States will require substantial math or science preparation.

The fastest-growing jobs may be STEM-related, but America is also a major service-based economy. What is the fit between STEM skills and the needs of a service economy? Will good STEM skills lead to good STEM jobs? Should a state invest in developing its young talent, or instead rely more on importing talent from other states and countries? Several states have highly educated STEM workforces, yet their high school and higher-education attainment rates are only average.

The ties between STEM education and the “new” economy sometimes are loosely woven, partially understood and/or paradoxical.

**PUSH AND PULL OF ASSESSMENTS, STEM EDUCATION**

Second, there is the vigorous pursuit of high academic achievement for all and the need to find ways to build the capacity of educational systems so that they can deliver better quality with higher fidelity.

Can and should our educational systems be reconfigured to produce significantly greater numbers of high-quality college graduates with STEM skills that offer the highest potential for employment and economic growth? Are we bringing more clarity or clutter when we strive to align college readiness, career readiness and STEM readiness? Do we have the resources and capacity to deliver STEM literacy for all?

Numerous and noble efforts are being made to build STEM into the existing educational infrastructure. At the same time, STEM challenges the philosophical premise and core operation of most educational enterprises: The push for content-based standards and narrow assessments of individual learners and learning can sometimes be in conflict with the pull of open inquiry, collaborative creativity and personalized learning. The focus of STEM education is on developing our individual and collective capacity to design, solve problems and engage in real-world challenges.

**HURDLES FOR UNDERREPRESENTED GROUPS**

Third, there is America’s historic struggle for social equity and to make education a realistic pathway for academic and economic success.
There is little disagreement about the need to bump up the comparatively low numbers of women, minorities and underrepresented student populations pursuing STEM academic fields and careers. There is substantial disagreement on how to make STEM education rigorous, relevant and cost-effective in order to increase the chances and choices of such students—particularly when poverty enters the equation.

Rising costs and personal debt burdens make the pursuit of a college education a risky proposition for more and more middle-class families, let alone low-income households. A commitment to social equity includes making STEM education attractive, accessible and affordable.

**TEACHING, LEARNING FOR THE DIGITAL AGE**

Fourth, there is an unmistakable drive to connect and develop human ingenuity through the power of digital media, knowledge networks and technological innovation.

How can STEM education be designed to spark the creative and problem-solving capacity necessary to confront the great challenges of our age—climate, energy, water, food, health and security?

Building a broader and stronger pipeline of scientists, technologists, engineers and mathematicians certainly might help, but millennial minds nurtured in a digital age require whole new forms of technologically enhanced teaching and learning.

Today, there are 3.5 billion cell phone contracts in the world, yet many students are asked to "power down" when they enter the classroom, leaving their smart phones and IPods at the door.

We have learned from "Science 2.0" endeavors such as the human genome project that communication technologies and expert networks can connect and leverage creative capacity faster, better and more cheaply.

As Science 2.0 becomes Science 3.0 and Web 3.0 becomes Web 4.0, education will more and more become an edgeless enterprise. STEM skills will be vital in how and how well we navigate the challenges and opportunities of a highly connected world.

**Public and private partnerships are evolving in numerous states. There is a real opportunity to wire these and other networks together in our shared effort to spread advances in STEM education.**

**STEM 101 for policymakers: Reduce confusion, increase relevance**

This brings us back to the fundamental question raised earlier: What new minds and skills are needed for the future?

It is a question that can be used not only in helping craft state policy, but also in delivering a clear message about the importance of STEM education.

Every day, economic competition within and across states and foreign countries grows more and more intense.

At the close of World War II, Winston Churchill noted that the empires of the future would be empires of the mind.


Their main argument is that the demands for skills are altered as technology advances.

If the workforce can rapidly adjust to the demand for new skills, then economic growth is enhanced without significant increases in economic inequality. If, on the other hand, the workforce is not prepared, then growth is slowed and inequality widens.

Knowing what new skills will be demanded in the future is desirable, but how confident are we in our predictive ability, particularly in a global context?

Many of the skills for today, no matter how sophisticated, can be outsourced. Moreover, skills for which a computer program can substitute are also vulnerable.

The safest route for personal economic security is having desired skills for which there are imperfect international or technological substitutes.

Goldin and Katz note: “We see great demand today for the highly analytical individual who can think abstractly and who understands such disciplines as finance, nanotechnology and cellular biology in a deep, not routine, manner. … College is no
longer the automatic ticket to success. Rather, degrees in particular fields and advanced training in certain areas are now exceedingly important."

STEM education offers a relevant foundation for the skills that will be demanded in the future. We cannot prepare today’s students for “knowledge-based jobs” that have not yet been invented.

However, we can prepare them for adaptable skills that enable an individual to inquire (science), use and/or create tools (technology), employ non-routine problem solving and invent innovative solutions (engineering), and apply quantitative reasoning to understand and to communicate how things work (mathematics).

In addition to these skills, STEM education prepares minds to navigate successfully in a highly connected world, one in which learning is 24/7 and involves a broad and growing range of media.

Making STEM advances “contagious”

How do we make STEM education and improvements to how it is taught and learned “contagious”?

One way is to use the power of digital media and social networking, which can attract and invite talented minds to work together.

Another way is to take a new approach to educational research and development, so that promising innovations in teaching STEM education can be discovered and more widely spread and used.

A third way is the type of approach now being tried in Ohio.

The Ohio STEM Learning Network (OSLN) connects state and regional educational innovation leaders in public policy, business, and the state’s universities and K-12 schools.

The main aim of the network is to make educational and economic renewal a reality in Ohio. Essentially, the public-private OSLN is taking a systems engineering approach to advancing STEM-driven education and economic development. It applies three basic strategies to “amplify and accelerate” promising practices in STEM education.

We can prepare students for adaptable skills that enable an individual to inquire (science), use and/or create tools (technology), employ non-routine problem solving and invent innovative solutions (engineering), and apply quantitative reasoning to understand and to communicate how things work (mathematics).

- Maintain a working map of “high-leverage problems” (teacher capacity, for example), the multiple pathways toward solutions, and an integrating framework for forming a coherent field of improvement.

- Support a participatory design culture and process that engages STEM education designers, developers and researchers to work in close collaboration with practitioners on workable solutions to high-leverage problems.

- Connect and develop Ohio’s portfolio of STEM initiatives (platform schools, K-8 programs of excellence, scholarships, internships and venture capital for technology-based economic development) around open-source technologies, digital media and social networks.

Distinct but related network-centric approaches to public and private partnerships are evolving in numerous other states (Colorado, Hawaii, Minnesota, Pennsylvania, Virginia and New York, for example). There is a real opportunity to wire these and other networks together in our shared effort to spread advances in STEM education.

New federal dollars, new opportunity

Improving STEM education also could be part of a state’s strategy to secure additional federal dollars through the newly established “Race to the Top” fund, created earlier this year as part of the American Recovery and Reinvestment Act.

The $4.35 billion fund is allocating competitive grants to states based on their plans to improve education quality and results.

A quick look at the four assurances that the U.S. Department of Education is requiring for Race to the Top eligibility shows strong connections to STEM education innovations: 1) teacher quality and equitable distribution of teaching talent; 2) longitudinal, value-added performance data systems; 3) rigorous standards for college readiness; and 4) turning around low-performing schools.

A key choice when crafting a Race to the Top strategy is to determine whether STEM is simply part of a broad portfolio of reforms, or whether it serves as the basic scaffolding for the state’s educational and economic renewal.
The provincial perspective:
The Canadian provinces are working to increase student and teacher engagement in mathematics and the sciences.

In this section, some key initiatives in the Canadian provinces to improve math and science education are highlighted. The principal author of this section is John Murray, a science education consultant with the Manitoba Department of Education. He wishes to acknowledge the helpful contributions of Sherry Perih and Heather Knight of the Manitoba Department of Education; Maureen Callan of the Ontario Ministry of Education; the Saskatchewan Ministry of Education; and Christina McDonald of the Manitoba Department of Science, Technology, Energy and Mines.
There are challenges in Canada in terms of the future health of science and mathematics among young people. Nevertheless, there are important initiatives taking place within the three provinces that are affiliate members of the Midwestern Legislative Conference: Saskatchewan, Manitoba and Ontario. Three particular areas will be highlighted here: reforms to curriculum design in science and mathematics, innovations and supports for science and mathematics, and education for sustainable development.

Curriculum Reform in the Provinces

SASKATCHEWAN IN FOCUS

In Saskatchewan in 2008, a new government plan for the province’s education system was announced. It is conceived as an agenda that recognizes that the entire education sector has an essential role in securing economic growth and preparing young people to take their place in Saskatchewan’s economy. A quality public education system is also viewed as a key support for Saskatchewan’s families and in attracting new families to the province’s communities.

In 2009, Saskatchewan released new curriculum frameworks for grades 6-9 science that link specific learning outcomes to indicators of student achievement. These frameworks build on the Pan Canadian Protocol’s “K-12 Common Framework of Science Learning Outcomes.” Such common curriculum alignment provides for synergy in terms of learning-resource development, student mobility and teacher development in regions of the Canadian system that share common characteristics and geography.

MANITOBA IN FOCUS

Manitoba is nearing completion of a science curriculum renewal process that began at the kindergarten level and is now in its final stages at grades 11 and 12. As with Saskatchewan, this work is based upon the Pan Canadian Protocol’s science framework.

As part of this curriculum renewal, Manitoba has introduced two new secondary-level science courses that support greater local autonomy in design and implementation. A new grade 11 course, “Current Topics in the Sciences,” examines the sciences from an issues-based perspective, and it is designed to encourage an interdisciplinary approach to the teaching and learning of science. A complementary grade 12 course, “Interdisciplinary Topics in the Sciences,” encourages teachers to develop local content. Specific topics of study are not mandated within the curriculum framework, but are developed in closer alignment with local and regional characteristics (known as “place-based,” experiential learning).

Manitoba is one of seven jurisdictions comprising the Western and Northern Canadian Protocol for Basic Education (WNCP). As part of the WNCP, Manitoba is in the process of curriculum renewal in mathematics. In 2008, Manitoba released new K-8 mathematics curriculum frameworks, followed in 2009 by release of grades 9-12 frameworks. These frameworks are based on the “Mathematics Common Curriculum Frameworks” published by the WNCP in 2006 and 2008.

The frameworks are based on the belief that students of mathematics are curious, active learners with individual interests, abilities and needs. They come to classrooms with varying knowledge, life experiences and backgrounds. A key component in successfully developing numeracy is making connections to these backgrounds and experiences. These new mathematics frameworks identify forward-looking beliefs about mathematics and achievement indicators agreed upon by the seven WNCP jurisdictions.

ONTARIO IN FOCUS

The Ontario curriculum supports the development of mathematical skills in a way that is intended to be meaningful and relevant to students. Students not only learn proficiency in mathematical computations and procedures, but also develop a depth of understanding that will enable them to apply the mathematics they have learned in real-world situations. Attention to the mathematical processes, rather than correct final responses and rote learning, is considered essential to a balanced mathematics program.

The revised curriculum seeks to change the focus of science and technology education in Ontario schools from the teaching of specific topics to using these subjects to teach and assess for deeper, conceptual understanding. To develop this conceptual understanding, the curricula were designed around the idea that students should relate science to technology, society and the environment at all stages of learning. Students are encouraged to frequently ask “why?”; to uncover and explore scientific concepts, theories and scientific positions in the context of what matters to their experience; and to become increasingly confident in conversing about the issues of the day that are informed by the sciences.
Innovations and supports for science and mathematics in schools

THE SASKATCHEWAN CONTEXT

In Saskatchewan, there is a commitment to the view that educators, including teachers, administrators and school district personnel, play a significant role in the educational success of the province’s children. To fulfill this role, educators engage effectively with parents, community members, human-services professionals and others involved in the system to achieve excellence in the learning program and to meet the varied needs of students.

In 2008, the Ministry of Education published an extensive analysis of the current state of the education system “The Provincial Education Indicators Report” that reported on achievement among its First Nations (Aboriginal) students, including specific reporting and recommendations related to mathematics achievement.

In June 2008, with the publication of the document “A Time for Significant Leadership: A Strategy for Implementing First Nations and Métis Education Goals,” there was a call to “actualize” the curriculum (inclusive of science and mathematics) in a manner that would support the realization of the aspirations of Saskatchewan’s Aboriginal peoples. This implies that the learning experiences of youth in science and mathematics would have a “culturally responsive” component and contain indigenous peoples’ perspectives on the land and the nature of science.

THE MANITOBA CONTEXT

Of interest in Manitoba is a focus on student engagement. Research has shown that engagement in learning is critical to students’ success in school as well as their capacity to be lifelong learners.

With this in mind, Manitoba has implemented a provincial assessment policy at the seventh-grade level that includes not only mathematics, but student engagement as well. The student engagement portion has teachers and students reflecting on the following competencies:

- demonstrating an interest in his/her learning,
- engaging in self-assessment,
- being aware of learning goals of a unit of study and/or personal learning goals,
- participating in lessons more actively, and
- accepting increasing levels of responsibility for assignments.

The impact of this assessment with reference to mathematics teaching and learning has yet to be analyzed, but is a guiding force for educational leaders in teaching students in their middle years.

Professional learning activities target building teacher confidence in mathematics. Of importance now is developing an inclination in teachers to reflect seriously upon their classroom practices and make professional decisions based in large measure on the actual needs of students, as well as providing the tools needed by teachers to recognize where their students stand in terms of mathematical development and how to keep moving them forward along a continuum of success.

Manitoba Education’s Science Initiative provides for a wide diversity of real supports to student engagement and achievement.

Manitoba government science-curriculum specialists are engaged with the Centre for Research in Youth, Science Teaching and Learning in ongoing field research in the areas of early-years science literacy, identifying supportive and risk factors affecting student success in science, improving the teaching and learning of chemistry through research-based new practices, and meeting the particular needs in the teaching of science in francophone schools.

Winnipeg will act as host city to the 8th International Student Science Fair in 2012, allowing Manitoba to showcase a local school and its commitment to making connections to the university research community and the larger international community of students who are highly engaged in science-related activities.

THE ONTARIO CONTEXT

Each year, thousands of Ontario teachers benefit from the professional learning opportunities offered through the Ministry of Education’s secretariat.

The secretariat sponsors literacy and numeracy professional learning opportunities for elementary teachers. These sessions provide educators with the opportunity to collaborate, observe specific teaching strategies and reflect on their practices.

Educators from across the province have also participated in regional math forums held during “Math Implementation Days” in seven regions across the province. Participants learned about mathematics for teaching, as well as strategies for job-embedded professional learning within schools and families of schools to improve instructional student achievement.

Education for Sustainable Development: a New Imperative

Education for sustainable development, or ESD, reflects the vision defined in 1987 by the World Commission on Environment and Development: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” As a complex, interactive system
encompassing economic, environmental, and human health and well-being dimensions, ESD has as its core both responsible citizenship and good governance.

Canadian jurisdictions recognize the urgency of strengthening the processes within the education system and indeed re-orienting that system to ensure that young people develop the knowledge, skills and values consistent with making real contributions to a more sustainable future.

**ESD IN SASKATCHEWAN**

The objectives of education for Saskatchewan reflect the vision and principles of ESD through such goals as understanding and relating to others, membership in society and positive lifestyle choices.

In particular, the material in the Common Essential Learnings addresses aspects of ethics, human rights, technological literacy, cultural diversity and social responsibility. The expectation is that ESD outcomes exist throughout all new curricula where possible and appropriate. The renewed curricula are very inquiry-oriented, and it is anticipated that many opportunities for inquiry will address topics of personal interest to students, including issues related to the principles of sustainable development.

**ESD IN MANITOBA**

The Council of Ministers of Education, Canada (CMEC) has engaged Manitoba as the lead jurisdiction in ESD, one of its key activity areas in Learn Canada 2020, a framework to enhance Canada’s education systems, learning opportunities and overall education outcomes at all levels.

Manitoba is helping to ensure the presence of ESD at the provincial, national and international levels.

A Manitoba ESD Working Group was established with partners (including Learning for a Sustainable Future in Ontario, Manitoba Education, and Environment Canada) to build capacity and promote ESD in midwest Canadian jurisdictions. One influential outcome for the working group in 2008-09 was the planning and delivery of a major international conference on education for sustainability, “Choose the Future.”

Manitoba Education supported and participated in the development of a new Sustainability and Education Academy through York University in Ontario. The academy provides ESD education and training to school officials (school superintendents, trustees and principals, for example). The launch of this program took place in October 2007 in Ontario, followed by an academy in Manitoba in fall 2008. Another academy is planned for fall 2009.

Most recently, at the UNESCO World Conference on Education for Sustainable Development in April 2009, Manitoba helped craft the Bonn Declaration Call for Action on ESD. This important event stands as a benchmark at the midpoint of the United Nations Decade for Education for Sustainable Development, and will provide impetus for education system change across the Canadian west.

**ESD IN ONTARIO**

The seminal 2007 work of the Ontario Working Group on Environmental Education, chaired by Canadian astronaut Dr. Roberta Bondar, led to the release of the call-to-action document “Shaping Our Schools, Shaping Our Future.”

<table>
<thead>
<tr>
<th>Country</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>548</td>
</tr>
<tr>
<td>South Korea</td>
<td>547</td>
</tr>
<tr>
<td>Netherlands</td>
<td>531</td>
</tr>
<tr>
<td>Switzerland</td>
<td>530</td>
</tr>
<tr>
<td>Canada</td>
<td>527</td>
</tr>
<tr>
<td>Japan</td>
<td>523</td>
</tr>
<tr>
<td>New Zealand</td>
<td>522</td>
</tr>
<tr>
<td>Belgium</td>
<td>520</td>
</tr>
<tr>
<td>Australia</td>
<td>520</td>
</tr>
<tr>
<td>Denmark</td>
<td>513</td>
</tr>
</tbody>
</table>

*The Organization for Economic Cooperation and Development is an economic coalition of 30 industrialized countries. The United States ranked No. 25, with an average score of 474. Scores are reported on a scale from 0 to 1,000, and the average score for all OECD countries was 500.

Source: Program for International Student Assessment (2006)
Education in Ontario Schools.” It has come to be known as the “Bondar Report” on environmental education, and intends that the education system will prepare students with the knowledge, skills, perspectives and practices needed to be environmentally responsible citizens.

In terms of curriculum policy, this new emphasis will clearly state what students should know and be able to do, as well as the perspectives they need to consider as responsible citizens in a changing world. While environmental education rests on a foundation of knowledge of both the sciences and social sciences, this knowledge will be applied across the curriculum. Environmental education will be visible in an age-appropriate way throughout the K-12 curriculum through strands, topics and expectations, and will be recognized as a key provincial priority area not unlike that of Manitoba’s commitment to education for sustainability. School science in Ontario, with its action-oriented approach related to the urgencies identified in the world of today, will necessarily be transformed by the Bondar Report findings.

**APPENDIX**

**The provincial perspective:** The Canadian provinces are working to increase student and teacher engagement in mathematics and the sciences.

---

Canadian jurisdictions recognize the urgency of strengthening the processes within the education system — and indeed re-orienting that system — to ensure that young people develop the knowledge, skills and values consistent with making real contributions to a more sustainable future.
For more than 75 years, The Council of State Governments has provided state leaders with a network for identifying ideas and sharing solutions. As the only nonpartisan, nonprofit association representing all three branches of government, CSG is committed to fostering innovation in state government, promoting dialogue and information sharing among leaders, and helping advance promising approaches to public policy. CSG Midwest supports the region’s lawmakers and their staff through the Midwestern Legislative Conference. In addition, the Canadian provinces of Manitoba, Ontario and Saskatchewan are affiliate members of the MLC.