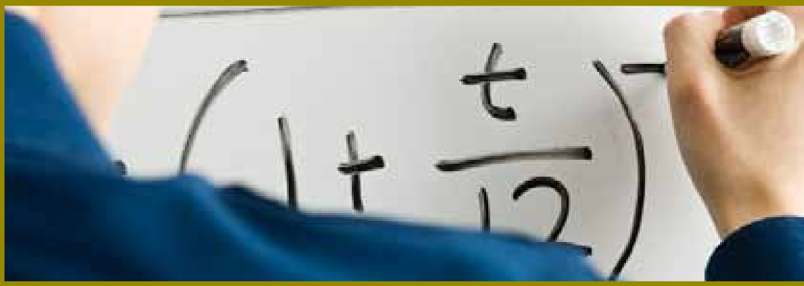
SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS (STEM)

CATALYZING CHANGE AMID THE CONFUSION



CENTER ON INSTRUCTION

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CATALYZING CHANGE AMID THE CONFUSION

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CENTER ON INSTRUCTION

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INTRODUCTION

Over the past eight years or so, educators have struggled to make sense of the many views and definitions of science, technology, engineering, and mathematics (STEM) education and what constitutes quality in STEM practices. The multitude of recent STEM funding opportunities has done little to create a common understanding about how to best engage students, schools, districts, and states in STEM education. This document offers an overview of the role of STEM in current educational improvement efforts. It offers a brief history of STEM initiatives and publications and attempts to capture important trends and dispel confusion over the goals and approaches of STEM initiatives. We also present several important considerations for state and district educators developing STEM programs that serve the needs of their students. We do not advocate for one STEM approach, but provide some thinking tools and rationale for states and districts to compare and contrast the available STEM approaches.

> *We describe important trends and dispel confusion over the goals and approaches of STEM initiatives.*

Economic issues have led to a focus on STEM

The publication of the report *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (National Research Council 2007) established the critical importance of science, technology, engineering, and mathematics education to the economic well-being and quality of life in America. The ensuing wave of invocations and calls to action resulted in the development of many new STEM education initiatives. A consensus has emerged that for the U.S. to be successful in an increasingly global marketplace, all its people should possess a working understanding of STEM content, and we must increase the number of people who pursue higher degrees in STEM disciplines and enter STEM-based careers. We recognize that the quality of modern life depends on innovation and development in the STEM disciplines. As a result, the national conversation about our education system now emphasizes science, technology, engineering, and mathematics as integral parts of current educational improvement efforts and funding streams.

What content should STEM instruction include?

Perhaps for the first time since the launch of Sputnik, educators broadly agree on the value of STEM education for ensuring America's edge in the global economy. Yet teachers, administrators, and policy-makers find themselves confused about what it means to successfully implement STEM programs and initiatives. A recent study (Brown, et. al, 2011) found that fewer than half of the school administrators surveyed could adequately describe the concept of STEM, even though they supervised teachers who were obtaining Master's degrees in STEM education. Even more telling, while a majority of teachers and administrators in the study agreed that STEM education is important, they varied widely in their ideas of what it means to implement a STEM-based educational program.

While most educators believe that students can benefit from increased study of science and technology, they are less sure about which fields of science and what kind of technological understandings should be required for students to be STEM literate. The National Science Foundation proposes that the sciences of psychology, economics, sociology, and political science should be included in the STEM definition (Green, 2007 cited in Chen, 2009). However, the National Research Council of the National Academy of Sciences stated emphatically that the social sciences are not part of the *Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012)* and will not be included in the resulting *Next Generation Science Standards*. Even the definition of technology varies, ranging from using technology to solve problems and increase understanding of the natural world to learning about computer programming and information technology. Choices about the fields of science and technology to include result in very different approaches to incorporating STEM content into K–12 instruction.

Educators are less sure about which fields of science and concepts of technology should be required for students to be STEM literate.

What should be the goals of STEM instruction?

STEM programs have focused largely on two distinct goals: preparing a science-literate public and developing a STEM-savvy work force. Of course, the two goals overlap and are closely linked and some programs claim to address both. However, emphasis on one goal over the other has led to many divergent approaches. STEM approaches can range from strategies for extending student learning in each of the STEM content areas (addressing literacy goals), to providing specific training for STEM-related careers (addressing STEM workforce development), to creating a fully integrated STEM education program (which serves both goals). Conflicting definitions of STEM are often created *ad hoc* to the preferred STEM goal. For example, some refer to STEM as a collection of related disciplines while others highlight the overlap between STEM content areas. This disparity has created a seemingly chaotic situation, and the lack of an adequate research base further complicates the establishment of best practices related to either of these two main STEM goals.

Unpacking common STEM definitions

A review of the different definitions of STEM can inform the development of a rationale for choosing one STEM methodology over another.

In 2008, the State Educational Technology Directors Association's (SEDTA) *Science, Technology, Engineering, and Math (STEM)* report put forth this definition:

> "STEM refers to the areas of science, technology, engineering, and mathematics. STEM initiatives started as a way to promote education in these related areas so that students would be prepared to study STEM fields in college and pursue STEM-related careers. Schools with a strong emphasis on STEM education often integrate science, technology, engineering, and mathematics into the entire curriculum."

The driving idea in this definition seems to be that important connections can be made between STEM and core subject areas (such as language arts, mathematics, and social studies) to help prepare students for advanced study and STEM careers. SEDTA primarily defines STEM as a group of related content areas, not unlike how some view the humanities as a collection of disciplines important to pursuing a liberal arts education.

One view of STEM shared by several large-scale STEM collaboratives focuses on exposing students to authentic experiences and applying rigorous content to solving real world problems:

> "STEM education is 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 the ability to compete in the new economy." (Tspuros, 2009 cited in Gerlach, 2012)

Similarly, Merrill (2009) proposed this perspective:

> "STEM teaching and learning focuses on authentic content and problems, using hands-on, technological tools, equipment, and procedures in innovative ways to help solve human wants and needs."

Industry and state departments of education generally echo these views of STEM. They agree that a key purpose of STEM is to prepare students for the 21st century workforce, to keep the economy healthy and to keep the U.S. competitive.

Another view published in an article titled *Understanding STEM: Current Perceptions* found in Technology and Engineering Teacher (Brown, et al., 2011) defines STEM this way:

> "a standards-based, meta-discipline residing at the school level where all teachers, especially science, technology, engineering, and mathematics (STEM) teachers, teach an integrated approach to teaching and learning, where discipline-specific content is not divided, but addressed and treated as one dynamic, fluid study."

These and similar documents reflect the emerging view that STEM can be an important way to bridge related disciplines, while providing essential cognitive building blocks and developing problem-solving skills. This evolving consideration of STEM as a "meta-discipline" that surpasses and provides added value to individual content areas has important implications for the development of instructional materials, curricula and the program elements needed to support large-scale STEM initiatives. A fully integrated STEM education program that combines individual content areas into a single course or courses would require extensive, wide collaboration and expertise across disciplines and the creation of innovative instructional materials and teaching strategies.

Thinking of STEM instruction as a separate course or courses in addition to the standard instruction in the disciplines has the advantage of maintaining the curricular integrity of subject areas like math and science. The mathematics education community has just begun to develop a common vision of the role of mathematics content in STEM, and many already agree that important content-specific instruction should not be sacrificed in order to reach STEM-specific education goals.

Examples of STEM education programs

Given the many views about the definition, benefits, and goals of STEM programs, it is not surprising that diverse methodologies exist for introducing these elements into educational systems. Here we examine some examples of programs that implement innovations for instruction and learning throughout the K–16 STEM pipeline.

Many current STEM programs focus on the secondary level. The North Carolina New Schools Project is redesigning one hundred secondary schools so that every student graduates "ready for college, a career, and life." Thirty-four of those schools have a specific goal of immersing high school students in the STEM disciplines through technology, design, and inquiry. These experiences include project-based learning, internships with STEM professionals, summer STEM study programs, extracurricular activities, and virtual experiences related to STEM. The New Schools project defines STEM education as the integration of science, technology, engineering, and math with instruction that engages students in projects, real-life issues, and collaborations. New Schools aims explicitly to teach students how to approach everyday life with analytical thinking skills and enthusiasm for learning.

These programs view STEM-focused high schools as the best route to generating students' STEM interests and preparing them for careers in these disciplines. STEM high schools often target students with outstanding STEM talents or students who come from groups underrepresented in the STEM fields. STEM schools devote more time, resources, and teacher preparation to deliver a rigorous curriculum to highly motivated students. Although they may produce the intended results, STEM programs from these schools are not easily disseminated on a broader scale because they tend to draw from select student populations, are highly resourced, and are often excused from state testing requirements.

Several networks have sprung up to connect people with regional resources to support their STEM education efforts. One statewide example, the Missouri Mathematics and Science Coalition (METS Coalition), represents an alliance of business, education, government, and community leaders. The METS Coalition strives to advance Missouri students into STEM careers, increase students' STEM performance, and build statewide awareness and support for STEM education. Some of the coalition's strategies include reviewing Missouri's mathematics and science curricula, developing a technology plan for all schools in the state, providing incentives to recruit and retain high quality STEM educators, and expanding the number of Missouri students interested in STEM careers. This network, sponsored by local industry, clearly focuses on workforce preparation.

> *Some view STEM-focused high schools as the best route to generating students' STEM interests and preparing them for careers in these disciplines.*

Another statewide initiative, The Ohio STEM Learning Network (OSLN), created in 2007, provides $200 million in funding for public and private STEM initiatives for Pre-K–16 education in Ohio. The network comprises education, business, and philanthropic partners who share best practices and innovative ideas. The initiative creates STEM schools and "hubs" to increase the number of undergraduates in STEM disciplines and the supply of STEM researchers in higher education and to improve professional development for STEM teachers, with a vision of universal STEM literacy. OSLN defines STEM education in a broad manner, describing it as "trans-disciplinary," beyond science, technology, engineering, and math, to encompass connections of these disciplines to the arts and humanities through approaches to problem-solving.

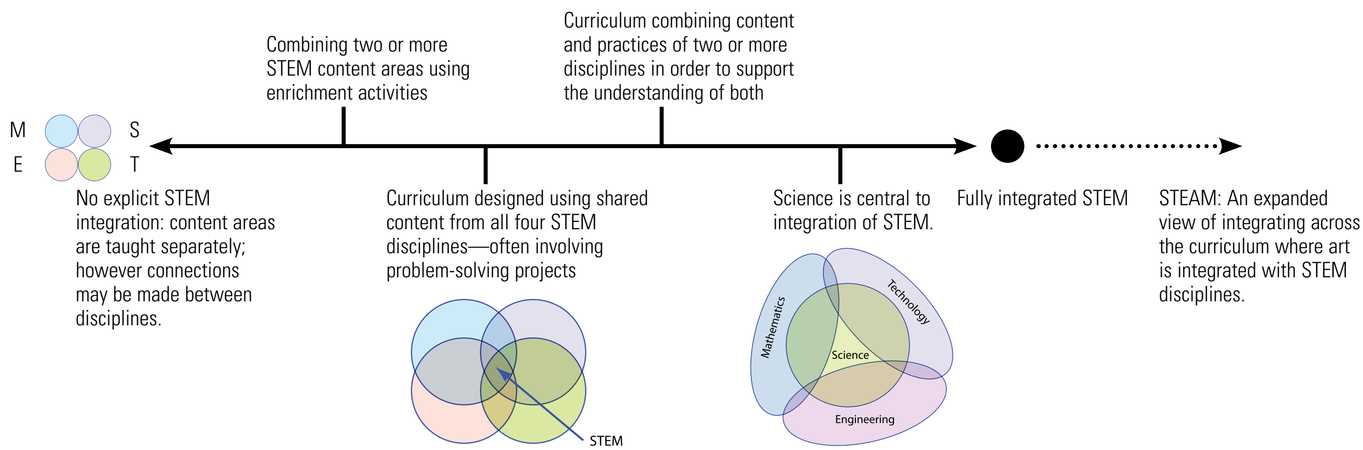
Project-based learning in STEM has earned some prominence because of its interdisciplinary nature and its integration of scientific understanding, engineering design skills, and technological and mathematical tools. Proponents believe that the problem-solving context helps to deepen students' understanding of all four subjects and actively engages them in the essential practices of STEM fields. Projects can involve designing tools for specific purposes, addressing environmental issues, solving societal problems, or collecting data to further scientific understanding.

In the project-based Journey North, an Annenberg Foundation-funded initiative, students track the migratory patterns and seasonal changes of the monarch butterfly. More than 890,000 students participate in field observations outside their classrooms, listen to scientists talk about science content, and collect and enter data into an Internet-based data system on the project website. Background lessons and challenge questions support STEM content learning, critical thinking, questioning, and reasoning skills. Teachers may incorporate additional interdisciplinary learning through the mapping of the migration patterns and learning about different geographic regions, people, and cultures.

Educators often ask whether teaching the STEM subjects separately constitutes a valid method of STEM instruction, or if the subjects should be partially or fully integrated among themselves (or across other subject areas). While many businesses and state departments of education believe that STEM education means project-based learning that integrates all four disciplines, other science agencies and tier one research universities have a different definition. The National Research Council of the National Academies of Science, the National Science Foundation, NASA, and the National Oceanic and Atmospheric Administration often simply cluster their programs that fund or conduct education in science, technology, engineering, or mathematics and call them STEM. Similarly, many scientists, educators, and educational researchers think of STEM education as a collection of four related disciplines that can be, often are, but do not need to be taught as an integrated curriculum. They hold that the main goal of STEM is to create a broadly science-literate public capable of using their understanding of the natural world and the practices of science and engineering to make decisions, solve problems, and improve the quality of their lives.

We find ourselves with an elaborate continuum of well-reasoned approaches to STEM education that range from enhancing and expanding existing STEM content instruction to implementing a fully integrated STEM curriculum that emphasizes the connections among all four disciplines (see Figure 1). The choices made by educators can have a tremendous impact on the effectiveness of STEM education programs. For example, it can be much easier to add science/technology or math/engineering enrichment activities to an existing curriculum than to create new STEM-integrated courses or curriculum.

Figure 1: Approaches to STEM education



Educators find themselves considering these critical questions:

- How do schools and districts make strategic decisions about designing STEM education programs while considering the different approaches along the STEM continuum?
- Which methods and approaches to STEM are the most effective for their particular goals?

NRC framework and Next Generation Science Standards support STEM

Fortunately, significant recent contributions have established a clearer picture about the methodologies and the rationales behind the widespread implementation of STEM instruction. In 2012 the National Research Council released *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* to guide the development of the *Next Generation Science Standards (NGSS).* Currently, 26 lead states have signed on to participate in their development and 40 states are preparing to incorporate the new standards into their science programs. Written by scientists, educators, and cognitive scientists, the framework describes 15 years of learning about how students learn complex science concepts. The framework organizes science into three dimensions: (1) Scientific and Engineering Practices, (2) Crosscutting Concepts, and (3) Disciplinary Core Ideas. The Scientific and Engineering Practices capture what scientists and engineers do, while Crosscutting Concepts convey the ways in which scientists and engineers view the world (e.g., patterns, cause and effect). Disciplinary Core Ideas represent traditionally held science content understandings. The vision for science literacy presented in the framework involves exposing students repeatedly to all three of these dimensions in an integrated fashion. The framework focuses on significantly fewer big ideas that students should understand by the end of grade 12. It arranges concepts as developmentally sound progressions of learning that lead to understanding of those few big ideas.

The NRC framework rarely uses the term "STEM," and intentionally includes engineering and technology as important applications of science. To this end, engineering, technology, and the applications of science become one of the four Disciplinary Core Ideas, equivalent to life sciences, physical sciences, and earth and space sciences. Aspects of mathematical thinking are also included as part of the Scientific and Engineering Practices. The following statement from the framework makes it clear that STEM, while not named as such, occupies a central place in guiding the eventual development of the national science standards:

The NRC framework stresses active student participation in the practices of science and engineering that will prepare them for working and living in the modern world.

> "The overarching goal of our framework for K–12 science education is to ensure that by the end of 12th grade, *all* students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology." (p. 1).

The framework stresses the idea that all students should participate actively in the practices of science and engineering to prepare them for working and living in the modern world. This engagement in practices serves two purposes: to deepen their understanding of science content and to expose them to how these ideas are generated and ultimately ratified by the scientific community. The framework familiarizes students with the science actually being practiced in the 21st century—fields such as climate science and biophysics, which tend to blur the boundaries of the STEM disciplines.

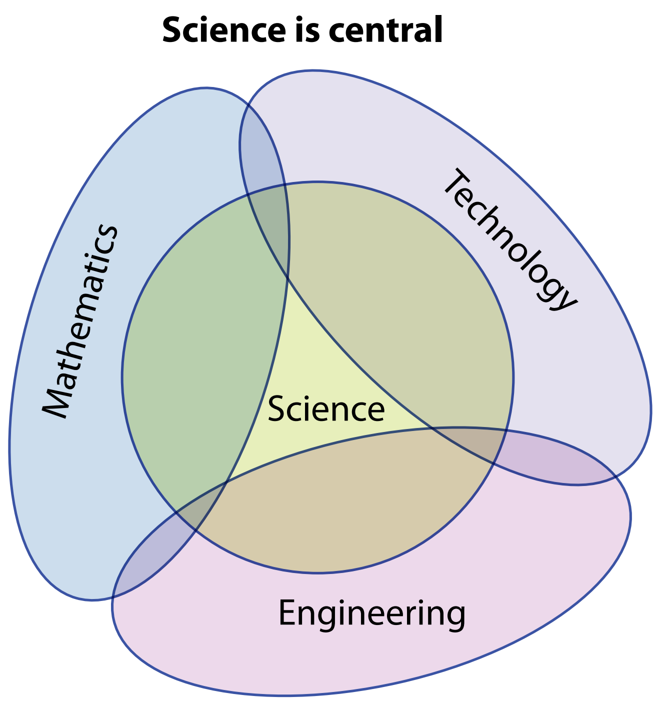
The Scales Technology Academy in the Tempe, AZ school district follows the practice of blending knowledge and 21st century learning skills into a unified approach to teaching and learning. Three of every four Scales students receive free and reduced-price lunches and are from low-income families with limited or no access to technology outside of school. Students from kindergarten through fifth grade receive a laptop and work with interactive whiteboards, document cameras, and other technological tools. They learn to infuse technology into every subject and to use technology as a means for meeting the differentiated instruction requirements of the Arizona state standards.

While the document *Standards for K–12 Engineering Education?* (National Research Council, 2010) cites the lack of broad agreement about the core ideas of engineering, consensus exists that the process of design offers many opportunities for students to apply scientific knowledge in the classroom and engage in engineering practices; this is already a focus of many K–12 engineering curricula. For this reason, the framework delineates the following core ideas for teaching in this content area:

- *Engineering Design:* defining and delimiting an engineering problem; developing possible solutions; and optimizing the design solution.
- *Links among Engineering, Technology, Science, and Society:* interdependence of science, engineering and technology; and influence of engineering, technology, and science on society and the natural world.

Authors of the framework assert that the *Next Generation Science Standards* should strive to strengthen K–12 science education and not to replace existing curricula in engineering and technology (or in mathematics, for that matter). The integration approach (as advocated by the NRC) emphasizes the connections among disciplines that can strengthen basic understandings of science as a powerful means of explaining the natural world (see Figure 2). The framework also touts the value of expertly weaving together science, engineering, and mathematics practices along with important cross-cutting concepts and core ideas of science. The document emphasizes that this task will be challenging at best, and there is no one way to achieve a coordinated curriculum.

Figure 2: A perspective on STEM integration based on the NRC Framework for K–12 Science Education



National Governors Association advocates for using STEM approaches

The National Governors Association (NGA) report *Building a Science, Technology, Engineering, and Math Agenda: An Update of State Actions* (Thomasian, 2011) provides further insight into states' efforts to integrate STEM into their curricula. The report reiterates the two main STEM goals put forth by other organizations: (a) to expand the number of students who enter postsecondary study and pursue careers in science, technology, engineering, and mathematics, and (b) to boost the proficiency of all students in basic STEM knowledge. The second goal reflects a pragmatic purpose to improve students' ability to assess problems, use STEM concepts, and apply creative solutions in everyday life. The strong emphasis on the application of knowledge underscores the philosophy of using STEM knowledge in the pursuit of work in the STEM disciplines, as well as in non-STEM fields. NGA identifies several transferable skills students can gain from STEM study:

- using critical thinking to recognize a problem;
- using math, science, technology, and engineering concepts to evaluate a problem; and
- correctly identifying the steps needed to solve a problem (even if not all the knowledge to complete all steps is present).

NGA (Thomasian, 2011) notes that most aspects of the STEM agenda align directly with current educational improvement efforts. For example, the skills stated above are not unlike the student outcomes in *Framework for 21st Century Learning* published by the Partnership for 21st Century Skills (2011). This document has formed the basis of several state STEM initiatives such as Arizona's STEM Education Center. Not surprisingly, *Framework for 21st Century Learning* also posits critical thinking, problem-solving, creativity, communication, and collaboration as essential skills in the modern workplace. The Common Core State Standards Initiative also endeavors to better prepare students for advanced educational opportunities and future careers through the nationwide implementation of rigorous academic standards.

For these reasons, NGA urges states to adopt the improved K–12 science (NGSS) and math (CCSS) standards and use associated assessments that test deeper knowledge and the application of concepts. To prepare students to meet these standards, NGA recommends adopting STEM programs that develop the "ability to understand and use STEM facts, principles, and techniques." (p.12).

Developing effective STEM approaches

States, districts, and schools must consider a key question when developing STEM education programs: which methods and approaches to STEM are the most effective and the most feasible, given the general lack of resources for education? We would suggest a second question for consideration: For which students and under what conditions? Responding to the need for better data on STEM efforts, the Committee on Highly Successful Schools and Programs for K–12 STEM Education has been charged with "outlining criteria for identifying effective STEM schools and programs and identifying which of those criteria could be addressed with available data and research…" The resulting report, *Successful K–12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics* (National Research Council, 2011), offers useful information for those considering these questions.

Successful K–12 STEM Education found that available student outcome data, such as test scores and graduation rates, do not offer useful criteria for measuring the success of STEM programs.[1] Researchers find it difficult, if not impossible, to disentangle the effects of the school from characteristics of the students themselves. Although many educators use test scores to determine students' preparation for post-secondary study, these tests do not necessarily measure the skills and dispositions required to pursue and succeed in a STEM career or to be STEM literate. We have little data linking instructional practices and school cultural/organizational conditions to student performance.

> ***Successful instruction capitalizes on students' early interest and experiences, builds on what they know, and gives them experience in the practices of science and math.***

The report found that the most promising path to generating students' interest and understanding in STEM disciplines is the implementation of research-based, highly effective instructional approaches in science and mathematics. The existing research on cognitive studies in science and mathematics education tells us that successful instruction capitalizes on students' early interest and experiences, identifies and builds on what they know, and provides them with experiences in the practices of science and math. Similarly, *Building a Science, Technology, Engineering, and Math Agenda: An Update of State Actions* (Thomasian, 2011) cites doing hands-on activities, writing long answers on tests and assignments, discussing results and analyzing data from investigations, and working with others as key instructional practices and experiences that support student achievement in science.

As mentioned before, most STEM advocates argue that student-centered, experiential learning facilitates a deeper understanding of core STEM ideas and concepts shared across those disciplines. They also believe that teachers must

1 Because most of the research and data concerning STEM is related to math and science education, this report focuses primarily on these disciplines in their analysis.

help students connect core ideas in STEM with real world applications practiced in STEM careers. We can reasonably conclude that a STEM-literate student population depends on renewing and re-energizing a commitment to these highly effective educational practices and supporting teachers in their use.

Potential barriers

Prevailing conditions in states, districts, and schools have resulted in a lack of equity for students and quality of instruction in STEM programs. Uncertainty and lack of guidance about how particular STEM practices can meet student needs have created disorganization, incoherence, and reluctance to address the issue at all. Recruiting and retaining STEM-qualified teachers has become difficult because other STEM professions pay higher salaries. Even those with degrees in STEM disciplines who are willing to accept lower salaries often find it difficult or prohibitively time consuming to become certified to teach. And the overriding systemic focus on reading and writing has reduced funding and the commitment of instructional time for STEM programs, especially in low performing schools.

This unintended outcome of policies and legislation such as No Child Left Behind has disproportionately denied under-represented and low-income students access to science, exacerbating the very problem that the legislation set out to remedy. In numerous low-performing schools, African American, Latino, and Native American students; English language learners; and students from low income families have been categorically left behind when it comes to science. Moreover, retention and graduation of African-American, Latino, and Native American students in the life science majors continues to be low. Between freshman and senior years of college, 40 percent of science, math, and engineering majors drop out of these programs, mostly within the first two years (Seymour, 2001). The biological sciences in particular lose students at a rate of 50 percent compared to 20 percent for physics and 40 percent for engineering. Male students continue to enroll in mathematics and science majors at higher rates than female students. Seymour and Hewitt (1997) report that students of

A shift in culture that requires a new type of capacity and infrastructure in school leadership seems critical.

color leave the science or math majors at a rate of 65 percent (compared to 37 percent of White students) with half of this population switching to another major and half dropping out altogether. Astin and Astin (1993) report that two thirds of Latinos leave their science, mathematics, and engineering majors.

These issues demonstrate the need for increased systemic support for schools, districts, and communities to implement effective STEM education programs. Support must include, as always, high quality professional development and excellent instructional materials. But a shift in culture about the status quo in STEM education also seems critical—a shift that requires a new type of capacity and infrastructure in school leadership. Administrators and policy-makers must consider STEM content to be just as important as reading and math skills. Our education system must move forward to support the instructional practices we now know are effective for all learners, and especially for deepening the understanding of science, technology, engineering, and mathematics.

The University of Texas's UTeach program exemplifies a systemic effort designed to support STEM teaching and learning. A postsecondary program, UTeach works to increase the pool of qualified and certified STEM teachers by helping undergraduate students develop deep content knowledge in a STEM area while developing their knowledge of research-based teaching strategies. Students earn their undergraduate degrees while completing their teaching certification. These future teachers complete a paid internship in a neighboring school, where they use their newly acquired STEM instruction methods. Ninety percent of UTeach students begin their teaching careers immediately after graduation, 85 percent remain in the profession for at least five years, and 45 percent teach in underserved schools. Due to its resounding success, UTeach has been replicated nationally in 22 universities.

Aligning goals with appropriate STEM approaches

Many more examples of STEM-oriented programs and state initiatives exist and demonstrate what is possible for our national STEM agenda. Each program, no matter its place on the continuum of approaches to STEM, needs an explicitly stated goal and specific strategies for achieving that goal.

For example, STEM networks intend to look broadly across a state landscape to build infrastructure and raise opportunities for the advancement of STEM education programs. Project-based learning curricula focused on team-oriented engineering challenges and contests are well-suited to prepare students to enter the workforce in STEM-related careers. Courses and curricula with high quality, well-rounded science and mathematics instruction prepare students to pursue advanced degrees and/or to contribute as STEM-literate members of society. STEM-focused schools are designed for the purpose of achieving access, engagement, and performance for a particular population of students. STEM teacher education programs are designed for increasing the quantity and quality of a future workforce of STEM teachers.

Effective STEM programs require clear goals at the state and district levels before starting a new initiative or pathway. Staff and student needs must be thoroughly considered, as should the expertise and infrastructure available to support new systemic STEM efforts. Whatever their specific goals, STEM programs must give 21st century students the ability to apply knowledge to solve problems in the real world using an understanding of science, engineering, technology, and mathematics. The ultimate goal should be to nurture students as critical thinkers and effective problem solvers who lead fulfilling lives.

Finally, a messaging and marketing campaign that changes school culture and raises the prominence of STEM must be in place. Parents and community members should see that science, technology, engineering, and mathematics matter for our students, and adjust curricular expectations accordingly. Science and technology can no longer be perceived as mere enrichment, second in value to language arts and mathematics. Many schools have already learned the hard lesson that "literacy" encompasses more than developing reading and writing skills, and engaging in literary analysis. Content reading and writing skills, as well as evaluating evidence from non-fiction texts, now appear in the Common Core State Standards for English Language Arts. STEM education gives students access to disciplinary literacy skills—skills essential to reading and writing STEM content—and that are essential to a productive life in this century.

Essential questions for an essential discussion

Here are some suggested questions for shaping a conversation about STEM education in your school, district, or state.

- Is there an agreed-upon definition of STEM education for the stakeholders? If so, what is it?
- Is there an agreed-upon goal for STEM in your context? If so, what is it?
- What are the teaching approaches and instructional strategies used in the adopted math and/or science program? How do they align with research-based practices?
- For which students and under what conditions is the STEM approach you've chosen the most appropriate?
- To what extent are technology and the applications of science addressed?
- To what extent are the practices or content of engineering addressed?
- Are any of the four STEM disciplines integrated in instruction or the curriculum?
- What STEM resources are available that could help you design STEM programs (e.g., business partners, scientists, universities, curricula)?
- What are the gaps in staff expertise for STEM? What professional development is needed?
- What types of assessments would be needed to measure student achievement in STEM, as opposed to measuring just science and mathematics?
- What policies are in place related to STEM education? What types of policies need to be developed to support STEM efforts?
- To what degree are parents and community committed to improving STEM education in your region?

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