PUTTING IT ALL TOGETHER

Supporting K-12 STEM Education in Illinois

C-STEMEC
Chicago STEM Education Consortium

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ABOUT C-STEMEC

The Chicago STEM Education Consortium (C-STEMEC) comprises four science, technology, engineering, and mathematics (STEM) education-related university centers: the Center for Elementary Mathematics and Science Education at the University of Chicago, the Center for Science and Mathematics Education at Loyola University Chicago, the Learning Sciences Research Institute at the University of Illinois at Chicago, and the STEM Center at DePaul University. Together, we have decades of combined experience researching and supporting PK-12 teacher, administrator, school, and district improvements in mathematics and science teaching, learning, and leading.

Our work is aimed at fostering smart decision-making about STEM education in Illinois. Our work is governed by a set of principles that describe how we operate and produce our policy recommendations.

Support for C-STEMEC comes from the Searle Funds at The Chicago Community Trust. At the C-STEMEC website http://www.c-stemec.org is more detail about our work, our funders, and our experiences.
Algebra acts as a gatekeeper for high school graduation and post-secondary success. Students who pass Algebra 1 by the end of ninth grade are more likely to take advanced mathematics courses, graduate from high school, and succeed in college. Yet persistent inequities in access to rigorous algebra due to issues of placement, preparation, and quality of instruction have kept the gate closed for a large proportion of students, particularly minority and low-income students. In response, “Algebra for All” policies have been implemented whereby all students are required to take Algebra 1 by a designated grade level—typically eighth or ninth grade. This paper provides recommendations to: (1) better prepare students to succeed before taking Algebra 1; (2) enhance learning opportunities for underprepared learners during Algebra 1; and (3) enhance teaching capacity to support all learners, particularly those who are underprepared to succeed in Algebra 1.

The adoption of the Common Core State Standards for mathematics and accompanying PARCC assessments will have profound consequences for schools and districts. Since standards interact with other aspects of the educational system—curricula, assessments, human capital, district, and school organization—isolating collateral impacts is difficult. This decision has five important consequences for schools and districts:

- More (and different) learning for students.
- More (and different) learning for teachers.
- More (and different) learning for administrators.
- Different (and more challenging) assessments.
- The system is in a greater state of flux than in the recent past

Based on these consequences, this brief presents six major recommendations for schools and districts preparing to implement the new Common Core State Standards for mathematics.

DePaul University convened a working group to provide a set of recommendations to districts and schools around the upcoming transition to the Next Generation Science Standards (NGSS). The working group included 19 members from universities (both science and education experts), schools systems (both within and outside of CPS, including teachers, principals, network administrators, and central office administrators) and non-formal educational institutions. The essential question that was addressed by the group was how we can ensure that all students receive a high quality, rigorous education in science that will prepare them to be informed citizens and demonstrate to them the personal and societal value of science and engineering.

In the report the group described the hallmarks or elements of an educational system that is fully aligned with the NGSS, focusing on three clusters of actions: curriculum and instruction, assessment, and system capacity. The group presented this picture to serve as a vision for districts, schools, and classrooms as administrators and teachers begin their conversations about how to implement these “fewer, clearer and higher” standards. Following these hallmarks, the group outlined some suggestions for closing the gap between the current reality and the vision for K-12 science education.
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Executive Summary

Improving science, technology, engineering, and mathematics (STEM) education is critically important for Illinois and our children. Our world is defined in many ways by these disciplines, and in the future they will only play a larger role in the lives of the people of the Land of Lincoln. While there have been national and local improvements in some aspects of STEM educational outcomes, we are still not obtaining the results our students deserve. We believe now is the time for a concentrated effort within Illinois to improve PK-12 STEM teaching, learning, and leading for four connected reasons:

1. The overall education policy context is well positioned for substantial improvement.
2. Illinois is “STEM-rich.”
3. Building a solid foundation for improvement now will enable rapid growth when the economic situation improves.
4. Much can be done for students now at low or no cost.

To do this, we make four overall recommendations. While the primary audience is Illinois policy makers, education leaders and staff at the Illinois State Board of Education, there is a part to play for business leaders, university faculty, classroom teachers, and school-level leaders, who may also find this document informative.

Our four recommendations:

1. Illinois needs a stem education definition.
2. Refocus the implementation of the common core state standards for mathematics.
3. Move forward with the next generation science standards.
4. Illinois needs a stem education plan and mechanism to manage it.
What Is This Paper, Who Is It For?

This paper articulates a set of recommendations that will support PK-12 Science, Technology, Engineering and Mathematics (STEM) education improvement in Illinois. While the primary audience is Illinois policy makers, education leaders, and staff at the Illinois State Board of Education, our hope is that others, such as business leaders, university faculty, classroom teachers, and school-level leaders, will also find this document informative.

This document complements another C-STEMEC report, Implementing the Next Generation Science Standards: Hallmarks of a Fully Realized School System (Jackson et al., 2013). That report describes the elements of an educational system that is aligned with the vision of science instruction based on the Framework for PK-12 Science Education (National Research Council, 2012) and the recently-released Next Generation Science Standards (NGSS Lead States, 2013). It focuses on three clusters of actions: curriculum and instruction, assessment, and system capacity. The Hallmarks paper is intended to provide guidance to school administrators and teachers as they begin their conversations about how to implement these “fewer, clearer and higher” standards.

This document also builds on the C-STEMEC report Getting Serious About Implementing The Common Core Standards for Mathematics: An Implementation Guide for Schools and Districts in Illinois. The adoption of the Common Core State Standards for Mathematics (CCSS-M) and accompanying PARCC assessments will have profound consequences for schools and districts. Because standards interact with other aspects of the educational system—curricula, assessments, human capital, district, and school organization—isolating collateral impacts is difficult. That paper identifies five important consequences for schools and districts and then offers six major recommendations about implementation of the new Common Core State Standards for Mathematics. (C-STEMEC, 2013).

These three papers—on STEM Education, implementing the CCSS-M, and preparing for the NGSS—address different layers of the educational system, from the state to districts to schools to classrooms. Collectively, they paint a picture of the issues, components and stakeholders involved in systematic change to promote greater student learning and achievement in mathematics, science, engineering and technology.

STEM Education Is Important For Illinois

What should STEM education do for Illinois? One argument is that STEM education “should contribute to (1) a STEM-literate society, (2) a general workforce with 21st-century competencies, and (3) an advanced research and development workforce focused on innovation” (Bybee, 2013), goals that seem very reasonable as a starting point for this state.
Understanding STEM broadly is important for students; we live in a world that is defined to a large degree by science and technology. A population that can make scientifically informed decisions helps us all. The economic and social benefits of scientific thinking and STEM education are widely believed to have broad application for workers in both STEM and non-STEM occupations (Gonzalez & Kuenzi, 2012).

Our economy depends on STEM careers as well. As argued by the National Academy of Science (Committee on Prospering in the Global Economy of the 21st Century, 2006) and the U. S. Chamber of Commerce (Hess, Kelly, & Meeks, 2011) among others, a shortage of STEM-savvy workers creates challenges for many of the corporations and industries that drive economic growth in this country.

Illinois needs to improve its STEM education. While eighth graders have improved recently on the National Assessment of Educational Progress (NAEP) tests in mathematics, still only about one third of Illinois students meet proficiency levels (National Center for Education Statistics, 2012). Only about one quarter of Illinois students are proficient in science (National Center for Education Statistics, 2011), and 13% of Illinois community college students need remediation in mathematics, which costs the state $11,644,265 each year (Change The Equation, 2012).

In Illinois, STEM skills have stayed in demand even through the economic downturn. Change The Equation estimates that for every unemployed person in Illinois, there are 1.6 unfilled jobs that require STEM knowledge and skills (Change The Equation, 2012).

Now Is the Time For A Concentrated Effort

We believe now is the time for a concentrated effort within Illinois to improve PK-12 STEM teaching, learning, and leading for the following four connected reasons:

1. **The overall education policy context is well positioned for substantial improvement.** New mathematics standards have been adopted by the state and implementation of them is underway. New and better mathematics assessments will be available soon. Illinois is poised to adopt the Next Generation Science Standards (NGSS), and their roll-out and implementation can be built upon lessons learned from similar work in mathematics.

2. **Illinois is “STEM-rich”.** Illinois is home to over 200 institutions of higher education and ranks 6th in the nation in terms of overall output of doctoral graduates in science and engineering (Illinois Science & Technology Coalition, 2013). Fermi National Accelerator Laboratory and Argonne National Laboratory are both national treasures. Across higher education, laboratories, and industry,
the Illinois Science & Technology Coalition estimates nearly $12.5 billion is spent annually on STEM research and development in Illinois. Moreover, there are also many available STEM educational resources that could be more connected to schools or students (Lyons, 2013).

3. **Building a solid foundation for improvement now will enable rapid growth when the economic situation improves.** Even with the current, unsteady state educational financial condition and rising state revenues not expected for five or six years (Leachman & Mai, 2013), there is an opportunity to get the STEM education strategy right and build appropriate coalitions which can then be leveraged to produce earlier and more robust results when more resources are available.

4. **Much can be done for students now at low or no cost.** As described further in this report, there are many things that can be done in the short term, for no or little cost, that have the potential to help improve STEM education outcomes for students significantly.

**Why Is This Report Different?**

Our review of the literature indicates that not much has been written about STEM education policy in Illinois in recent history. The most relevant prior work is *Keeping Illinois Competitive*, developed at Northern Illinois University in June 2006 with funding from the Illinois Business Roundtable (Northern Illinois University P-20 Task Force, 2006). This report provides a wealth of data that describes the current economic and business development condition in Illinois and connects these conditions to educational issues. The report concluded with five important challenges facing Illinois and STEM education but contains relatively little discussion on solutions to those challenges. In our conversations with the leaders of the *Keeping Illinois Competitive* effort, their sense is that this report helped raise awareness for STEM education issues throughout the state, and in particular galvanized business support for the Common Core State Standards.

In our report, we aim to build upon this important work in three significant ways:

1. **More recommendations, less analysis.** There has been much analysis nationally about the STEM education crisis and we do not repeat those arguments or analyses. *Keeping Illinois Competitive* provides a good foundation of the current evidence about STEM education performance in Illinois. In this report we focus more on proposing recommendations to address those challenges. Our sense is that the data describing the problem are well understood, but solutions are harder to come by.
2. **Student learning as the goal.** We believe that improving STEM education is important for issues related to workforce and business development, but more fundamentally, it is important for students and their families. The STEM disciplines shape the modern world, and facility with them is essential for our students’ futures. Our focus here begins with the goals of student learning and builds from there.

3. **Formal PK-12 System focus.** Lastly, we focus primarily on the formal PK-12 education system at the district and state levels. There are clearly many things that can be done to improve STEM teaching, learning, and leading that occur outside of the traditional and formal school system—in after school settings, with museums and libraries, and with the general public to name a few. While leveraging and connecting those resources is certainly important, we provide only passing attention to them here.

**Why Putting It All Together?**

Fundamentally, our appraisal of the current STEM education approach in Illinois is that it consists of a system with great potential but with many pieces that are not nearly as connected and aligned as they could be. As a result, our efforts remain inefficient, and our collective direction is unclear. We hold out hope, however, that the right players could put these pieces together in a fashion so the whole is greater than the sum of the parts. Doing so would require strong partnerships between stakeholders with the expertise and experience needed to improve STEM learning at scale, and the political will to help STEM education partners shift their efforts in the service of the greater good.
RECOMMENDATION 1

Illinois Needs A STEM Education Definition

**FUNDAMENTAL ASPECTS OF STEM**

STEM is an acronym for four disciplines: the study of mathematics, science, engineering and technology. There are clear connections between all of these disciplines, with an interplay that generally varies as the context. These are four related disciplines that all overlap, but STEM is not a unique entity unto itself.

**Mathematics is core.** Mathematics is foundational to all the STEM disciplines. As the Next Generation Science Standards state, “science is a quantitative discipline” (NGSS Lead States, 2013). Mathematics is an essential component of being college and career ready.

**Science is essential.** Science educators describe three interrelated aspects of science—a body of knowledge, a method or process, and a way of knowing or constructing reality—that are essential understandings for all students (Lederman, Lederman, & Bell, 2003). As the Framework begins, “Science... permeates nearly every facet of modern life, and [holds] the key to meeting many of humanity’s most pressing current and future challenges” (National Research Council, 2012). Science is important for students because science is important for people. For further explication of the value of science and science education, we refer readers to the previously mentioned Hallmarks report (Jackson, et al., 2013).

**Science disciplinary content areas overlap.** In the Next Generation Science Standards, the various scientific disciplines—life science, physical science, and earth and space science—are considerably intertwined, reflecting the way boundaries between modern science disciplines are more and more permeable (NGSS Lead States, 2013). Within NGSS, the Science and Engineering Practices and the Crosscutting Concepts serve as a framework for the interdisciplinary nature of scientific and engineering enterprises and for understanding the connections among the STEM disciplines.
Many people are working on STEM education in Illinois but there are nearly as many different definitions and meanings of this work as there are players. What is STEM education? Is STEM a new integrated subject? Is it just about mathematics and science? Which letter in STEM is the most important? Is it mostly about jobs and the workforce? Does STEM imply a particular pedagogical perspective? While many aspects of a definition certainly depend on the context in which they are used (Bybee, 2013), a clear and common definition for STEM education would provide the foundation for better and clearer collaboration among many entities within the state.

A definition would enable Local Education Agencies (LEAs) to identify goals and outcomes that are relevant to them. A definition would help schools decide on particular strategies and resource allocations. A definition would help supporting organizations, such as universities and museums, to align their resources and programs. Given that much support for mathematics and science tends to come from sources external to the schoolhouse (Spillane, 2005), state-wide clarity will help focus the marketplace so as to serve schools better.

Many aspects of engineering are important aspects of science. Engineers use scientific thinking and processes to solve problems, and as broadly defined in the Framework, engineering is “engagement in a systematic practice of design to achieve solutions to particular human problems” (National Research Council, 2012). Per the NGSS, engineering is included as part of science in PK-12, but not as a separate or distinct discipline (NGSS Lead States, 2013). As the National Academies have concluded, “K–12 engineering education may improve student learning and achievement in science and mathematics; increase awareness of engineering and the work of engineers; boost youth interest in pursuing engineering as a career; and increase the technological literacy of all students” (National Research Council, 2009). This includes, by and large, the definition of technology and engineering literacy as recommended by the National Assessment Governing Board (National Assessment Governing Board, 2013).

Technology should be part of school, and not unique to STEM. Computing technology—handhelds, networks, software, desktops, and the like—should be pervasive in all disciplines and enhance learning. Computing technology has revolutionized businesses and created huge new sectors and markets, and few doubt that similar changes will soon occur in the education sector. Computing technology is a tool, important to English and physical education classes as much as to science and mathematics. In our thinking about STEM, technology undergirds many aspects of schools—not just the STEM pieces. Further, we agree with the authors of the Framework who define technology to include “all types of human-made systems and processes—not in the limited sense often used in schools that equates technology with modern computational and communications devices” (National Research Council, 2012).
Computationnal thinking is important. In our definition of STEM education, the “T” also means a focus on computational thinking—which, in one definition, can be thought of as a “focus on the intellectual skills necessary to apply computational techniques or computer applications to... problems and projects in any discipline” (Barr & Stephenson, 2011).

Implications of this definition

When STEM is considered as above, several implications for school and district leaders quickly emerge. Based on the importance of mathematics, science, engineering, and technology as disciplines, the evolution of those as disciplines, and the need to think expansively about these disciplines and their relationship to one another, some implications for classroom, school and district strategies will emerge.

For all. STEM Education is important for all students at all levels. Both the Common Core State Standards for Mathematics and the Next Generation Science Standards make the point repeatedly that the expectations they describe are for all students—not just those who are gifted or advanced.

Mathematics is the primary driver. We understand that mathematics remains the primary driver for federal school accountability. Moreover, it remains a major barrier for many students seeking postsecondary education. As such, it should receive disproportionate attention and resources.

Science warrants attention. That said, a focus solely on mathematics is not wise—a strong science program in all grades is an important element of promoting college and career readiness, a powerful way to engage students in the natural world, a critical context for developing robust mathematical understanding, and crucial for developing an informed citizenry.
BE CAREFUL ABOUT

In our discussions with teachers and schools about STEM education, and upon reviewing the national dialogue, we see a lot of misconceptions that arise from various definitions of STEM.

Equating STEM with “real world”. Simply because a course or subject could have real world applications does not ensure that students will develop a deep understanding of the content and be able to apply this knowledge later in school or out of school. Nor does it guarantee that the student will relate to the course content or be more engaged in learning. Research shows that students who experience higher levels of “authentic instruction” demonstrate higher achievement (on both standardized tests and non-standardized assessment). But authentic instruction must go beyond simply having a theoretical or superficial connection to the real world (Newmann, Bryk, & Nagaoka, 2001). It involves students’ (1) constructing deep conceptual understanding of the disciplinary concepts, which includes a command of the knowledge and facts that make up the discipline, (2) engaging in the inquiry processes used by professionals in the disciplines, and (3) have actual meaning and value to students beyond school (Newmann, King, & Carmichael, 2007). Student engagement is important, and teachers and schools often need help motivating students. The “real world” can be a helpful motivating tool—but isn’t necessarily so. Engagement and “real world” applications are relevant to most disciplines, not only the STEM ones.

Integrating STEM too soon. As stated above, the boundaries between scientific disciplines have become less sharp as research in these fields advances, and likewise the crosstalk has increased between mathematics and science. However, most efforts to integrate mathematics and science tend not to move either mathematics or science instruction forward, and finding teachers with the right credentials to do this is challenging. Moreover, creating the collaborative, supportive school environments and structures that an interdisciplinary approach demands remains a significant challenge (Allensworth, 2012). However, as noted above, the NGSS promote a much more integrated view of science than most current practice.

Equating business engagement with STEM. Businesses and other community entities should be involved in schools. Robust partnerships can be helpful but they need to complement the STEM learning goals rather than define them. For example, it is admirable when an engineering firm adopts a school and provides some resources and interactions with students and practitioners around engineering careers—but that does not, by itself make for a STEM program.
Other STEM Perspectives

There are many definitions of STEM used around the country. Here, we'll discuss some examples and explain how they align to what we believe is appropriate for Illinois.

NCTM President J. Michael Shaughnessy calls STEM “an advocacy position, not a content area” and describes the evolution of the term as one that arose from organizing efforts at the federal level and has been misappropriated as “educational jargon” at the state and local level. He states that

“There can be no STEM programs... without concrete, identifiable, innovative content accompanied by specific teaching goals and implementation plans. The actual mathematics and science content and teaching in any STEM program... should be transparent.”

We find much to agree with his description, particularly the focus on mathematics as a core component of STEM education. His charge to program leaders— “those who are implementing any STEM program should be able to identify the specific mathematical foci of the program”—is good advice to STEM actors in Illinois (Shaughnessy, 2012).

Scholars associated with Carnegie Mellon University have offered the following definition of STEM:

“...an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy.” (Tsupros, Kohler, & Hallinen, 2009)

This definition appropriately includes both “STEM literacy” and workforce issues (“ability to compete”) but puts more emphasis on interdisciplinary approaches and real-world lessons than is advisable for early implementation.

The Teaching Institute for Excellence in STEM, at http://www.tiesteach.org/, focuses on STEM as an engineering-centric design process: “[STEM] asks for a multiplicity of pathways to offer a series of plausible solutions. From that process has come the power of prototyping, and beta testing.” (Teaching Institute for Excellence In STEM, 2013) We think such ideas are important, but they are too narrow and are more appropriately positioned within the Next Generation Science Standards as a component of science education.

The Science Foundation Arizona has produced a STEM guide at http://stemguide.sfaz.org/ that includes a four-stage toolkit “for Arizona schools and districts to integrate STEM education.” Unfortunately, it is relatively silent on the content and skills that make up STEM, seems to equate STEM with project-based learning, and implies that “full immersion” is about the choice of particular programs instead of student learning goals or instruction. When considering STEM education, the content for students matters.
STEM Instantiated at a School

School districts across the state are opening or considering the establishment of STEM schools. There is no single model that defines such a school but there are characteristics of good STEM schools.

UIC College Preparatory High School in Chicago is one such school. The school, a campus of the Noble Network of Charter Schools, serves largely low-income students. The focus there is on college readiness, coupled with a unique program involving the health sciences. The school's emphasis on high-quality instruction in the core disciplines has resulted in the highest average ACT score of any, non-selective enrollment high school among public schools in Chicago. 100% of its graduates have been accepted in four-year colleges. All students enroll in four years of mathematics and three years of core science courses. In addition, they take a four-year course sequence in the health sciences that was developed in conjunction with researchers and health professionals at the neighboring Medical Center campus of the University of Illinois at Chicago (UIC).

Students in the health sciences program learn via a well-developed, problem-based approach that tackles real-life, messy problems. They work in teams on a series of “cases” (problem-based investigations) that were developed by UIC doctors, nurses, dentists, public health scientists, pharmacists, social work researchers, and other health professionals. They research the problems, examine data, and develop their own solutions to the problems introduced in the cases. They develop communication skills through written, digital, and oral presentations of their solutions. They conduct an in-depth investigation of a problem that interests them as part of a capstone project in their senior year. Throughout their four years, they have regular and varied interactions with UIC health professionals and researchers, and develop a solid awareness of diverse career opportunities in the health professions. The work in the health sciences classes complements robust instruction in traditional mathematics and science courses.

While it does not define itself specifically as a STEM school, UIC College Prep’s emphases on: high expectations and solid core instruction in mathematics and science; an in-depth focus on a STEM career pathway; regular investigation of real-life problems through a problem-based approach; quality partnerships with STEM professionals; and development of key workplace and college-readiness skills, such as problem solving, teamwork, critical thinking, and communication are representative of many of the characteristics that should be evident in a good STEM school.

Still, UIC College Prep HS is an example, not a model. The school has a special relationship with and access to personnel and resources at an adjacent, large medical center complex. Even with the close proximity of the school to the UIC Medical Center campus, sustaining a high level of involvement by busy health professionals and researchers at the Medical Center is a recurring challenge that requires ongoing commitment, nurturing, and support on the part of both the school and the university. The unique conditions that enable the school-university partnership to thrive at UIC College Prep would be difficult to replicate elsewhere.
**RECOMMENDATION 2**

**Refocus the Implementation of the Common Core State Standards for Mathematics**

**RECOMMENDATIONS FOR MATHEMATICS**

*Make PARCC the best test possible for Illinois students.* Illinois is a governing state in the Partnership for Assessment of Readiness for College and Careers (PARCC) assessment consortia. It is clear that the PARCC testing consortium is struggling. Some states have left or are considering leaving and are looking for other assessment alternatives. We believe that Illinois should remain involved with PARCC and leverage its status as a PARCC governing board member to help ensure that PARCC delivers on their promise of state-of-the-art, next-generation assessments.

*Scale-up promising models for school improvement.* Throughout the state, school districts are attempting to address the new expectations of the Common Core State Standards. Some of these efforts, such as the Suburban Cook County Mathematics Initiative in west and south Cook County, have potential for broader statewide impact. Scaling up this type of sensible and cost-effective initiative can build the capacity of districts to improve their mathematics instruction far more than current efforts that focus narrowly on standards and accountability, and we encourage the state to redirect existing revenue streams to focus more promising approaches.

*Create a statewide strategy for Algebra in the era of CCSS-M.* An algebra “toolkit” for districts that describes recommended course definitions, assessments, and entry requirements would be tremendously helpful in implementing broad, high quality algebra instruction. Algebra I is a critical course for all subsequent mathematics instruction and is gatekeeper course for many students. The CCSS-M creates new challenges for teachers, schools, and students regarding Algebra I instruction and will force districts to reevaluate their current programs, including their policies for enrollment in Algebra I courses prior to high school. State guidance about this important course would be a great resource for districts and school leaders, and is badly needed. There is wealth of knowledge in Illinois from which to draw that can help shape sound policy recommendations, including what to do for underperforming students (Stoelinga & Lynn, 2013). For example, we believe that much of the work done in Chicago around the Algebra Initiative (Jabon et al., 2010) could be taken statewide with little cost.

*Provide robust guidance on high school pathways.* The Common Core State Standards for Mathematics provide guidance on two parallel course sequences for high school mathematics: The
In *Getting Serious* (C-STEMEC, 2013), we described recommendations for schools and districts to make around implementing the new Common Core State Standards for Mathematics (CCSS-M). In this section, we offer some additional advice and insights for state-level actors that likely will help schools and districts move forward with these efforts.

“traditional” sequence of Algebra, Geometry, and Algebra II, and the “integrated” pathway of three courses (Mathematics 1, Mathematics 2, and Mathematics 3). ISBE rightly decided not to mandate one particular pathway for Illinois high schools (Illinois State Board Of Education, 2013b). However, there is emerging evidence that the integrated pathway provides better opportunities for students (Tarr, Grouws, Chávez, & Soria, 2013). For any given high school, making the change from traditional to integrated high school mathematics has major implications and involves a myriad of decisions and tradeoffs. Many schools would benefit from additional capacity and consulting in this process. Some targeted assistance to LEAs about high school mathematics course sequences and arrangements has the potential for significant benefits to students.

**Build a network of mathematics support.** Illinois has a host of mathematicians and mathematics educators with tremendous experience and expertise about mathematics teaching, learning, and leading. If consulted, these individuals could help Illinois develop and implement better strategies for mathematics instruction, more effectively increase the capacity of teachers and schools around mathematics implementation, and provide rationales and supports for the difficult decisions that are inherent in efforts to improve schools at scale. ISBE can and should play a lead role in organizing a network of these experts. To make this happen, ISBE would need to review current staffing configurations and ensure that those responsible for mathematics education have the knowledge, experience, and organizational authority necessary to convene and lead this effort. For any state mathematics improvement effort to take hold, however, ISBE needs to ensure that the different pieces impacting mathematics instruction—such as curriculum and standards, assessment and accountability, teacher certification and evaluation, support for struggling districts, and targeted funding initiatives—are all aligned to a common, clear, and public vision for improving mathematics instruction.
The Suburban Cook County Mathematics Initiative (SCCMI)

The Suburban Cook County Mathematics Initiative is composed of two sister initiatives, involving 32 high-needs school districts in west and south Cook County (the West Cook Mathematics Initiative and the South Cook Mathematics Initiative). SCCMI promotes a comprehensive strategy for improving mathematics teaching and learning, with an emphasis on strong, instructional leadership that supports high-quality instruction leading to improved student achievement.

The initiatives have created communities of school districts and practitioners in west and south Cook County that are working together to provide their mathematics students with instruction that meets the demands of the Common Core State Standards for Mathematics (CCSS-M). The initiatives are based in the West 40 and South Cook Intermediate Service Centers and are directed by personnel from UIC’s Learning Sciences Research Institute.

SCCMI uses proven tools, including a set of well-designed mathematics performance assessment tasks, to help teachers and administrators focus their energies on understanding student thinking, and on facilitating instruction that moves student thinking forward. In the process, teachers are learning effective strategies for providing instruction that reflects the high-cognitive-demand expectations of the CCSS-M and the coming PARCC assessments. Principals and district administrators are developing a better understanding of what high quality mathematics instruction looks like and how to support it in their schools and districts.

In collaborating on improving their mathematics programs, SCCMI has developed regional, rather than district-based approaches to mathematics instructional improvement. The collaboration has leveraged significant grant funding that would not have been available to the districts individually. It has also provided districts with access to professional development opportunities for teachers and administrators, in-school coaching, national experts, and other resources that, similarly, would not have been as available to individual districts. Most importantly, coming together around mathematics improvement provides regular opportunities for teachers and administrators from neighboring districts to learn from each other and look for new avenues where collaboration would be beneficial, such as better articulation policies between eighth and ninth grades, a common performance assessment across the 32 districts, and a regional task force that is examining ways for districts to refine their assessment systems in light of new federal and state mandates and accountability requirements.

For more information about SCCMI, please visit http://www.lsri.uic.edu.

Starting in 2012, the Chicago Public School (CPS) District initiated a professional development program to support high quality mathematics instruction that builds on the work in suburban Cook County. This project currently reaches all 20 school networks in CPS, with deeper support for six provided by the STEM Center at DePaul University. The DePaul work is impacting over 100,000 CPS schoolchildren.

Funding for SCCMI and the DePaul work with CPS is provided by the Searle Funds at The Chicago Community Trust.
The Case Of Illinois Pathways

Illinois Pathways (at http://www.ilpathways.com/) is a “a new and innovative State of Illinois-led STEM education initiative designed to support college and career readiness for all students.” It is jointly led by the Department of Commerce and Economic Opportunity, the Illinois State Board of Education, the Illinois Community College Board, the Illinois Board of Higher Education, the Illinois Student Assistance Commission, and the Illinois Department of Employment Security. For the past several years, it has been the highest profile STEM education project in the state, and is funded by Illinois’s Race To The Top grant (Illinois State Board Of Education, 2013a). The project consists of pathways, which are sequences of courses, work-based learning, and credentials or assessments aligned to career focused clusters, such as agriculture, architecture, or energy. Each pathway has a corresponding STEM Learning Exchange, which is a...

“...new, innovative public-private education partnership that is organized to support local implementation of P-20 STEM Programs of Study by coordinating and reducing the transaction cost among statewide networks of education partners, businesses, industry associations, labor organizations, and other organizations. Learning Exchanges are organized by career cluster and work to coordinate planning and investment, aggregate resources, and review talent supply-chain performance” (Illinois Pathways, 2013).

The Illinois Pathways work has brought together many disparate actors to leverage considerable capacity against some critical pieces of the STEM education system in Illinois. Yet Illinois Pathways was not intended to be a comprehensive STEM strategy. The different learning exchanges do not include many of the tools and supports teachers and schools need to advance core mathematics and science instruction. And it is not focused on the elementary grades, which are critical for advancing STEM understanding.

While the coordinating function of the STEM Learning Exchanges likely could help bring alignment to multiple efforts, we know that real instructional coherence requires a compelling instructional vision as well as sustained capacity (Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010). The focus on career readiness and training that pervades the Illinois Pathways material presents an incomplete view of both STEM education and of school improvement.

Individual STEM Learning Exchanges engage interested stakeholders and provide a wealth of information about possible STEM careers. As such, the Pathways initiative should be considered an important component of a comprehensive STEM education strategy for Illinois. We encourage Illinois to develop, fund, and implement the additional pieces of comprehensive STEM education plan, that would focus primarily on core instruction in STEM disciplines and that spans all grades.
Mathematics Curriculum In Illinois

In June 2012, the Illinois legislature passed and the Governor signed SB3244 into law as Public Act 97-0704, which amends the Illinois school code to include a section on “mathematics curriculum models”. We applaud the legislature for focusing on mathematics education improvement, but consider this a well-intentioned but misguided effort to improve student outcomes in Illinois. The law calls on ISBE to “coordinate the acquisition, adaptation, and development of middle and high school mathematics curriculum models to aid school districts and teachers in implementing standards for all students” but also notes “no additional fiscal cost is expected for school districts” (Illinois General Assembly, 2012).

ISBE has moved ahead to follow the law as it must, and has created model curriculum frameworks in an attempt to help districts think about their mathematics programs in light of the Common Core State Standards for Mathematics. (For details, see http://www.isbe.state.il.us/common_core/htmls/math-models.htm) The Model Curriculum Frameworks provide districts with one way to start in their transition, with some assistance and resources for developing replacement units based around specific standards.

ISBE’s Model Curriculum Framework should not be perceived as the beginnings of a coherent curriculum for mathematics or as a framework or districts to use in developing a full curriculum. It can help districts start to think about changes that will be required by the CCSS-M. Leading districts down a road that encourages the use of the frameworks to develop their own curriculum would be a mistake. Developing robust and coherent curriculum is challenging and requires specific expertise; teaching and leading mathematics well also is challenging and requires specific expertise; these spheres of expertise have some intersection but are certainly not identical. High quality teaching is at the heart of the CCSS-M. It is the most important work of our schools, with a deep intellectual component, and deserves appropriate attention and support.

Promoting good teaching should now be the focus of ISBE’s work rather than continuing to invest time and resources in building out the model framework, which, at best, will have a marginal impact on good teaching and could have the unintended consequence of promoting less, rather than more coherence in districts’ mathematics curriculum. Developing strong leadership at the school and district level—consisting of individuals who understand the importance of robust tools for teachers and know how to support high quality mathematics instruction—should also be prioritized more than continuing the Model Curriculum work.

We all should work with our legislators to substantively adjust the school code regarding mathematics, especially addressing the funding needs associated with obtaining curriculum materials and training teachers.
RECOMMENDATION 3
Move Forward With The Next Generation Science Standards

RECOMMENDATIONS FOR SCIENCE

Adopt NGSS. While imperfect, the new standards are an improvement over the current Illinois Learning Standards (Porter-Magee, Wright, & Horn, 2013). Remember, however, that adopting is the easy part; providing structures and supports that result in better instruction and better student learning is the real challenge.

Be intentional and go slow. There are many Illinois children who desperately deserve better science instruction. However, it is clear that there are not the resources or the capacity at the present time for a major push to improve science education. ISBE should set long timeframes for NGSS adoption and implementation and use the intervening time to lay the foundation for a robust implementation in the future. This will also provide the time to make the systemic changes necessary to make supports genuine and helpful to schools and districts. Professional development to support the transition must be part of this systemic change.

Upon adoption, be clear about an accountability plan and measures. Science should be part of the school accountability framework in Illinois. While delaying the science accountability provisions is appropriate, ISBE needs to provide clear guidance to LEAs about the role of science accountability. Without clear accountability provisions coupled with appropriate supports, we do not believe science will be taught to the degree necessary in our schools.

Better science assessments. The current assessment suite that ISBE uses for science was in need of a major makeover prior to NGSS. With new standards, the need for change is even more pressing. We encourage ISBE to work with other states to develop better science assessments aligned to these new standards. Performance assessments should be included. The College Board Advanced Placement Content Frameworks for new AP Biology (The College Board, 2011a) and Chemistry courses (The College Board, 2011b), which informed the redesigned AP exams in those
The Next Generation Science Standards (NGSS), developed by a consortium of lead states with help from Achieve, Inc. were released in early 2013 (NGSS Lead States, 2013). As of this writing, the state of Illinois is poised to adopt them. The recommendations and cautions that follow are intended to be sensitive to this context.

Focus outreach efforts on leaders, not teachers. At the onset, focus on developing the capacity of school and system leaders about NGSS—teacher leaders, department chairpersons, curriculum directors, and principals as well as leaders from universities and informal science centers. Participants should learn how these standards are different from the current Illinois Learning Standards, but also how enacting them in their schools and districts will need to be different—new accountability provisions, new instructional materials, and new teacher evaluation mechanisms. While classroom teachers clearly will be the heart of implementation strategies, efforts to reach out to high numbers of teachers in the initial years are likely only to dilute the message.

Prepare for a long journey. Short, teacher-focused sessions to unpack the NGSS, to align curriculum, or learn about instructional shifts are not needed initially. The writers of the NGSS learned from the CCSS-M experience and designed the NGSS with a full architecture intended to obviate the need for “unpacking” (NGSS Lead States, 2013). One-off workshops are a poor substitute for the deep ongoing learning that teachers and schools will need to fully understand the embedded nature of the three strands of disciplinary core ideas, practices and cross-cutting concepts in each performance expectation—Illinois would be better served by working with science education leaders initially to develop the strategies needed to ensure Illinois teachers have all the NGSS supports needed to be successful. A key element of those supports will likely be more guidance regarding the types of evidence that students need to be able to provide to fulfill the performance expectations that are part of NGSS (Pellegrino, 2013).

Focus on quality. Do not assume that all resources that are NGSS-related are of high quality. Illinois should work with other interested states to develop a careful process to gauge alignment to the NGSS.
RECOMMENDATION 3

Move Forward With The Next Generation Science Standards

of professional development offerings, instructional materials, and other resources, and then carefully monitor their enactment to assess effectiveness on student learning.

**Build a network of science support.** As mentioned for mathematics, there is an incredible wealth of knowledge and experience in science education in Illinois that is ready and waiting to be utilized by the state. Leveraging that expertise would make for better science education strategies and an easier time implementing them. The efforts led by the Illinois Pathway project would be a natural place to begin building such a network, as would the emerging Building Capacity for State Science Education work that that Illinois is participating in.

**Clarify instructional time for science, especially at the elementary grades.** Recommendations from ISBE about the amount of time per day or week to be spent on science at the elementary grades would be helpful. While data isn’t available in Illinois, efforts in other states show that generally science receives little attention in the lower grades (Dorph, Shields, Tiffany-Morales, & McCaffrey, 2011).

**Potential Pitfalls for NGSS Implementation**

**Assuming adoption is sufficient.** New standards are welcome—but only the beginning of the work. The much more difficult and important work is providing structures and supports that result in better instruction and better student learning. The *Hallmarks* paper (Jackson et al., 2013) will be useful to districts, schools and teachers when embarking upon the transition.

**Rushing ahead.** The state has its hands full with CCSS-M implementation and plenty of groundwork to lay before making big moves in science. Be slow and intentional about implementing the NGSS.

**Outreach to all teachers.** Teachers will be critical to the success of new science standards for Illinois. However, a “roadshow” that introduces teachers to the standards absent core instructional materials and professional development supports will not be effective. Focus instead on instructional leaders, as described above.

**Adopting without accountability, better measures, or adequate support.** Currently, many schools and districts do not pay much attention to science instruction as it is absent the accountability framework. It would be a mistake for the state to adopt new science standards without a plan for better science assessments and accountability provisions to accompany them.

**Create curriculum maps and frameworks.** Such efforts would certainly duplicate efforts in other states and regions, and are not especially helpful to teachers and schools regardless. Better to provide tools (adoption guidelines, recommended materials lists, coordinated professional development opportunities, etc.) that are of high quality, and the supports for schools and districts to use them well. Crosswalks, frameworks, and curriculum guides generally are not very helpful, for reasons described in *Getting Serious.*
Move Forward With The Next Generation Science Standards
RECOMMENDATION 4 Illinois Needs A STEM Education Plan And Mechanism To Manage It

WHY THIS IS NEEDED

There are several reasons why a statewide STEM plan is needed.

Bring coherence. There are many people and organizations interested in improving STEM education in Illinois, mostly working alone or on individual projects. We’re not serving teachers and students as efficiently or effectively as possible.

Provide a vision. There are clear and appropriate limits to the state’s authority around schools and schooling—rightfully LEAs make many of the decisions about how they educate their students. In many cases, the STEM education knowledge and experience within LEAs is limited, so a clear vision can help ensure local strategies and plans are as robust as possible. We know from work in Chicago that providing a clear and compelling vision about what STEM education means and how to get there can help many schools (Wenzel, 2010).

Bring research to practice. We know that a persistent challenge for state agencies is bridging the gap between research and practice. There is emerging evidence that by identifying shared problems of practice between researchers, other experts, and practitioners with the accompanying cultural and trust transfer leads to the sorts of sustained networks that foster more research-based practice (Goertz, Barnes, Massell, Fink, & Francis, 2013). By connecting state and district staff closely with external partners, and sustaining that connection over time, relationships and cultural connections can be made that enhance the transfer of knowledge and ideas in all directions.

BE SURE TO CONSIDER

The source of the charge matters. The call to action should come from the governor or state superintendent so stakeholders know there is relevance and interest at the highest levels.
WHAT THIS MEANS, WHAT SUCCESS LOOKS LIKE

A comprehensive plan would bring coherence in STEM education to a state with a number of stakeholders invested in STEM education. It would also let the state more ably manage resources to achieve better outcomes for students. An Illinois STEM Education Plan would:

- Describe goals and outcomes for STEM education in Illinois. Such goals might describe the level of performance—or rate of improvement—desired for students in STEM disciplines as well as other indicators (attitudes, enrollment) that are worthy benchmarks.
- Outline key strategies for reaching these goals and the resources/changes needed, all based on the unique context that Illinois provides.
- Define stakeholder roles and responsibilities for various aspects of the plan (namely, what parts ISBE is coordinating and what parts other players such as universities and informal science institutions should own).
- Make it a state-led effort and not a state education agency led effort. Empower a broad-based team such as Illinois utilized during its lead state participation, and engage representation and participation by key stakeholders of the NGSS.

 Involve the right people. The strategy should be developed in conjunction with the ISBE/IBHE personnel and appropriate educational and civic leaders. This adds gravitas and helps ensure the smartest solutions are developed. We would recommend tackling head-on the silos between curriculum and career and technical education throughout the state.

 Include support. Provide technical assistance and/or staff to the planning entity, so work can move forward. While we expect that many people would willingly donate their time to such an effort, having the resources to collect documents, synthesize research, and manage meetings will make for a better product. We suspect that seeking grant funding for such an effort would not be particularly challenging.

 Make the process transparent. The process of developing and executing a STEM education strategic plan should be as open as possible to best leverage existing work in the community. Set the expectation of periodic updates to constituents. The goal is strong communication to increase buy-in and support for the overall recommendations.

 Build on what is there already. There are many networks and resources—the math/science partnership community, university researchers, the Learning Exchange participants—who can and should be included in the plan’s development.

 Listen. There are lots of great ideas about how to improve STEM education in Illinois. As part of the STEM strategic plan work, be sure to do lots of listening.

 Iterate. Make the plan dynamic so it can change as new evidence emerges.
RECOMMENDATION 4

Illinois Needs A STEM Education Plan And Mechanism To Manage It

BE CAREFUL ABOUT

Over-compromising. Some discordance among stakeholders is a sign of a good strategy—there is no need to mollify constituents.

The “not invented here” mentality. A plan designed without partners or that assumes that Illinois is so unique that resources developed in other states or districts cannot be borrowed or utilized will not be very effective or efficient.

The fiscal reality Designing a plan that is unrealistic given likely resources is a mistake.

OTHER IMPORTANT CONSIDERATIONS

In the course of creating a STEM education strategy for the state, there are many aspects that can and should be included. A partial list follows below—all of which should be expanded and considered in more detail.

Early childhood and elementary school. The early years are critical for STEM teaching, learning, and leading. Yet they are often given low priority in discussions about STEM education. The PK-8 grades present a different and unique context for reform, so it should go without saying that imposing a high school model on the early grades would be ineffective.

Teacher credentials and licenses. There has been considerable work to define and articulate the role of K-5 STEM specialists in schools, and Illinois should consider including such configurations for teachers (Campbell, 2009).

STEM for school leaders. Regrettably, Illinois principals are not expected to know any mathematics and science. There is compelling evidence that schools organize and function differently for different subject areas (Spillane, 2005) and exploring mechanisms that shore up leaders’ capacity around STEM education would be welcome.

STEM schools. Many districts are creating or expanding “STEM schools,” which have disparate models and configurations. A network for these practitioners to learn from one another as they create these models would be very helpful.

Department of Education’s Math-Science Partnership. The U. S. Department of Education provides roughly $6M per year to Illinois for STEM programs (U. S. Department of Education, 2013) for the state to distribute to districts and partners. Aligned to an Illinois STEM education strategy, these resources can and should be used to target specific, strategic STEM education needs. Moreover, Illinois is a diverse state with a huge number of dissimilar district structures, and evaluation designs need to be flexible enough to be sensitive to the variety of contexts that we have here; one-size-fits-all metrics that will not be useful to the partners nor move our understanding of how to support districts, schools and teachers forward.
Illinois Needs A STEM Education Plan And Mechanism To Manage It

State Practices Worthy Of Attention

Illinois can learn much from efforts in other states. Massachusetts continues to perform well in mathematics and science, scoring well on international comparisons (U. S. Department of Education, 2012). It is likely that three connected components contributed to this: additional resources, particularly to urban schools; high standards; and well-designed high-stakes tests aligned to those standards. More significant is that these reforms were put in place 20 years ago, and by-and-large, the state has stayed the course since then (Chang, 2013).

A large-scale evaluation of the Alabama Math, Science, and Technology Initiative (AMSTI) shows quite promising results around student learning (Newman et al., 2012). The strategies employed by AMSTI are similar to those utilized by the Chicago Math & Science Initiative in the mid-to-late 2000s (Wenzel, 2010) and likely could be rebuilt into statewide strategies.

Several other states give STEM education much more political attention and support than Illinois does. In Washington state, HB 1872 was signed by the Governor to establish “...a comprehensive initiative to increase learning opportunities and improve educational outcomes in science, technology, engineering, and mathematics through multiple strategies and statewide partnerships” (63rd Washington State Legislature, 2013). In California, the state superintendent of public instruction has created a “STEM Task Force” to consider and advise on curriculum, resources, professional learning, assessment, and business partnerships with a wide array of stakeholders (California Department Of Education, 2013).
References


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