STEM Education in Maine:
An Executive Summary of Student Performance, Teacher Preparedness, and STEM Programs
Executive Summary

Background

It is clear that Maine’s economic success depends on effectively preparing students for life and jobs in the 21st century. Therefore our educational system must be able to respond to this need by preparing students to thrive in an increasingly technological world and to solve the challenges of the state’s future in key areas such as energy, environmental conservation, and health care.

Effective science, technology, engineering, and mathematics (STEM) education is key to meeting these needs. Maine has set the stage for solid improvement to take place: over the past decade, a focus on improvement in STEM education in Maine has resulted in the formation of a proliferation of both in-school and informal out-of-school STEM programs, the Maine STEM Collaborative, and the recent formation of the Governor’s STEM Council. However, a number of important systemic elements are not yet developed, and it is time to more thoroughly coordinate efforts at a statewide level and understand their impact on student preparation and achievement in STEM.

However, in order to be effective, it is first necessary to understand the current landscape of STEM education in the state including student performance, teacher qualifications, and Maine’s strengths and challenges in STEM education. To this end, the Maine STEM Collaborative, the Maine Department of Education, and the Maine Mathematics and Science Alliance commissioned four reports in 2010 and 2011 that highlighted specific aspects of the Maine STEM landscape. This document is intended to provide a brief summary of these reports, which include:

- **Maine STEM Landscape Technical Assistance: Mathematics and Science in 5th, 8th, and 11th Grades**
- **Maine STEM Landscape Technical Assistance: K-12 Certification Endorsements, 2009-2010**
- **Teachers of Science in Maine Schools, Grades 1-12: A Descriptive Study**
- **Briefing Paper on STEM Education in Maine**

These reports build a baseline picture of STEM in the state, and provide a solid foundation for fostering discussion about what additional data is needed and what steps will most effectively move STEM education in Maine forward. They provide an overview of student performance data in mathematics and science, teacher preparedness in science education and educator STEM endorsements, and the status of STEM education programs and improvement efforts in Maine.

Together, they clearly establish the need for STEM education improvement in specific areas and also highlight recommended leverage points for this coordinated effort, based on Maine’s unique strengths and challenges in developing its students for a 21st century workforce that will continue to require increased STEM knowledge and skills.
The Need

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% higher than wages for other occupations in Maine. The Maine Office of Innovation has identified seven STEM occupational clusters that are key areas for economic development: biotechnology, composites, environmental technology, forest products and agriculture, information technology, marine technology, and precision manufacturing. Those involved in workforce development and STEM education are appropriately concerned about the ability of Maine students to assume these jobs of the future.

Student Performance on State Assessments In Mathematics & Science

The Maine STEM Landscape Technical Assistance: Mathematics and Science in 5th, 8th, and 11th Grades report builds a baseline picture of mathematics and science achievement for Maine students based upon the percentage of students meeting or exceeding standards on state assessments, using grade 5 and 8 Maine Educational Assessment (MEA) data and grade 11 Maine High School Assessment (MHSA) data.

In subjects that are essential to STEM careers, Maine students show a decrease in mastery from middle school through high school. This may account for the high mathematics remediation rate of well over 50% for incoming university and community college freshmen. Lack of preparation in science and math has been cited as a key factor in failure to complete college. Although these trends are national and not unique to Maine, it is a key area of concern.

At all grade levels, student achievement in math and science is somewhat discouraging. In 2009, 65% of grade 5 students met or exceeded the state standard in mathematics. This decreased to 53% of 8th grade students and only 41% of 11th grade students. Particularly striking is the decrease in 11th grade MHSA mathematics and science scores compared with 5th and 8th grade MEA scores. High school students are not making sufficient progress in STEM skills to achieve success in college or the STEM workforce.

There is some good news in small increases from 2006-2007 to 2008-2009 in the percentage of students who met or exceeded the math standards at all three reported grade levels. Only grade 8 science achievement dropped slightly in the timeframe studied.

Among the key findings of this report are factors that show effects on student performance:

- **Ethnicity.** Significant variation by ethnicity persists. The achievement rates in grade 5 mathematics for African American/Black, American Indian or Native Alaskan, and Hispanic students are all 13 percentage points or more below the state’s overall average rate and the rates for Caucasian/White or Asian/Pacific Islander students. Very similar patterns of results according to ethnicity repeat in the data for all grade levels reported, for both science and math.

- **Economic Disadvantage.** In 2008-2009, about 40% of grade 5 students, 36% of grade 8 students, and 25% of grade 11 students were identified as economically disadvantaged. Economic disadvantage was clearly tied to reduced achievement in both science and math. The disparity in achievement for economically disadvantaged students compared with their counterparts is even more pronounced in higher grades. Less
than one quarter of economically disadvantaged students meet standards in math at the 11th grade level.

- **Geography.** Regional data show that students in Aroostook and Washington superintendent regions achieve proficiency at rates roughly 10 percentage points lower than students in the Cumberland and York superintendent regions, with the other regions between these extremes.

A pattern of improvement in science from grade 5 to grade 8 exists to at least some extent across all superintendent regions, although scores drop again from grade 8 to grade 11. Formal science courses often begin in the middle grades, whereas teachers in grades 1-5 often teach all subjects.

MEA and MHSA are state tests. Maine also participates in the National Assessment of Education Progress (NAEP), also referred to as the Nation’s Report Card, as required by the U.S. Department of Education. This provides national comparison data for grades 4 and 8 (grade 12 is currently being piloted and there is no Maine data yet). In 2009, 45% of Maine 4th graders and 35% of Maine 8th graders were proficient or above in mathematics based on NAEP. This is much lower than the state assessment results; 53% of Maine 8th graders met the state math standards the same year. Maine’s grade 8 mathematics standard maps to NAEP Basic level. Even though fewer students meet the national proficiency standard than the state one, Maine is ranked 9th nationally in grade 4 math and drops to 20th at grade 8. In science, Maine ranks 7th (42% proficient or better) at grade 4, and 19th (35% proficient or better) at grade 8. This drop relative to other states is surprising when compared with the increase in positive results on state standards from grade 5 to grade 8.

Overall, Maine is above the national average in student math and science proficiency. However, this achievement level is not where students need to be to perform well in STEM careers.

### Teacher Qualifications & Preparedness

No effort to build a baseline picture of STEM activities in the state would be complete without a thorough review of teachers at the K-12 level who provide instruction in science and math. The *Maine STEM Landscape Technical Assistance: K-12 Certification Endorsements, 2009-2010* report builds a baseline picture of STEM educator endorsements in Maine. *Teachers of Science in Maine Schools, Grades 1-12: A Descriptive Study* examines the educational background, content knowledge, and teaching status of K-12 science teachers in Maine, using surveys developed by Maine’s Energy Education Future (MEEF) and the Maine Experimental Program to Stimulate Competitive Research (EPSCoR) at the University of Maine at Orono.

**STEM Endorsements in the Classroom and Administration:**

Of the 16,378 K-12 classroom teachers and special education teachers in Maine in 2009-2010, 2,633 (16.1%) were STEM-endorsed teachers who did not also hold a position as an administrator. While the vast majority of STEM endorsements are classroom teachers, there is also representation of STEM-endorsed educators in school administration. Fourteen superintendents hold STEM endorsements, and overall 158 male and 105 female administrators hold STEM endorsements.

Student-educator ratios for 2009 for educators with STEM endorsements ranged from 82:1 in the York superintendent region to 61:1 in the Aroostook region. These ratios are significantly affected in regions with low numbers of students by relatively few educators achieving endorsements, who may not actually reach a proportionate number of students because of large distances between small schools. For example, there is only one middle level science STEM-endorsed teacher in the Aroostook region, compared with 14 in the Cumberland region.
Of note is a significant number of Computer Technology endorsed educators relative to other topic areas. The Cumberland superintendent region alone has 98 such educators. This data reinforces the commitment Maine has made as a state to integrating technology into education.

**Teacher Preparedness:**

A 2007 National Academy of Sciences report, *Rising Above the Gathering Storm*,\(^\text{11}\) stated that teachers must not only know the content 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 both content and teaching methods, and all teachers need ongoing high-quality professional development.

Based on teacher surveys of science content knowledge and preparation, Maine’s high school science teachers are generally well-prepared to teach science content. However, the data raises questions about the preparedness of middle level, and especially elementary level, teachers for teaching science.

Among the report’s key findings are that none of the elementary teachers held a science endorsement, none majored in science or had a science concentration, only 7% minored in science, and none of the elementary teachers had taken more than three science courses since their BA, compared with half of high school teachers and 22% of middle school teachers.

The lack of preparedness of teachers at the elementary level may be a factor in the lower science achievement of students in grade 5 compared with grade 8. Teacher qualifications are a cornerstone of education improvement, and the lack of science content knowledge held by Maine’s teachers must be addressed in any comprehensive STEM education initiative.

A national study in 1994 found that about one in five teachers taught subjects outside their areas of preparation, and that this was more pronounced in rural areas and for science teachers.\(^\text{12}\) Most national studies of teacher preparedness in science and mathematics focus on middle and high school teachers, including *Rising Above the Gathering Storm*. There is more work to be done to put the data from *Maine STEM Landscape Technical Assistance: K-12 Certification Endorsements, 2009-2010* and teacher preparedness data from *Teachers of Science in Maine Schools, Grades 1-12: A Descriptive Study* in a national context.

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**Maine’s STEM Education Assets and Obstacles**

The Maine STEM Collaborative commissioned the EDC’s *Briefing Paper on STEM Education in Maine* to develop an overview of Maine’s assets and challenges in STEM education along with solid recommendations for moving forward. The following sections summarize the key elements of the EDC report.

The qualitative study combined a review of research on school improvement nationally with interviews of 29 Maine policymakers and important players in the area of STEM education. In the review of national efforts, the report focused on successful national Race to the Top proposals, and on two major factors identified as instrumental to efforts to improve STEM education: (1) instructional quality; and (2) alignment and coherence in the curriculum across the P-16 system.
The responses of the interviewees, who represented local, state, nonprofit, and business sectors, were grouped into seven themes:

- State leadership and coordination
- Maine’s external champions
- Local control and capacity
- P-16 alignment and accountability
- Career and technical education
- Incentive programs
- Teacher preparation and curriculum and instruction

The report provides background and a description of Maine’s assets and obstacles to improvement in each of these key areas. Only one—external champions—was seen as a very strong asset for the state with minimal obstacles. Maine has significant resources devoted to STEM educational programs, as the state’s abundant natural resources and industry growth sectors have spurred the development of a number of projects and institutes to promote STEM research and education. In other areas, Maine’s current landscape has specific local areas of strength, but lacks coordinated statewide structures and systemic depth. In short, the Maine STEM education landscape has peaks of excellence separated by difficult terrain.

**Maine’s School Improvement Efforts:**
Maine has seen mixed results in efforts to improve the public educational system. Among its biggest successes is the Maine Learning Technology Initiative, which has placed a laptop computer in the hands of each seventh and eighth grade student and all teachers in grades 7-12. The program, designed to use technology to enhance learning, is also meant to improve online resources for teacher development.

Maine participates on a regional and national level to align standards and assessments and is one of 46 states that have adopted the Common Core State Standards. From Math and Science Partnerships that provide targeted professional development in STEM subjects, to a new federal grant to improve its student and teacher data tracking system, the Maine DOE is moving forward on multiple projects that align with STEM education objectives. Significant funding and staff reductions at the Department of Education since the 1990s have reduced its capacity and caused some setbacks in the implementation of state initiatives. Obstacles to implementation of the state standards, the Maine Learning Results, have included limited professional development and the DOE’s requirement that local school districts develop sophisticated local assessments.

As of 2010, Maine had taken limited action in areas that have been identified as critical to educational improvement: 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. Overall, Maine had some strategies in the initial stages, and a number of assets from which to draw in identifying key leverage points for intervention.

**Key Recommendations:**
The recommendations of the EDC briefing paper fall into three areas of improvement: state leadership, P-16 alignment, and instructional quality. The report discusses a wide range of recommendations, with the following being identified as the most critical priorities:

- **Coordinate and invest statewide.**
  - Institute coordinated state management of the educational improvement system by a high-level cross-agency task force. (The Governor’s STEM Council, which was recently formed and met for the first time in December 2011, is tasked with working toward this goal.)
  - Invest state resources in increasing the capacity of the Department of Education, and in supporting local districts in implementing the Common Core standards.
• Align all grades.
  o Build on the P–16 Leadership Council that was established in 2004 to align all grades.
  o Ensure that the university system becomes a partner in P–16 improvement. Define career and college readiness with the university and the community college systems.
  o Build on current dual-enrollment programs and partnerships.

• Prepare teachers better.
  o Introduce incentive programs to attract undergraduate STEM majors to teaching and to entice STEM teachers to teach in hard-to-staff schools.
  o Improve STEM content in pre-service teacher preparation programs.
  o Develop STEM master-teacher-leader programs.
  o Improve teacher professional development to ensure quality instruction.

To succeed, the state needs to establish structures that will enable students to stay in school, take rigorous coursework, enroll and succeed in secondary education, and graduate with the skills necessary for entering STEM jobs. A coordinated state effort must reflect the fact that the future economy of the state is extremely dependent upon its success. 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.

For more information about the Maine STEM Collaborative and to download the complete STEM landscape reports, visit: www.umaine.edu/epscor/STEMCollab.htm.

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1 Maine STEM Landscape Technical Assistance: Mathematics and Science in 5th, 8th, and 11th Grades, Craig Hoyle, Regional Educational Laboratory at the Education Development Center (EDC), August 9, 2010.
2 Maine STEM Landscape Technical Assistance: K-12 Certification Endorsements, 2009-2010, Peter Tierney-Fife, Regional Educational Laboratory at EDC, July 22, 2010. (Draft still in progress.)
3 Teachers of Science in Maine Schools, Grades 1-12: A Descriptive Study, Bill Nave, Ed.D., May 2011.
6 Ibid.
7 Interviews with the presidents of the University of Maine at Augusta and the Community College of Southern Maine. August 2010, cited in Briefing Paper on STEM Education in Maine.
12 The Condition of Education in Rural Schools, Joyce D. Stern, Ed., Office of Educational Research and Improvement, June 1994, p. 34.