Briefing Paper on STEM Education in Maine

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Introduction

The state of Maine has significant resources devoted to educational programs in science, technology, engineering, and mathematics (STEM). The state’s abundant natural resources and access to solar and off-shore energy, ocean resources, and bio-fuels have spurred the development of a number of projects and institutes to promote science, technology, engineering, and mathematics research and education. The Maine Office of Innovation has identified seven STEM occupational clusters within the Maine economy that hold great promise for development and jobs of the future. These clusters are biotechnology, composites, environmental technology, forest products and agriculture, information technology, marine technology, and precision manufacturing.

It is estimated that in the next decade one in seven new Maine jobs will be in STEM-related areas, and these jobs will produce wages that are 58 percent higher than wages for other occupations in Maine. Across the state a number of institutes and programs have been funded and developed to enhance research, development, and education in STEM areas. Those involved in workforce development and planning for the future are concerned about the ability of Maine students to assume these jobs of the future. In subjects that are essential to STEM careers, such as science and mathematics, Maine students show a decrease in their mastery and course taking from middle school through high school. In 2009, only 53 percent of Maine 8th grade students met the standard in mathematics, which may account for the high mathematics remediation rate of well over 50 percent for incoming university and community college freshmen.

More ominous for the state’s future economic viability is the fact that only about 34 percent of current 9th grade students are expected to enroll in and graduate from a community college or university program in 2006. On the Achieve Pipeline Career and College Readiness Profile, the state scored below the national average of top states in the percentage of 8th graders taking algebra and in students scoring a 3 or above on College Board AP examinations. From 2004 to 2006, Maine students were well below the national average in the number of high school graduates enrolling in college who obtained a degree in three to six years.

The Study

Addressing the issue of preparedness of Maine students for jobs in STEM areas has been a concern of the legislature, the Maine Department of Education, the Office of the Governor, and a number of business and research institutes across the state. In the spring of 2010, policy researchers from Education Development Center, Inc. (EDC) were asked by members of the Maine STEM Collaborative Steering Committee to develop a briefing paper on the status of science, technology, engineering, and mathematics programs in Maine. Three members of the Collaborative’s Steering Committee (Anita Bernhardt of the Department of Education, Jan Mokros of the Maine Mathematics and Science Alliance, and Vicki Nemeth of Maine EPSCoR) provided important information for the report.

The study had as its basis a review of research on school improvement in several states, with an emphasis on local control states. This research had been documented in three previous studies by EDC and a recent review of national studies and STEM proposals in Race to the Top grants. The second part of the study consisted of 29 interviews with Maine policymakers and important players in the area of STEM education. The interview questions focused on both STEM initiatives and the state’s educational improvement system.
An important factor identified in EDC’s previous research indicates that STEM initiatives must be part of a state systemic improvement system, and cannot be accomplished on their own. We developed an interview protocol that first asked respondents to tell us their opinions of the status of STEM education in Maine, emphasizing both the assets and obstacles to improvement. Many mentioned the state systemic issues that have affected general education improvement. We focused those discussions and questions on the following major factors that our funders had identified: (1) state coordination and leadership, (2) Maine Department of Education capacity and state funding, (3) local school and district capacity, and (4) alignment of the K–16 system. The interviews yielded a number of major themes that we have addressed in our findings.

The study was qualitative in nature. Responses of the interviewees were transcribed and important themes documented. Local, state, nonprofit, and business sectors were represented. Because Maine is a small state, most respondents were familiar with state and local issues and were able to speak about systemic issues and strategies important to STEM and general education improvement. If they were unaware of systemic issues, they were encouraged to describe their own STEM initiatives. The limitations of the study include the subjective nature of the interviewing process, the small number of persons interviewed, note transcription, and theme extraction. Wherever possible, we have cited national or other research studies to support our findings.

Although several interviewees represented local educational agencies and were forthcoming about their efforts and plans, the study did not track or study in depth the variety of STEM curricula and instructional approaches, or local partnership programs being developed between high schools and community colleges, or K-12 schools and non-profit organizations, STEM-related institutions, or institutions of higher education. These would be useful to describe and if these programs are successful in improving student outcomes, they could become part of a curricular data base or resource network. And although several schools and non-profit groups have developed curricula, it was not possible for us to identify the extent to which these curricula are standards based or represent best practices in research and design.

National Efforts to Improve STEM Education

Several state departments of education have been working with Achieve, Inc., and the National Governor’s Association for the past several years to ensure that their public school curricula and instruction are preparing students for the 21st century. Of particular concern has been the performance of U.S. students in the area of mathematics, science, technology and engineering. In mathematics, many students enter college with insufficient preparation and must spend time taking general studies courses or remedial courses before they can move on to the regular course of study. This results in heavy costs for students and the state in tuition grants, fees, and time.

At the national level, it is expected that the demand for employees to fill STEM-related jobs will grow by 22 percent in the next four years. As will be true in Maine, these jobs will be higher paying than traditional manufacturing jobs; therefore, some states are pursuing strategies that focus on a strong coordinated effort to ensure that STEM programs are rigorous and integrated into all improvement efforts, and that students are arriving at college with the skills needed to succeed in the coursework. By early 2010, 21 other states had defined high school requirements as those skills and knowledge that students will need to succeed in the first year of college. These skills were most often represented by rigorous courses and end-of-course tests.
In a review of state initiatives to improve STEM education conducted by EDC (2008), states had defined two major factors as instrumental to improvement efforts: (1) instructional quality, which includes teacher quality, research-based curricula and instruction, and research-based professional development; and (2) alignment and coherence in the curriculum across the P-16 system. The successful strategies that states employed in the area of alignment to support improvement varied, but included the formation of a P-16 Leadership Council, the establishment of rigorous graduation and course requirements, and the development of graduation tests or end-of-course assessments that measure career and college readiness. More than 40 states operate some form of P-16 Council.

In the area of instructional quality, states emphasized teacher preparation and professional development, with strategies that included redesigning teacher preparation programs to include more STEM content, providing incentive programs for students interested in STEM subjects to also pursue undergraduate teaching degrees, and instituting guidelines for curriculum and instruction to ensure quality across the state.

A summary of the major state educational improvement strategies that other local-control states have employed and that were identified in EDC’s 2008 study are listed below.

**Instructional Quality**
- Teacher preparation and licensure upgrades in STEM.
- Teacher incentives for science teaching, especially in hard-to-staff schools.
- Guidelines for professional development that stress research-based practices.
- Regional professional development collaboratives or STEM resource banks.

**Alignment**
- P–16 Council-coordinated state leadership.
- College and career readiness defined with rigorous standards in STEM.
- Proficiency college and career readiness assessments in STEM subjects.
- High school redesign with early-college/dual-enrollment/STEM high schools. (Early college high schools provide high school and community college courses in a five-year program leading to an associate’s degree or 24 hours of college credit. Dual enrollment schools permit high school students to take courses for college credit while in high school.)
- Special attention to early career planning and transition supports to college and careers.
- A comprehensive preK–20 data system.
- Career and technical education alignment and rigor.

During the past year, STEM education programs have received national and state attention and focus. Each state’s Race to the Top plan contained requirements to address STEM education as an integrated part of an overall state plan. States responded with a number of strategies that were supported by research and experience. Proposal writers and policymakers saw early on that the STEM proposals had to be integrated into the whole-state improvement plan. As one RTTT educator stated, “We made it very clear that STEM was not stand alone...that it was very much integrated across the state’s efforts to improve education.” Another successful RTTT state superintendent stated, “What we saw was that we had lots of STEM education initiatives happening in different parts of the state, but none of them were
connected in a way that we thought would make them more powerful collectively.\textsuperscript{15} The proposals had to show an alignment of STEM initiatives that were integrated with all state improvement efforts.

Initiatives in the proposals include a variety of programs to inspire and educate students and teachers. The examples below are from states whose Race to the Top proposals were funded. The common denominator among these states is that each has a strong Department of Education and has formed partnerships with state colleges and universities and other agencies to implement a variety of STEM improvement strategies. These strategies were well along in their development prior to the grant application process.

**New York.** The New York proposal contains plans to implement the common core standards, revise and improve science standards, and work on curriculum alignment. Also proposed are enhanced strategies to recruit and retain talented STEM teachers, to employ incentives for teachers in hard-to-staff schools, and to improve professional development systems.

**Massachusetts.** The Massachusetts plan builds on work that has already been accomplished, including high standards and performance in STEM areas, including engineering, and rigorous requirements in math for elementary teachers. The state has established a P-16 STEM Council with representation from higher education and business. New efforts will include plans to recruit highly skilled STEM teachers, implementation of the MassCore curriculum, and the establishment of six early college STEM high schools.

**Rhode Island.** In 2005 Rhode Island established the Blue Ribbon Panel on Science and Math Education which sought to improve teacher quality and curriculum and instruction in STEM areas. The state has partnered with the University of Texas Dana Center to provide professional development for teachers and has established the Rhode Island Center for Excellence in Technology at Rhode Island College. Rhode Island plans to establish high schools that focus on natural resources, oceanography, and technology and is partnering with the university system in many STEM efforts.

**North Carolina.** The state requires all high school students to complete a “future ready” curriculum that includes four years of mathematics, three years of a laboratory science, and a mastery of computer skills. The state currently has 112 career academies in STEM areas and 60 pre-engineering programs. New, more-rigorous standards in STEM areas are being implemented. The state has two major collaboratives of business and STEM supporters working with the Office of the Governor.\textsuperscript{16}

In September of this year, the President’s Council of Advisors on Science and Technology (PCAST) issued a report\textsuperscript{17} that placed STEM education as a priority for policy attention and funding by the administration. The report stressed the importance of encouraging talented students to take more rigorous STEM courses and to recruit and train talented STEM teachers for middle and high school grades. The report seeks to spur the development of 200 high schools and 800 elementary and middle schools with a STEM focus.

**Maine’s School Improvement Efforts**

Maine has had a decade of mixed results in efforts to improve the public educational system. By far the most interesting and successful initiative is the Maine Learning Technology Initiative, developed by Governor Angus King in 1999. The program has placed a laptop computer in the hands of seventh and eighth grade students and all teachers in grades 7-12. A significant number of high school students also
have one to one computing. The program is not a computer program but was designed to use technology to enhance learning by fostering technology integration into content. The program is also meant to improve online resources for teacher development. The program had a strong beginning phase, but the lack of clear goals, budget constraints, and personnel changes limited the development of many good proposals for enhancing the system. Among our respondents there was continuing interest in employing this initiative to improve technology transfer into all areas of curriculum and instruction, including the Common Core standards, and teacher development. The use of technology to promote innovation is a key recommendation in the PCAST report to the White House, and one that Maine is poised to develop.

In the late 1990s the Department of Education funding and staff were markedly reduced. In this decade, the Department was restructured and reductions in staff were absorbed across the departments. Attrition continued to be employed as a means to reduce staff, and the current employees are required to take 10 furlough days per year. The resulting reduction in capacity has caused some setbacks in the implementation of state initiatives, including state standards, The Maine Learning Results. In 2006, Walter Harris and Janet Fairman published a paper on the implementation of the first set of state standards, in Maine schools. At the time of the study, local schools were supportive of the standards, and many schools and districts were finding resources through grants and other means to deliver the content to students. But other local schools soon became frustrated when technical assistance to help teachers implement the standards was not sufficient to overcome several implementation obstacles.

The implementation of the standards became more complicated when the Department of Education charged local school districts with developing sophisticated local assessments that had statistical validity and reliability. Such development is time consuming and expensive. In a study conducted by educational experts Michael Fullan and Nancy Watson in 2006, the researchers found that the state had ceded too much responsibility to local schools and districts in the development of these assessments, and had provided little technical assistance to schools to build capacity in a number of areas.

Despite major reductions in its capacity, the Department has taken several recent actions towards fostering improvement. In 2009 the Department of Education joined Vermont, New Hampshire, and Rhode Island in adopting a set of common standards and assessments (NECAPs) for mathematics, reading, and writing. Maine is also a member of the Common Core Consortium and will soon be implementing the rigorous standards for mathematics and English language arts that 48 states have adopted. The state is a member of the SMARTER Balanced assessment program, a consortium of 48 states that will develop summative and formative assessments linked to the common standards.

The state has channeled federal dollars into Math and Science Partnerships that seek to provide targeted professional development in STEM subjects to participating districts; instituted the College Board SAT as a college and career readiness assessment to be taken by all 11th graders in the state; and received a large federal grant to improve its student and teacher data tracking system. In addition, the office for Title I administration has sponsored technical assistance sessions across the state to foster improvements in Title I schools.

Among the initiatives that hold promise is the Maine Aspirations Program, which has been co-sponsored by the Mitchell Institute. This dual-enrollment program provides opportunities for Maine high school students to receive tuition funding and credit for taking college-level courses. In 2010, 1,245 students took courses that promised immediate or deferred credits. More than half of the students taking these courses are career and technical education (CTE) students, who can only take courses in specific
technical areas and who do not get immediate credit. To gain these credits, students must graduate
from high school and matriculate at the community college partner organization. However, the fact that
Maine is investing in a strategy that promises better transitions for students to higher education is
couraging.

Despite these initiatives, Maine has taken limited action in areas that have been identified as critical to
educational improvement and referenced in the preceding sections of this paper: increasing
requirements for mathematics and science coursework, defining career and college readiness with the
college and university systems, and improving undergraduate teacher education in STEM areas.

Maine's STEM Assets and Obstacles

In interviews with 29 major players in STEM education in Maine, we identified a number of themes.
These themes focused on state strategies for leading educational improvement, the necessary basis for
STEM improvement.

State Leadership and Coordination

What we know: According to a 2009 Achieve study, “most successful education reforms are led by some
combination of governors, state K–12 and higher education commissioners, and legislators. States need
elected and appointed officials with the stature to make change happen and the courage to push ahead,
even in the face of system inertia or resistance.”

In a study of other states, EDC researchers have identified a number of groups that have led coordinated
state efforts. In most states, the collaboration of the K–12 system (as represented by a strong
Department of Education) and the higher education system has resulted in effective strategies. In
others, the post-secondary system or business community alone has led the push. Most states
eventually formed P–16 Councils with leadership from the governor and legislators to build sustainable
c coalitions and resist efforts to derail needed improvement efforts. In the recent Race to the Top
proposals, states identify a number of interesting partnerships involving the business community, state
university systems, community colleges, and education agencies to coordinate and lead both general
education efforts and STEM improvement. The common denominator in funded proposals is a
partnership among the state department of education, the community college and university systems,
and other governmental and business agencies.

Obstacle: Among our respondents, the absence of strong, coordinated state leadership for educational
improvement was a major topic of discussion. The lack of a strong group or agency, with funding and
legislative power, was deemed a major roadblock, both for STEM education in particular, and for all
educational improvement efforts in general.

In Maine, no such coalition or group has emerged. The legislature has significant control over the
Department of Education operations. While there are some important STEM advocates among
legislators, strong regulatory oversight by the legislature may result in important improvement
initiatives being derailed by lobbying efforts.

Of particular note has been the limited involvement of the University of Maine system in PK-16
improvement efforts. Although the University has a number of STEM courses and programs, its
involvement in the important state-level issues, such as aligning admission standards across the system,
defining college and career readiness, and improving undergraduate teacher preparation, has been weak.

A recent National Science Foundation grant awarded to a physics researcher to develop curricula in physical sciences in conjunction with several school systems is a promising effort. The University Chancellor’s Office has begun an initiative to try to coordinate all University K-12 STEM programs, and the RiSE Center at the University of Maine is studying how to improve its offerings in science education and teacher preparation. These initiatives are in the beginning stages and it is not clear how they will address the state systemic issues. According to one respondent, a P–16 Council that formed in 2004 had two or three meetings, but the “University system and the Department were not engaged.” According to the Achieve study, “When leadership is siloed, or resides with only one leader, reforms are often more vulnerable in the long run.” In the case of Maine, strong leadership by an agency or coalition with funding and regulatory power has been missing in a number of areas in recent years.

Maine’s External Champions

What we know: Our recent review of other state STEM efforts and a review of improvement studies indicate that external advocates and champions can assist reform by providing pressure to state policymakers and ensuring that the push continues, despite state political changes. Among the external champions are individuals in business and within agencies, the legislature, and nonprofit groups who have taken particular active stances to bring some coherence to the system. But these champions must join a strong state system to effect improvement.

Assets: In a review of documents and websites and through interviews, we were able to document a list of the institutes and programs that are providing a rich assortment of student, teacher, and curriculum development programs. Our review identified 152 different programs in 52 entities that offer or offered these services. Many of these programs or projects were time limited or externally funded projects that had expired, but nevertheless, the number was encouraging. Rough estimates are that several million dollars from federal grants and private foundations are devoted to these programs each year. A partial list is included below:

- **Maine STEM Collaborative**: This collaborative is a partnership of education, research, business, government, and nonprofit sectors that promotes STEM education, research, and workforce development. It sponsors STEM summits, which bring all sectors together and promotes the message that STEM careers are key to prosperity and productivity in the 21st century. The collaborative is also seeking to coordinate initiatives across the state in an effort to have a wider effect on students and teachers in districts not directly connected to present programs.

- **Maine Mathematics and Science Alliance**: The alliance is the principal provider of STEM teacher professional development and programs in Maine and is funded through a variety of sources. Examples of professional development offered are programs to improve mathematics teaching, enhance middle school teaching in environmental sciences, bring new biology into high school science classes, and produce leaders in STEM teaching and administration.

- **Acadia Institute of Oceanography and Marine Science**: The institute provides teacher and student development in the marine sciences, with a hands-on student curriculum using the national park as a classroom.

- **Bigelow Laboratory, Bloom and Darling Marine Center, University of Maine**: This center partners with NASA to develop curriculum about ocean systems. The Bloom Fellows Program provides
research fellowships to undergraduates and talented high school students. Darling Center programs offer summer hands-on courses for students in the marine sciences.

- **Challenger Learning Center of Maine**: This center supports K-12 student learning in mathematics and science.
- **Chewonki Foundation**: The foundation funds camp and educational programs to expose students to the natural heritage of Maine.
- **College of the Atlantic**: The college offers a number of programs for families, teachers, and students to engage them in the ecology of Downeast Maine.
- **Foundation for Blood Research**: The foundation develops biology software in conjunction with the laptop initiative that focuses on immunology and other areas of biology.
- **Gulf of Maine Research Institute and Foundation**: The research institute develops programs and curricula for students in biology, environmental sciences, ecology, and environmental research.
- **Jackson Laboratory**: The laboratory sponsors high school and teacher research fellowships.
- **Maine Space Grant Consortium**: The consortium provides internships for students and teachers to encourage and support the introduction of NASA curricula into coursework and funds a variety of space-related programming.

For a rural state with a small population, Maine has a rich foundation upon which to build the systems that must be in place to improve STEM education across the state. Among the important partners and potential partners in STEM education efforts are several businesses and business leaders. Participating in the STEM summit this year were Habib Dagher, professor of engineering at the University of Maine and advocate for Maine’s off-shore wind initiative; Sarah Burns of Central Maine Power, who talked of the increasing need for STEM workers in the power industry; Joseph Lumiszczca of TechMaine; Lisa Martin of the Maine Aerospace Alliance; Stephen Van Vogt of Maine Marine Composites; and Paul Williamson of the Maine Wind Industry. Several other companies had displays, including Lockheed Martin and FIRST Robotics.

**Obstacles**: Despite this abundance of institutes and projects, developing and sustaining STEM reform is dependent upon strong state leadership and coordinated systems. As one interviewee stated, “We feel really good about our programs. We can reach 10 to 12 middle school teachers and hundreds of students each year. But we have no ability to scale up our programs to reach those schools that do choose not to participate, or those students in geographically isolated areas that don’t have access to our programs.”

Although local and individual efforts and programs can deliver exemplary content and instructional resources, the problem of coherence and equity remain. Many of the programs have just begun to align their offerings to state standards. More high-resource districts can participate in partnerships and institutes, leaving low-income students and districts outside the loop. Various programs may deliver different content, leaving some students with gaps that result in the need for remediation later.

**Local Control and Capacity**

**What we know**: Developing coherence in curriculum and instruction has been determined to be critical to improving education in STEM areas. In a 2008 report by the National Science Board, the Board stated:
STEM content standards and the sequence in which content is taught vary greatly among school systems, as do the expectations and indicators of success. Students do not always obtain mastery of key concepts at the elementary and middle school levels, thus limiting success at the high school level.

The lack of coherence has been a major criticism of the U.S. educational system. Asking local schools to invent coherent systems, one at a time, that will result in statewide improvement has not been shown to effect state improvement. The work of the past decade by Achieve, Inc., and the National Governor’s Association has focused on the development of coordinated state systems. The development of coherence requires, in turn, investments in state and local capacity. In a 2002 paper for the RAND Corporation, NCEE President Marc Tucker described the major problems in asking local schools to be accountable for higher performance, and identified local school and district capacity as central to the improvement efforts. Issues that arise when a state devises a system that relies on local school districts to fund and create their own improvement systems focus on the lack of equity, capacity, coherence, and outcomes.

**Assets:** The matter of local control and its influence on state policies was mentioned frequently in our interviews. Many of our respondents talked of the efforts that individual districts and schools were making to improve high school offerings and integrate career and technical education centers with more rigorous curricula. Two examples of local initiatives include an effort to alter an entire high school program to a project-based, 21st century learning environment, and a project to bus potential students in danger of dropping out of high school to community college campuses for welding and other classes. Some interviewees stated that “any change must start at the local level.” Among the local efforts that were mentioned were partnerships with community or other colleges and nonprofit organizations to develop curricula, increase student learning, or provide professional development for teachers. As noted in the previous section, these are important resources in the effort to improve STEM education, but may not be sufficient in the absence of a state system.

**Obstacles:** Many of our respondents noted that Maine is a “unique state” and that any improvement “has to start at the local level.” This local-control emphasis has been supported by the fact that the Board of Education is “weaker than those of other states” and has significant oversight by the legislature. This oversight makes it easier for various lobbying organizations to derail systemic initiatives. Also emphasized by respondents is the funding formula and the fact that local districts feel that any state mandate must be accompanied by funding. These strategic emphases work against school improvement in Maine for the reasons discussed above.

The local capacity for improvement district by district varies according to the leadership and resources of the district, leaving some students in low-resource districts with inequitable access to rigorous coursework and programs. Because of the economic downturn, local and state funding will be decreasing through 2012, and it is difficult to determine how local districts can undertake such work without strong state technical assistance and funding. The lack of such capacity building at the local level has been a significant deterrent to education reform.

**P–16 Alignment and Accountability**

**What we know:** The improvement of STEM education cannot take place without the alignment of the P–16 system combined with defined requirements for college and careers admission. Many other state improvement efforts over the past decade have been devoted to bringing alignment to the educational system. Studies of other countries’ systems have yielded the important information that coherence in
curricula and depth of learning are key factors in improving student outcomes. This alignment is particularly critical for low-income students. Providing the support and resources for deep learning in rigorous coursework and for transition to higher education is a key leverage point for improving the chances of post high school success for all students.

**Assets:** Maine began the standards and alignment effort with the introduction of the Learning Results system of standards and has proceeded to improve and upgrade those standards and accountability systems over the past decade. The NECAP standards and assessment system is one of the most effective in the country. The state is now moving to implement the Common Core system, a system of nationally developed standards that will upgrade content rigor and accountability. Initial meetings on the Common Core standards have been well attended by local school personnel. A general attempt to make schools accountable includes the Maine assessment system and the administration of the College Board SAT test to all high school juniors.

In 2008, the Department of Education began the Pathways Project to support the development of high school courses that align with the Maine Learning Results. Teachers develop course syllabi that are reviewed by external reviewers to confirm the inclusion of the standards. These course syllabi, representing several areas of emphasis, are meant to confirm that students taking different pathways to career or college are getting the necessary content to succeed. Some respondents had suggested that this program is a career and college readiness program, but it is difficult to determine how a collection of syllabi, even if aligned with standards, would define a clear pathway to college.

Most respondents were aware that the state offers dual-enrollment opportunities for high school and Career and Technical Education students taking college courses. Most often cited were CTE dual-enrollment programs with community colleges. These institutions are required to offer dual courses for credit under federal rules, but CTE students can only take specific technical courses, and receive “escrow credit.” Other programs include courses for students who are advanced in their high school curriculum. The Lewiston High School program is extensive and enrolls 200 juniors and seniors in dual-enrollment college courses in partnership with three area colleges. In the class of 2006, 83 percent of students who had enrolled in early college courses later enrolled in college; only 61 percent of the entire graduating class enrolled in college. The school has added a staff member to manage the Aspirations program and to counsel students and serve as a liaison to colleges.

By 2008, the community college system had implemented a program that made counseling, scholarships, and access to some courses available to all high school students. These strategies provide an important foundation for the development of a system of early college high schools.

**Obstacles:** Although the Department of Education has moved to implement state standards, key efforts to bring alignment and accountability to the system have been missing. To ensure that students have access to the skills that they will need to participate in the 21st century workforce, they must be strongly encouraged to take more rigorous coursework that will prepare them for college or career entrance. Career and college readiness must be defined and must be uniform across the college and university system.

As one community college respondent stated, “Even the industries that used to require just a high school education now require advanced math and computer skills. The construction industry, manufacturing, energy workers, and health care workers all need these skills. Over 70 percent of our incoming students do not have the math skills they need to participate in our courses.” The community
college system is on the frontlines of this struggle for alignment, and many of the colleges are working with high schools to create innovative programs to improve this transition. However, if high schools do not prepare students for college work, students may gain entrance but drop out later.

Alignment is dependent upon strong state standards, including required rigorous courses and implementation. Among our interviewees, several stated that the current standards are “old” and have not been implemented very effectively. Two respondents stated that “standards have not made any difference and are not the answer,” and “our career students just need an industry certificate, not state standards that are irrelevant to their work.” While it is true that standards are not the only answer (there must be good teaching, interesting and relevant curricula, and accountability as well), the simple truth is that most well-paying jobs of the future will require at least two years of college and, more likely, a bachelor’s or master’s degree. Without a road map in the form of standards, and the capacity of schools to implement them in a way that taps the best practices, Maine students will continue to take less rigorous courses and will not be prepared for college or the jobs of the future.

Accountability for performance is another obstacle to improvement. As one state staff member put it, “there is no state accountability system for performance in Maine.” In contrast to other states that have systems for state intervention if schools are not performing, there are no consequences for lack of performance in Maine. In Title I schools, an intervention system requires the school to contract with outside consultants to improve performance, but provides few guidelines on how that improvement system should be constructed. Schools that must improve under the federally funded State Improvement Grants design their own improvement programs.

Career and Technical Education

What we know: At the national level, concerns about the preparation of career and technical education students for the jobs of the future have prompted a number of state initiatives to increase rigor and ensure state education standards are being integrated into career education. States have begun to work with students in early middle school to develop career plans that focus on the advanced mathematics, literacy, and technology skills they will need for jobs that previously required only a high school education.36

Assets: Despite Maine’s problems in integrating rigorous state education standards into their programs, many career and technical centers were praised for their project-based and work-connected curricula and for the fact that students who previously were failing in an academic track remain engaged and in school. State efforts are underway to improve the rigor of academic offerings for career and technical education students through math and literacy programs, and to foster more integration of high school and career and technical education. Efforts are also underway to integrate the Common Core standards with Industry Standards.

Obstacles: Many of our respondents referenced career and technical education centers as schools for students who had been “sidelined,” or who were having particular problems in the regular academic program. Students select the CTE pathway in their junior year in high school, often after they have not had success in the regular program. They may be bussed long distances to one of 27 CTE centers in the state, resulting in loss of educational time. Until recently, there had not been strong efforts to ensure that CTE students were being taught the state standards. As a result, CTE students’ mastery of those skills necessary for college and career has been weaker than those of students prepared in regular high school. In 2008, only 25 percent of CTE students met the state standard in reading, and 20 percent met the standard in mathematics.37
Incentive Programs

What we know: Other states have used incentives as a state strategy to attract talented students to STEM and teaching fields through scholarships, stipends, and internships. Incentives have also been employed by states to reward teachers for teaching STEM subjects in hard-to-staff schools. The UTeach program, which originated in Texas, has been adopted by several states and includes rewarding talented STEM undergraduates for moving into public school teaching with stipends, tuition remission, and job placement.38 A review of Race to the Top proposals identifies incentive strategies in STEM areas, including incentive programs for teachers in rural areas to enter STEM fields, and recruitment strategies for talented STEM students.

Assets: A number of the programs and institutes identified in this paper have combined interesting curricula, internships, and scholarships to attract students into STEM fields in Maine.

Obstacles: There is no statewide incentive strategy for attracting students to STEM fields, to upgrade teacher preparation and professional development, or to provide programs for STEM teachers in hard-to-staff rural schools. As one respondent stated, “You cannot teach science if you have had one or two courses in science.”

Teacher Preparation and Curriculum and Instruction

What we know: In 2007, the National Academy of Sciences published a report, Rising Above the Gathering Storm, that went into some detail about the issues involved in teaching science to elementary and secondary school students.39 Their observations are particularly applicable to other STEM areas. Teachers must not only know the content and know it well, but must also be able to present that content to students in a manner that helps them establish habits of inquiry and problem solving. To be able to teach STEM subjects, pre-service teachers need extensive preparation in content and pedagogy. Professional development must feature at least 50 to 120 hours of coursework and in-school practice.40

In the area of curriculum and instruction, certain research-based curriculum programs have been shown to be more effective than others, particularly in instructing students who are English language learners or who may have come to school with few learning experiences. A number of states have developed state curricula in science and mathematics or are in the process of developing resource libraries of research-based curricula and professional development programs.

Assets: A number of institutes and nonprofits in Maine have developed interesting curricula in STEM areas that focus on Maine’s natural resources. Among the topics are ocean systems, marine sciences, and natural ecosystems. There are also educational programs addressing the medical sciences (or biology), such as blood research. The Maine Mathematics and Science Alliance provides programs for teachers combining literacy and STEM subjects. The University of Maine has an excellent engineering program and has several other programs in STEM areas. The RiSE Center at the University of Maine is studying ways to improve its science and mathematics education programs, and a new grant will enable researchers to work with schools to develop a physics program.

Obstacles: The Maine Department of Education contracts with professional development providers to channel federal dollars for professional development. Many respondents at the local level stated that they select their own professional development programs, which may or may not be aligned with state and local improvement needs. Most districts in Maine pay tuition for credit courses towards a Masters Degree for teachers, but those credits can be devoted to any area of study and may not be directed
toward school priorities. Although the Department of Education has published a model that describes elements of best practices in professional development, it is not clear whether guidelines are enforced. There is no central state resource bank for research-based curricula, nor state or regional professional development centers. The Pathways Program inventories standards based lessons, but it is not clear how those are disseminated.

In the area of teacher preparation, there is a Master of Science in Teaching program for those secondary science teachers who wish to expand on their skills at the University of Maine. However, preservice teacher education programs provide a minimum requirement in STEM areas for prospective teachers.

**Summary and Recommendations**

Maine is a state with rich natural resources and an abundance of STEM champions working in government, nonprofits, businesses, and education sectors to promote STEM programs. These efforts are occurring without strong, coordinated state leadership and key systems in place to foster improvement of the educational system in general. This coordinated state leadership must occur at the highest levels of state government and must define what students need to know (enhanced rigor) for 21st century jobs, what constitutes college and career readiness, and what teachers will need to know to prepare students for STEM and technological programs. State leadership must also develop intervention systems for schools that are not improving student outcomes. These systems are the basis for any STEM improvement efforts to be successful.

Maine has been trying to improve education from the bottom up, with the participation of local schools, institutes and foundations, and scattered partnerships with the university and community college systems. These are rich resources that, when wedded to state system improvements, will propel the state to a leadership position.

The stakes for Maine are high. Although STEM jobs will be increasing in the years to come, there are doubts about the state’s ability to educate students to take those jobs of the future. Only 34 percent of 9th graders complete a college two- or four-year degree—a fact that does not bode well for the economic development and future of the state.

Our interviews and review of documents have identified several issues that may serve as leverage points around which a renewed STEM improvement effort may be successful. The following table illustrates Maine’s efforts in key areas that have been identified as critical to school improvement in general and STEM improvement in particular.

<table>
<thead>
<tr>
<th>Major State Improvement Strategies</th>
<th>Status of Maine Improvement Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinated state leadership</td>
<td>Individuals and some organizations trying to coordinate efforts but no strong state system.</td>
</tr>
<tr>
<td>P–16 alignment, successful implementation of state standards with increased rigor in STEM areas, and defined career/college readiness</td>
<td>Common Core in the process of being developed. No definition of college and career readiness or accountability for schools to teach standards.</td>
</tr>
<tr>
<td>Strong Department of Education capacity</td>
<td>Not fully funded to effect statewide improvement.</td>
</tr>
<tr>
<td>Local control and capacity balanced by strong state system</td>
<td>Individual schools and districts developing programs but these efforts are not balanced by state requirements.</td>
</tr>
<tr>
<td>Major State Improvement Strategies</td>
<td>Status of Maine Improvement Strategies</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Dual enrollment and early college programs</td>
<td>Emerging dual enrollment programs with opportunities to expand to early college high schools or STEM academies.</td>
</tr>
<tr>
<td>State accountability and intervention systems</td>
<td>Only Title I school interventions and local schools and districts design their own turnaround system.</td>
</tr>
<tr>
<td>Improvement in the CTE system to introduce more rigor</td>
<td>Literacy programs implemented. Math programs and integration of industry standards with Common Core in process.</td>
</tr>
<tr>
<td>University and community college involvement in P–16 reform issues</td>
<td>Weak involvement by the university system in P-16 systemic issues. Community college partnerships occurring across the state. University initiating efforts to define and enhance its role in STEM education.</td>
</tr>
<tr>
<td>Upgrades to teacher preparation in STEM areas</td>
<td>Not evident.</td>
</tr>
<tr>
<td>State system and guidelines for professional development</td>
<td>Not evident that guidelines have influence on professional development and no state resource centers for teacher professional development.</td>
</tr>
<tr>
<td>State resource banks of research-based curricula in STEM areas</td>
<td>Pathways Project is an effort to inventory standards based lessons, but it is not clear how those might be identified as effecting student outcomes. This effort might serve as a basis for a resource library.</td>
</tr>
<tr>
<td>State incentive programs for teachers and students in STEM areas</td>
<td>Some private fellowships and scholarships available through institutes and foundations, but needs to be expanded for state priorities.</td>
</tr>
<tr>
<td>External coalitions and champions</td>
<td>Yes. A major asset for STEM improvement efforts.</td>
</tr>
</tbody>
</table>

Maine has some strategies in the initial stages and a number of assets from which to draw in identifying key leverage points for intervention. The following is a list of key intervention points that we have derived from our study.

**State Leadership**

- Institute coordinated state management of the educational improvement system by a cross-agency task force that includes the governor, members of the legislature, non-profit organizations, university and community college executives, and business representatives. A mechanism is in place through the P–16 Leadership Council that was established in 2004 to “create a seamless pre-kindergarten through sixteenth grade educational system.”

- Form a statewide coalition of external champions with the P–16 Leadership Council to develop a communication plan for STEM awareness and recruitment and to ensure that improvements in instruction and teacher preparation are implemented.

**P–16 Alignment and Coherence**

- Implement the Common Core standards and devote resources to increase the capacity of local districts to implement them.
- Define career and college readiness with the university and the community college systems in terms of courses or competencies that must be mastered prior to college admission.
• Establish a system that holds local schools accountable for performance and provides for state intervention if improvement does not take place.
• Invest state resources in increasing the capacity of the Department of Education to do its job, and in investing in a strong state coordinated system that balances local control with state imperatives and programs.
• Build on current dual-enrollment programs and partnerships by defining the role of community colleges in forming partnerships with high schools, businesses, and CTE centers, and encourage the development of early college STEM high schools and academies for grades 9–13.
• Continue efforts to upgrade the rigor of offerings in the Career and Technical Education Centers.

Instructional Quality
• Ensure that the university system becomes a partner in P–16 improvement and that, as a first step, it improves STEM content in preservice teacher preparation programs.
• Introduce incentive programs to attract undergraduate STEM majors to teaching and to entice STEM teachers to teach in hard-to-staff schools. Develop STEM master-teacher-leader programs.
• Develop guidelines and resource banks for professional development and research-based curriculum programs. Use the laptop initiative in a variety of ways to disseminate best practices in curriculum and instruction.

Conclusion
Across the country, STEM education has been singled out as a major national and state priority in reports, funding programs, and most recently, in the Race to the Top grant program. The emphasis on science, technology, engineering, and mathematics education is not new for many states that are in the process of altering their educational systems to respond to the need to prepare their workforce for jobs in the 21st century. That preparation has included efforts to set the stage for improvement by ratcheting up course requirements, improving the quality of teachers, identifying the best curricular programs, and ensuring students are ready for college.

Maine is now trying to set the stage for that improvement to take place, but is missing a number of important systemic elements. Although Maine has several assets described in this report, the state has not established the structures that will enable all students to stay in school, take rigorous coursework, enroll in college, and graduate from college with the skills necessary for entering STEM jobs.

Maine is poised to gather the significant science, technology, engineering and mathematics resources already in place and integrate them into a more focused and state-driven improvement system. But that improvement depends upon a coordinated effort involving the Governor’s office, the Department of Education, the University and Community College systems, and business and non-profit groups. That effort must reflect the fact that the future economy of the state depends upon coordinated state action.
Appendix A: Interview Guide

INTERVIEW QUESTIONS:

- What is the current status of STEM education in Maine?
- How would you improve it?
- What are the issues that are serving as roadblocks to improvement?

PROBES:

- What is the state role in coordination of STEM initiatives?
- What is the local capacity to effect improvement?
- What is the status of K-16 alignment?
- What is the capacity of the Department of Education to be the chief state implementing agency for education reform?

INTERVIEW RESPONSE THEMES

In order of the number of times they were mentioned as major factors by respondents.

1. External Champions 28/29

All but one respondent began the conversation with a mention of the many institutes and programs in the STEM area operating in Maine. Many thought that this greatly increases the capacity of the state, but others noted the lack of being able to scale these programs up to affect all students and teachers.

2. State Leadership 24/29

Twenty-four of our respondents talked about state leadership. Most lamented the lack of strong state goals and action on improvement. Four respondents thought that the state could not lead any improvement efforts, and that these efforts must start at the local level. When asked who should lead, most thought that it would have to be the governor or the business sector.

3. University Involvement 20/29

Many interviewees noted the lack of University of Maine involvement and leadership in K–12 improvement efforts. While noting that the university has many STEM programs and research projects underway, the critical state leadership in improving teacher education and developing a uniform career and college readiness admission standard have been missing. Many stated that the university has its own “competition and funding problems.”

In contrast, the community college system is seen as a close partner with high schools and CTE centers. Several examples were provided of how these institutions collaborate to try to solve the college drop-out problem, and how to facilitate students’ arriving at the college door with better mathematics and literacy skills.
4. **Local Control 17/29**

Local control was a prominent topic. Respondents were mixed in their thoughts about how local control and capacity were affecting systemic reform. Several were wed to the idea than any improvements had to bubble up from the bottom. Others saw that without strong state leadership, a coherent system would not be possible. Many mentioned the fact that the funding system model provides for less state funding for many districts, and those districts feel they have no obligation to follow state directives unless funding is attached. Respondents provided several examples of how local schools were trying to invent new and better programs.

5. **Defining College and Career Readiness 17/29**

When asked if there is a common state definition of career and college readiness, the answer was no, but that the Common Core standards, if fully implemented, would provide that definition. Two respondents mentioned the Pathways Project, a syllabus review program that seeks to determine if courses taught across the state correspond to state standards. Several respondents suggested that local schools should define college and career readiness.

6. **Professional Development for Teachers 17/29**

Several of our respondents were connected to professional development programs, and there was praise for many of the programs that are delivered across the state. Department staff explained that the Department does not deliver professional development but, instead, contracts with other organizations to deliver teacher programs. When asked if there were state guidelines, regional centers, curriculum resources, or other examples of best practices, the answer was no. The Department does deliver some targeted programs for Title I schools.

7. **Department of Education Capacity 15/29**

The Department of Education capacity and relationships to the local schools was a prominent topic. Many local interviewees downplayed the importance of the Department and were critical of the manner in which initiatives had been implemented in the past seven years. In fact, some suggested that the Department should get out of the way and enable local districts to make their own plans. Others were complimentary about certain staff but noted that the Department does not have the capacity to really implement reform initiatives. Many mentioned the fact that the board of education and the Department are subject to more legislative control than in other states, and that a few of the important initiatives had been derailed by lobbying of groups opposed to them. Conversations with Department staff indicate that they are moving forward on a number of initiatives despite the funding and regulatory constraints.

8. **Standards 15/29**

Many respondents stated that the state standards, *Learning Results*, were not being implemented uniformly across the state, especially in STEM areas. Six respondents specifically stated that standards “are not the answer” to education improvement and that teaching and learning at the local level must be enhanced. Others stated that the adoption of the Common Core standards will begin to bring alignment and coherence to the system and that local schools must be held accountable for teaching them.
9. Laptop Initiative 12/29

The Maine laptop program was most frequently mentioned as a positive program implemented by the Department of Education. The program was meant to provide the means and the training for the integration of technology into courses and to enhance teacher professional development and student mastery. However, some respondents noted that the program had faltered through the lack of clear objectives and management and staffing issues. Others noted that the program was popular as a professional development vehicle and holds great promise for future improvement efforts.

10. Career and Technical Education 10/29

The CTE centers are a focus of much interest and were mentioned by 10 of our respondents. Issues center on the previous lack of mastery of state standards in literacy and mathematics by students in the centers. Community college respondents were quite concerned that the deficits of these students mean more time in general education courses, adding to student and state expenses and resulting in longer lines to get into key programs. Respondents involved with the centers cite a five-year effort to improve literacy and a new mathematics program, along with efforts to chart the Common Core standards within each of the Industry Standards programs.

11. Funding 8/29

Funding issues were interwoven into several responses. Funding was deemed instrumental in the development of local capacity; the decreases in the Department of Education budget were cited for the lack of capacity of that organization; and several interviewees mentioned the fact that the state funding system for education results in some wealthy districts getting little state support, enforcing the notion that the state has little leverage in developing a state systemic approach. A sharp drop in federal and state funding is due in 2012 and will restrict capacity further.

12. Incentives 8/29

Incentive programs for students and teachers are a major strategy other states have employed, especially in STEM areas. There are some incentive programs in Maine, most often introduced by institutes or other external funding programs. Among these are fellowships and internships in STEM areas, targeted scholarships, a tuition remission program, and programs to entice high school students to consider STEM careers. Also mentioned are dual enrollment and early college programs that attracted 1,200 students in 2009. There are no large state systemic efforts such as the UTEACH program or the development of STEM academies.

13. Communication Plan 6/29

Six respondents who were familiar with the literature on STEM education indicated that even if the state upgraded its college and career readiness standards, talented students still might not choose these careers. Many suggested that a coalition of supporters should begin a public awareness campaign on the importance of pursuing STEM careers.
Appendix B: List of Interviewees

Justin Alfond, Senator
Sara Burns, President, Central Maine Power
Don Cannan, Career and Technical Education Association
Jim Carignan, Former Chair, State Board of Education
Laurette Darling, Maine Science Teachers Association
John Dorrer, Director, Maine Department of Labor, Center for Workforce Research and Information
Grace Eason, Science Professor, University of Maine at Farmington
Deborah Friedman, Governor’s Education Advisor
Gus Goodwin, Technology Education Association of Maine
Allyson Handley, President, University of Maine at Augusta and Coordinator, University of Maine STEM Summit Collaborative
Susan Hunter, Senior Vice President and Provost, University of Maine
Marcia Leander, Associate Vice President of Staffing, Unum
Alan Lishness, Chief Innovation Officer, Gulf of Maine Research Institute (GMRI)
Bette Manchester, Executive Director, Maine International Center for Digital Learning (MICDL)
Jeff Mao, Maine Learning Technology Initiative, Department of Education
Susan McKay, Professor and Director, UMaine Center for Science and Mathematics Education Research
Jan Mokros, Executive Director, Maine Mathematics and Science Alliance (MMSA)
Wanda Monthey, PK-20 Team Leader, Department of Education
Vicki Nemeth, Director of Research Administration and Maine EPSCoR, University of Maine
James Ortiz, President, Southern Maine Community College
Patrick Phillips, Superintendent, SAD 61
Jim Rier, Management Information Systems, Department of Education
Elizabeth Schneider, Member, Joint Committee on Education and Cultural Affairs
Susie Valaitis, Associate Director, Institute for Broadening Participation
Jake Ward, Assistant Vice President, University of Maine
Shannon Welsh, Superintendent, RSU 5 and President of Maine Superintendent’s Association
John Wright, Dean, University of Southern Maine, School of Applied Science, Engineering, and Technology
Peter Zach, Director, Maine Energy Education Program (MEEP)
Bill Zoellick, Executive Director of the Schoodic Education and Research Center, Acadia National Park

Clarifying Interviewees

Anita Bernhardt, State Science and Technology Specialist, and Regional Representative, Maine Department of Education
Lora Downing, Director, Career and Technical Education
Meg Harvey, Department of Education, Perkins Plan
Nigel Norton, Department of Education, Career and Technical Education and Dual Enrollment
Rachelle Tome, Accountability and Title I, Department of Education
References


2 Ibid.

3 Interviews with the presidents of the University of Maine at Augusta and the Community College of Southern Maine. August 2010.

4 Ibid. p. 13


6 Ibid.


12 Ibid., p.10.

13 Ibid.

14 Statements from *STEM plans embedded in winning proposals for race to the top*. Education Week, 30, No. 3, September 15, 2010. p. 6.

15 Ibid., p.6.

16 A summary of Race to the Top priority 2 STEM proposals from all states prepared by the Education Development Center. 2010.

17 Executive Summary, Report to the President. (2010). *Prepare and inspire: K–12 education in science, technology, engineering, and math (STEM) for America’s future*. The White House: President’s Council of Advisors on Science and Technology.


20 Ibid., p.9.


23 Ibid. p.3

This topic came up in several of our interviews and was repeated by Department staff.


Ibid.

See attachment in Appendix A.


Ibid.


Maine Governor Executive Order. An order establishing the task force to create seamless pre-kindergarten through sixteenth grade educational systems.