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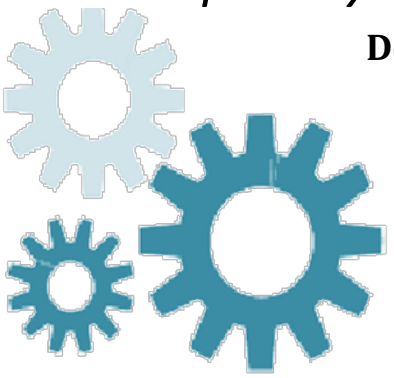
Maine STEM Education and Workforce Plan 1.0

Maine STEM Council

The Maine STEM Education and Workforce Plan 1.0

A Report by The Maine STEM Council

December 15, 2014



Maine STEM Council

www.mainestem.org/stem-council/

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Maine STEM Council

To Maine residents, STEM educators, and STEM-skilled workforce employers,

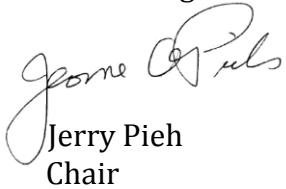
On behalf of the sixteen members of the Maine STEM (Science, Technology, Engineering, Mathematics) Council, I am pleased to present our Plan 1.0 to move Maine forward in STEM education and workforce issues. This plan is the culmination of phase one of the Council's work: to develop initial strategies and identify actions needed to improve STEM education and workforce preparation in Maine, as we were directed by our originating legislation. We have taken this work seriously and relied on research conducted through the University of Maine and the Maine Mathematics and Science Alliance. This research included reviewing STEM reports from other states, studying academic and organizational publications in Maine as well as nationally, and building on the professional knowledge and experience of Council members.

As you read this plan, you will note the variety of recommendations. The plan is designed to generate discussion and promote improvement and collaboration in all quarters, including pre-K-12 education, post-secondary education, and corporate training. We believe that an enhanced STEM workforce is a critical key to a continuously improving Maine economy. The exact wording of our recommendations is not the final outcome. We seek innovative strategies and initiatives that lead to a cohesive, effective, and fruitful STEM education and workforce system for Maine.

One of our next steps is to disseminate this report widely through the professional and personal networks of Council members, and we encourage you to so as well. Any of our Council members or Executive Director (identified in Appendix D) is anxious to present this plan to you and your group. We hope for a robust discussion of these issues.

Finally, I would like to acknowledge a number of the key players who shared in developing this report, with the full knowledge that I may leave some out—that mistake will be mine alone. First and foremost, the membership of the Council from its original cast to today's members have helped to generate our conclusions and strategies. An original member from the University of Maine System, Dr. Susan Hunter, funded an early research team led by Johanna Barrett of the University of Maine. We are fortunate to have the services of Laurie Larsen at the Maine Mathematics and Science Alliance to keep us organized and on track. And Tom Keller, Executive Director, has provided leadership and drive to bring us to this major summit. Thank you all.

Now let's get to work,



Jerry Pieh
Chair

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The Maine STEM Education and Workforce Plan 1.0

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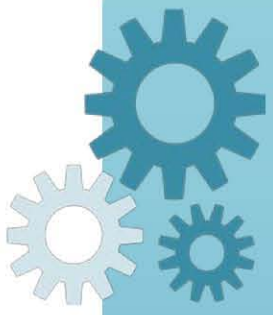

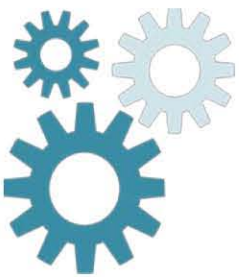

The Maine STEM Education and Workforce Plan 1.0
Maine STEM Council
Executive Summary and Recommendations for Immediate Action

The Maine STEM (Science, Technology, Engineering, and Mathematics) Council was established by an act of the Maine Legislature in 2011 and has sixteen members, eleven of whom are appointed by the Governor and five of whom represent major sectors and organizations (see Appendix D). The Council has engaged in both literature-based research and personal research across a wide variety of reports and topics since its inception. This report, purposefully noted as Version 1.0, points to immediate actions and those of longer term that emerged as a result of analysis and deliberation. The Council intends to use this report to start conversations and stimulate actions at the local, regional, and statewide levels. It is meant to be direct, to cause angst in some quarters, and to surface a fully functioning and effective system of STEM education and workforce in Maine.

This summary notes the goal, subgoals, and those milestones that are of immediate concern and for which immediate actions (during the 2014-2015 academic year) can be taken. The full report provides a rationale for these milestones and others of a longer term. One next action by the Council is to develop a dashboard of indicators to assess progress toward achievement of the milestones.

The overarching goal, as stated in the original legislation, is "*The council shall develop strategies for enhancing science, technology, engineering and mathematics education from prekindergarten through postsecondary education."* Council members have identified five subgoals and numerous milestones that we believe will lead to enhanced STEM education.

Subgoal A. To improve STEM achievement and interest among grades K-12 age students.

> **Milestone 1.** The Maine STEM Council recommends that Maine adopt the Next Generation Science Standards as soon as possible.
>
> **Milestone 2.** The Maine STEM Council recommends that certified teachers in the K-12 system who teach mathematics be required to pass a three-credit course in current mathematics content and pedagogy as part of the six-credit educator recertification process. Similar requirements should be considered for teachers of science, technology, and engineering.
>
> **Milestone 3.** Recognizing the critical importance of reading in the content areas, the Maine STEM Council recommends that the content literacy sections of the Maine Learning Results (Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects) be given significant attention in grades K-12 classrooms, particularly with a focus on STEM subjects.
>
> **Milestone 4.** The Maine STEM Council recommends that out-of-school and afterschool STEM programs across the state be catalogued and that program

providers be provided with opportunities for professional development in STEM content knowledge, pedagogy, and positive youth development.

Milestone 5. The Maine STEM Council recommends that the Maine Department of Education develop stakeholder-based content advisory committees in STEM (including computer science) content areas. The Maine Department of Education, with input from the stakeholder-based content advisory committees, should develop and actualize implementation plans for STEM subjects.

Subgoal B. To increase the percentage of students completing post-secondary degrees or certificates in STEM.

Milestone 1. The Maine STEM Council recommends that University of Maine System and the Maine Community College System initiate or expand system-wide professional development in research-based best classroom practices for instructors of STEM courses.

Milestone 2. The Maine STEM Council recommends that the Maine Department of Education gather and report data on remediation courses in STEM subjects at all public higher education institutions and cite best practices for overcoming remediation.

Subgoal C. To better align secondary (including Career and Technical Education) and post-secondary training with the state's workforce needs.

Milestone 1. The Maine STEM Council recommends that Maine develop a one-stop clearinghouse for internship opportunities, perhaps building off the Maine State Chamber of Commerce InternHelpMe.com and Educate Maine's efforts.

Milestone 2. The Maine STEM Council recommends that all Maine residents know about vocations and avocations in STEM.

Milestone 3. The Maine STEM Council recommends that a regular survey of Maine's top businesses and economic growth clusters be undertaken to assess their workforce needs in terms of STEM and other skills and knowledge.

Subgoal D. To create conditions across sectors in the state that promote STEM education and careers.

Milestone 1. The Maine STEM Council recommends that the Legislature consider ways to facilitate high school student participation in scientific endeavors at research labs through reducing liability of working in laboratories.

Milestone 2. The Maine STEM Council recommends that cognizant Maine agencies collaborate on STEM education and workforce issues. For example, there should be regular communication channels about STEM education and workforce issues:

- Among MDOE, UMS, MSSA, MPA, MEA, MCLA, MSTA, ATOMIM, MACTE, TEEAM and other important players.
- Among MDOL, MDF, Maine State Chamber, MTI, Coastal Enterprises, and other major economic development focused organizations.
- Between both groups identified above.

Milestone 3. The Maine STEM Council recommends that Maine recruit and retain talent though development of support systems for individuals and families moving to Maine, with the collaboration of the Maine Development Foundation and the Maine State Chamber of Commerce.

Subgoal E. To broaden opportunities for currently underrepresented populations of low income, first-generation college and minorities, including females, in all fields of STEM education and workforce.

Milestones are to be developed.

I. Introduction

The Maine STEM (Science, Technology, Engineering, and Mathematics) Council was established by an act of the Maine Legislature in 2011 with one goal and five explicit actions:

> The Council shall develop strategies for enhancing science, technology, engineering and mathematics education from prekindergarten through postsecondary education and:
>
> A. Review research that has been conducted on science, technology, engineering and mathematics education in the State and recommend strategic directions for consideration by policymakers as they identify future investments in science, technology, engineering and mathematics;
> B. Plan for coordinated state leadership with respect to science, technology, engineering and mathematics education and initiatives;
> C. Develop initiatives to promote science, technology, engineering and mathematics education;
> D. Devise strategies for promoting career and technical education alignment and supporting early career planning and transition supports from high school to college and to the workforce; and
> E. Propose methods for integrating out-of-school programs focused on science, technology, engineering and mathematics with school-based programs, with the goal of inspiring more students to concentrate in the fields of science, technology, engineering and mathematics.

This report is Version 1.0 in response to the given goal of "…develop strategies for enhancing science, technology, engineering and mathematics education from prekindergarten through postsecondary education…" in Maine. Each of the five additional goals (A–E above) is addressed through the plan and its milestones. The concepts of these are captured as an integrated whole rather than an analytic response so subgoals and milestones in this report do not necessarily fall neatly under one of the A–E goal statements and in fact may address two or more.

The Council has also taken into account three additional elements. First, while education remains a focus, the Council also recognizes in developing this plan the importance of linking its plans to workforce and economic development initiatives. Second, the Council has adopted a broad definition of STEM that includes both those fields that require a college education and technical fields ranging from plumbing to medical technology to welding and other fields that may not require a bachelor's degree. Third, the Council is well aware of the low numbers, rural, scattered, and diverse nature of Maine's population and its engagement with STEM. As a result, we are learning from other states' plans and reaching out to other states with planning efforts as we seek to build a set of prioritized plans appropriately unique to Maine.

It is expected that other versions of this report will be generated in future years as actions are taken, steps are completed, and new data become available. This, then, is Version 1.0.

The report has three major sections, ranging from a scan of the national and federal landscape for STEM education to reports of other groups in Maine to specific recommendations to be accomplished in Maine. The Council has benefitted from work by STEM councils and STEM organizations in other states, has undertaken an analysis of state and national reports, and has developed a unique set of recommendations. This report will also point to the recommendations and metrics of other state reports in an attempt to present a comprehensive approach rather than being yet another report about Maine's status and possibilities.

This report will summarize the current status of STEM education at the national and federal levels, seek coherence across a variety of education and workforce agendas in Maine, and set some benchmarks. Throughout these sections, we will propose actions that the STEM Council and other organizations should undertake to enhance STEM education from prekindergarten through post secondary education, always with the dual outcomes of increased interest and appreciation of STEM education and enhanced skills and knowledge of the STEM workforce.

A typical goal for STEM education and workforce centers on those individuals who reach the summit with a PhD or other advanced degree. The Maine STEM Council has chosen a broader definition, recognizing the need for and value of two additional levels of STEM expertise. One level includes that same top level of research and development scientists and engineers. A second level, much larger in number than the top level but equally important, is support and engagement in STEM careers in everyday life. These people include many occupations as varied as pharmacists, pharmacy technicians, welders, electricians, electronics repair specialists, bankers, and machinists. This level requires advanced training and certification beyond a high school diploma and numbers probably two or three orders of magnitude more than the number of bench or research scientists. The third level is the individual resident and their need to know enough about STEM to function well within a democracy that addresses issues such as climate change and energy policy. Each person in Maine needs to have a basic level of scientific and mathematical literacy as defined by the Maine Learning Results in science, technology, engineering, and mathematics (including computer science). It is also imperative that each person in Maine be competent in the Guiding Principles of the Learning Results—these are: a clear and effective communicator, self-directed and lifelong learner, creative and practical problem solver, responsible and involved citizen, and an integrative and informed thinker.

The final general outcomes proposed by the Maine STEM Council are two: one is to have a workforce that is interested in, competent with, and excited by STEM employment. The second is that the whole population of Maine appreciates STEM as a creative enterprise, an opportunity for learning, important to their lives and for enjoyment. 'STEM' should not be associated only with simple rote information retrieval. In addition to employment, STEM

offers fun activities such as beekeeping, robotics, and origami. These two outcomes are necessary for an attractive, vibrant, exciting State for current and future residents.

II. A Scan of STEM Across the Nation

Two efforts of the executive branch of the federal government are of most use to Maine STEM planning. First, the President's Council of Advisors on Science and Technology (PCAST) has issued several reports on various segments of the education and workforce systems that provide 'big picture' views embedded with concrete recommendations. They have released ***Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*** (2012) and ***Prepare and Inspire: K-12 Science, Technology, Engineering, and Math (STEM) Education for America's Future*** (2010).

The second effort is a Federal STEM Education 5-Year Strategic Plan, which was begun in May 2013. Through this Plan and Federal agencies' implementation efforts, the intention is to achieve significant, measurable impacts in five priority STEM education investment areas:

(1) improve (grades) P-12 STEM instruction;
(2) increase and sustain youth and public engagement in STEM;
(3) improve undergraduate STEM education;
(4) better serve groups historically underrepresented in STEM fields; and
(5) design graduate education for today's STEM workforce.

These two efforts corroborate the work of the Maine STEM Council, elaborate the reasons and rationales for this work, and provide models for how to accomplish it. The Federal STEM Education Plan is co-chaired by the Assistant Director for Education and Human Resources of the National Science Foundation and the Deputy Director for Technology and Innovation, Office of Science and Technology Policy, White House and has membership from the US Department of Agriculture, Department of Commerce (NOAA), Department of Defense, Department of Education, Department of Energy, Department of Health and Human Services (NIH), Department of Homeland Security, Department of the Interior, Department of Transportation, Environmental Protection Agency, and NASA. In a similar way, the Maine STEM Council has membership from the Maine Department of Education, Department of Labor, Maine State Board of Education, and business and education organizations.

The federal plan has five key indicators:

1. Percentage of high school mathematics and science teachers who hold degrees in their teaching field or in science or mathematics education.
2. Numbers of STEM bachelor's degrees earned annually.
3. Percentage of bachelor's degrees awarded to women, black or African American, Hispanic, and American Indian or Alaska Native students.
4. Teachers' science and mathematics content knowledge for teaching.
5. Numbers of STEM graduate students at institutions by mechanism of support and

supporting federal agency.

Tracking these indicators will provide Maine with measures of validity and reliability. Iowa and Massachusetts have emerged as leaders in STEM education policy and implementation at the statewide level. Their plans and their planning and implementation processes are models for us to learn from. While Maine does not have technological innovation to the scale of the 'Route 128 companies' in Massachusetts or the huge businesses of John Deere and Monsanto in Iowa, Maine does have STEM education and business assets. One of our advantages is that we are small enough for 'one degree of separation,' facilitating collaboration rather than competition. The Maine STEM Council recognizes that we can learn from other states such as Iowa and Massachusetts and should join with productive regional and national efforts.

Iowa's plan has four goals and eighteen indicators. These are detailed in Appendix B.

Similarly, Massachusetts has five goals with benchmarks and metrics. These are detailed in Appendix C.

III. The Case for Maine

Drawing on these national resources plus pioneering efforts and previous work done in Maine, the STEM Council developed this first plan to prepare Maine people for the future economy in STEM fields. Looking across these, the Council has identified five subgoals:

A. To improve STEM achievement and interest among grades K-12 age students.
B. To increase the percentage of students completing post-secondary degrees or certificates in STEM.
C. To better align secondary (including Career and Technical Education) and post-secondary training with the state's workforce needs.
D. To create conditions across sectors in the State that promote STEM education and careers.
E. To broaden opportunities for currently underrepresented populations of low income, first-generation college and minorities, including females, in all fields of STEM education and workforce.

Our proposed subgoals tie well into those of other groups doing similar work in Maine, a selection of which is included below.

The **Maine Technology Institute** (MTI), for example, has a mission that includes "encouraging, promoting, stimulating, and supporting research and development activity leading to commercialization of new products and services in the State's technology-intensive industrial sector." In a recent analysis for MTI conducted by the Battelle Technology Partnership, 13 technology clusters were identified along with identification of detailed product/service market growth opportunities within these clusters.

Each of these 'market growth opportunities' has need for a strong grades K-12 STEM education system and a relevant post-secondary training system. The Maine STEM Council urges that the Maine Technology Institute collaborate with us on successful implementation of this plan.

The **University of Maine System** issued a report in December 2011 titled "STEM in the University of Maine System: An overview of STEM education activities and research in the UMS." The main body of this report is an inventory of STEM-related activities at each of the seven campuses, but it also identifies six system-wide initiatives. These are:

- University-Business Information and Computer Science Partnership
- Nursing and Allied Health
- Sustainable Energy Education
- STEM Initiative
- Innovation Engineering
- Undergraduate Research Symposiums

The University of Maine and Bangor High School have developed an apprentice research program that engages 15-20 students per year in science and engineering practices with university- or industry-based mentors. This mentorship, which is an integral part of Bangor's STEM Academy, has attracted underrepresented minorities, including females, to STEM, engaged students in real world applications, and encouraged students to participate in scientific discovery and engineering practices. Several students have participated and received national and international awards.

Clearly the University of Maine System is an important player in Maine's STEM education and workforce systems. System-wide initiatives are an excellent way to build community and develop collaborations provided they are sustained. It is important to call attention to issues and it is equally important to maintain effort to overcome obstacles.

Methods and incentives for better coordination from secondary (including Career and Technical Education centers) through post-secondary (including community colleges and universities) education are needed. We must have more cooperation and less competition between learning institutions. A barrier to further development is the many policies that are institution based and not student or system based. Secondary schools need to give credit for work students accomplish at Career and Technical Centers—currently this is a decision made by the principal at each sending school. Students should be able to obtain credit for work outside of the four walls of school such as jobs that involve STEM and internships. Universally transferable credits for college courses taken at community college in the UMaine system remain a hurdle. The current system of individually negotiated articulation agreements are costly in time and money to the sending school's administration and their students and is discouraging in its bureaucracy when students learn that courses they have taken at one campus may not be credit-worthy at another campus.

In a more general view, the **Maine Economic Growth Council**, housed at the Maine Development Foundation, released "Measures of Growth In Focus 2014" on March 11,

2014. This is the 20th annual edition of this report that measures progress on 27 indicators that are meant to provide a comprehensive view of Maine's economy. Five indicators are particularly salient to our work in STEM:

- High Speed Internet Subscribers: Maine will reach the New England level of high-speed Internet subscribers by 2015.

- Higher Degree Attainment: The percentage of Maine residents age 25 and over with a higher degree will increase to at least the New England average by 2020. (*Note: By emphasizing multiple pathways instead of a single four-year college trajectory, the STEM Council believes that we can increase the success rate. Programs such as "The Bridge Year" that give students a head start on college and reduce their expenses need to be replicated and expanded across Maine.*)

- Fourth Grade Reading Scores: Maine's share of students scoring proficient and above will reach 50% by 2015.

- Eighth Grade Math Scores: Maine's share of students scoring proficient and above will reach 50% by 2015. (*Note: Without better training and professional development of teachers of math and science, especially in elementary schools, the STEM Council expects that little progress will be made. It is well known that students learn math phobia early and this comes from teachers (and parents) who are not comfortable and competent in teaching mathematics. Similarly, science becomes fact driven rather than concept and inquiry driven.*)

- Workforce: Maine's workforce will grow to 771,000 by 2020.

The Maine STEM Council commends the work of the Maine Economic Growth Council and urges that the two councils collaborate on successful implementation of this plan.

Educate Maine, a group comprised of business representatives and educators, issued a report titled "Education Indicators for Maine: 2013." Educate Maine has the goal that by 2023, 50% of Maine people will have a high-quality college degree, certificate, or industry credential. Relevant measures that are provided in this report include fourth grade and eighth grade proficiency on National Assessment of Educational Progress (NAEP) in reading and math (same as the Maine Economic Development Council), high school graduation, college enrollment, and college graduation, as well as other measures.

The Maine STEM Council commends the work of Educate Maine and urges that the two groups collaborate on successful implementation of this plan

In December 2010, the **Maine Department of Education** issued a Statewide Strategic Plan for Science, Technology, Engineering and Mathematics. This plan was finer-grained than the ones discussed earlier and has three goals:

STEM Achievement: Overall student achievement in science, mathematics, engineering and technology demonstrates a gain of 15 percentage points within four years as measured by the combined percentage of students who "meet" and "exceed" expectations on State assessments of science and mathematics.

STEM-related Careers: The number of students interested in pursuing STEM-related careers increases by 15 percentage points (from 33% to 48%) within four years, as reported on the PSAT and SAT student surveys; and the number of Maine students who graduate from two-year and four-year engineering and STEM-related programs statewide increases by 10%.

STEM Grants: The STEM initiatives of the Department of Education and the STEM Collaborative, which includes governmental, non- profit and business partners, are coordinated and three million dollars in federal grants is secured by the Department of Education to support STEM learning and growth in the State.

Of the twenty-nine key activities, the report lists five that have dates after 2014. Still, most of these key activities have not yet been successfully completed.

The **Three Ring Binder** project was a $25M effort funded through the National Telecommunications and Information Administration to create an open-access fiber-optic network across the whole state of Maine. It was titled "Three Ring" since one ring addressed the northern most part of the state, a second ring Downeast Maine, and the third ring western Maine, with the goal of linking unserved and underserved communities to a modern network. This middle mile provision of fiber-optic cable laid the potential for bringing cost-effective, high-speed broadband to these areas. This project has left the issues of final mile connection as well as service to areas that do not comprise the three rings but still are rural and disadvantaged.

Many other reports were analyzed for this report and deserve mention. The Education Development Center in Newton, MA conducted a landscape study that is especially valuable. The University of Southern Maine's Center for Education Policy, Applied Research and Evaluation issues regular reports that are of interest, including research briefs and reports. An unpublished research report by Bill Nave ("Teachers of Science in Maine Schools, Grades 1-12: A Descriptive Study," May 2011) is another rich resource. The Maine Campus Compact completed a study of STEM in Maine high schools and universities in 2014.

IV. Maine STEM Council Plan and Recommendations

This section of the report is a narrative report of discussions and data gathered by the Maine STEM Council pertaining to its original goal and actions. These include developing strategies for enhancing STEM education from prekindergarten through postsecondary

education, reviewing State research, recommending strategic directions for policymakers to consider, planning for coordinated state leadership, developing initiatives to promote STEM education and devising strategies for promoting career and technical education alignment, supporting early career planning including transition support from high school to college to the workforce, and proposing methods for integrating out-of-school programs with school-based programs. This extremely comprehensive examination of STEM education and workforce issues covers several large arenas including preK-12 schooling, career and technical education, 2-year and 4-year post-secondary schooling, out-of-school learning, and conditions for improving STEM education and workforce development.

The Maine STEM Council has approached this work as having one goal with five subgoals. The overarching goal, as stated in the legislation, is "*The council shall develop strategies for enhancing science, technology, engineering and mathematics education from prekindergarten through postsecondary education."* As indicated, we have expanded the charge to include youth and adults, not just students in the education system as well as implications of STEM education in workforce development and set five subgoals as:

A. To improve STEM achievement and interest among grades K-12 age students.
B. To increase the percentage of students completing post-secondary degrees or certificates in STEM.
C. To better align secondary (including Career and Technical Education) and post-secondary training with the state's workforce needs.
D. To create conditions across sectors in the state that promote STEM education and careers.
E. To broaden opportunities for currently underrepresented populations of low income, first-generation college and minorities, including females, in all fields of STEM education and workforce.

Milestone Recommendations for Subgoal A

The first subgoal of this plan focuses on improving STEM achievement and interest among grades K-12 aged students. The Maine STEM Council has a number of recommendations and suggestions regarding this subgoal. The major recommendations are listed in the table found in Appendix A.

Milestone 1. The Maine STEM Council recommends that Maine adopt the Next Generation Science Standards as soon as possible. This recommendation requires immediate action.

Rationale: Maine was one of the twenty-six states that came together to develop this set of standards based on recommendations from the National Academy of Sciences. Not only has this set of standards been judged to be superior to our present science standards, but also fourteen states have already adopted them, as have many districts in Maine. With standards-based proficiency graduation deadlines looming starting in 2018, Maine educators need to gear up immediately to prevent having to shift standards during implementation of these new graduation requirements. In fact many school districts have used the NGSS as the basis for their K-12 graduation

standards and performance indicators as well as the plethora of resources the national group has made available.

One of the many reasons for adoption and implementation of the Next Generation Science Standards is the prominent role that engineering takes in the standards. This is very consistent with Maine's priorities for economic growth, and opens up options for Maine's male and female students.

Milestone 2. The Maine STEM Council recommends that certified teachers in the K-12 system who teach mathematics be required to pass a three-credit course in current mathematics content and pedagogy as part of the six-credit educator recertification process. Similar requirements should be considered for teachers of science, technology, and engineering. This recommendation requires immediate action.

Rationale: With the adoption and implementation of revised standards, teachers' currency in how to use and implement conceptual and instructional shifts is called into question. The current system of recertification allows for taking 'off topic' training when the most significant changes in STEM instruction in the past fifteen years have been proposed. Our educators, including classroom teachers and administrators, must understand these changes, work with each other to implement them and have school, district, and state support in doing so.

The Council also recognizes that the large majority of elementary school teachers teach both math and science. With the current testing requirements, instruction time for subjects other than math and reading has been reduced. The teaching of science in the grades K-5 school years has tremendous power for keeping students in STEM trajectories, and without such teaching, those students will be lost.

Milestone 3. Recognizing the critical importance of reading in the content areas, the Maine STEM Council recommends that the content literacy sections of the Maine Learning Results (Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects) be given significant attention in grades K-12 classrooms, particularly with a focus on STEM subjects. This recommendation requires immediate action.

Rationale: The ability to read and comprehend literature and technical material is absolutely essential. It is no longer sufficient to have some capacity with just American or British literature; now people of all ages must be able to read and understand technical manuals, complex directions, and detailed reports. For too long, this type of reading has been assumed to be happening but is now the mission of all teachers in schools. This is not a call for science teachers to become reading teachers but for English teachers, for example, to understand the needs and methods of teaching reading in technical subjects. This requires leadership at the school, district, and state levels. The work of Maine's Cross Disciplinary Literacy Network exemplifies first steps. But this work must be expanded to each classroom in Maine.

Indeed, professional development opportunities are necessary for teachers at all levels and types of school. One professional development activity, conducted statewide for efficiency, is the development of a crosswalk between the Maine Learning Results/Common Core and the National Industry CTE standards and the Next Generation Science Standards. Literacy initiatives that include literacy training for content area teachers in STEM and CTE need to be expanded and made affordable.

Milestone 4. The Maine STEM Council recommends that out of school and after school STEM programs across the state be catalogued and that program providers be provided with opportunities for professional development in STEM content knowledge, pedagogy, and positive youth development. This recommendation requires immediate action.

Rationale: According to data from the National Academy of Sciences (Learning Science in Informal Environments, NRC, 2009), grades K-12 students spend 81.5% of their waking hours outside of a school classroom. This out of school time then provides more than four times as much opportunity for learning as the formal school classroom. Children could use this time, on their own or with a range of adults in their lives, to follow their interests in areas like robotics, farming, weaving, or backyard astronomy.

Adults in after school and out of school programming such as 4-H, Girls and Boys Clubs, 21st Century Learning Community projects, science centers, nature centers, libraries, community centers, etc. could support these children in following their interests in STEM. This would require adults to have access to sustained and ongoing professional development in STEM knowledge and practices, as well as youth development.

Milestone 5. The Maine STEM Council recommends that the Maine Department of Education develop stakeholder-based content advisory committees in STEM (including computer science) content areas. The Maine Department of Education, with input from the stakeholder-based content advisory committees, should develop and actualize implementation plans for STEM subjects. This recommendation requires immediate action.

Rationale: Built on the model of Program Advisory Committees (see descriptions at http://www.nd.gov/cte/forms/docs/AdvisoryCommitteeGuide.pdf or http://www.skylinecollege.edu/cte/cteprogadvcommittee.php of how these work) at Career and Technical Education centers, these groups will provide ideas and feedback to MDOE staff, serve as resources to their colleagues in the field, and help support implementation of science, technology, engineering, and mathematics curriculums throughout all of Maine's schools. This will be an opportunity for the MDOE to establish a base of informed ambassadors, to create reasonable plans that support implementation, and to provide opportunities for current educators to provide input, ideas, and feedback.

Implementation of standards would be greatly facilitated by stakeholder-informed plans and strategies being developed and widely disseminated.

Milestone 6. The Maine STEM Council recommends that incentives be provided to new and existing teachers of STEM subjects who are accredited in their content areas at the Bachelors level and beyond. Incentives include tuition reimbursements or additional stipends.

Rationale: The role of the teacher and her or his expertise in the content area has been well documented as being key to student success. This is especially important in the fields of science and mathematics considering the recent implementation of standards that focus on specialized content knowledge and pedagogical content knowledge (how to teach that subject well). This recommendation applies largely to teachers who hold grades 7 to 12 certification since these tend to be content area specialists. While deep and broad knowledge of the content area is necessary, it is not sufficient when considering the art of teaching. This recommendation is coordinated with the recommendation above that in-service teachers of math and science have regular updating as part of their recertification and a recommendation below that undergraduate STEM teaching be improved.

Milestone 7. The Maine STEM Council recommends that the Maine Department of Education develop, with the guidance of a stakeholder-based content advisory committee, a professional teaching endorsement for teaching computer science.

Rationale: Currently there is an endorsement (number 680) for teaching Computer Technology K-12. The preparation for this endorsement involves incorporating technology into the instructional process, examining issues relevant to the role of technology in public schools, and using educational software to develop, implement, and assess classroom lessons. Computer science, on the other hand, involves learning to code and program, development of animations and applications, and using programs to run machines. By creating this endorsement, the educational system will be responding to the business sector's plea for more employees competent in computer science.

Milestone Recommendations for Subgoal B

The second subgoal of this plan focuses on increasing the percentage of students completing post-secondary degrees or certifications. The Maine STEM Council has a number of recommendations and suggestions regarding this subgoal.

It is noteworthy that the STEM Council operates on the understanding of three levels of STEM knowledge. One level is the need for highly academic or research based personnel. These are typically the pinnacles of education, but employment is relatively limited for those with doctorate and other advance degrees. While the STEM Council acknowledges their contributions, the Council also recognizes that another level of knowledge is at the more technical level. Laboratory technician, welding, medical assistant, electrician, and

machinist are examples of careers that also depend on a solid knowledge of STEM subjects. And these positions are in high demand for both direct service and for support of the doctoral level careers. These careers require some level of post-secondary training though not necessarily a Bachelor level degree. The third level is the need for all residents of Maine to be STEM literate as was demonstrated by the recent controversy regarding Ebola quarantine requirements.

Milestone 1. The Maine STEM Council recommends that the University of Maine System and the Maine Community College System initiate or expand system-wide professional development in research-based best classroom practices for instructors of STEM courses. This recommendation requires immediate action.

> *Rationale:* Much improvement has been made in the teaching of undergraduate STEM courses as is described in the 2012 volume from the National Academy of Sciences titled "Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering Research." This volume "clearly shows that research-based instructional strategies are more effective than traditional lectures in improving conceptual knowledge and attitudes about learning. Effective instruction involves a range of approaches, including making lectures more interactive, having students work in groups, and incorporating authentic problems and activities." (page 3)
>
> In Maine, we have a tremendous opportunity due to our small population to build a learning community of higher education faculty that focuses on teaching and learning to a much greater extent than is found today. Indeed, Maine could become a national leader in this at the 2-year and 4-year institutional level through development and implementation of a professional learning community that elevates the quality of teaching to equal importance with academic scholarship.
>
> This is an opportunity as well to partner with private higher education institutions in the state such as Husson University, the University of New England, Bates College, Bowdoin College, Colby College, St. Joseph's College, Unity College and Thomas Collage to make effective, useful and 21st century learning the centerpiece of a college experience.

Milestone 2. The Maine STEM Council recommends that the Maine Department of Education gather and report data on remediation courses in STEM subjects at all public higher education institutions and cite best practices for overcoming remediation. This recommendation requires immediate action.

> *Rationale:* Developmental classes are taught at many of the University of Maine's seven campuses and the Maine Community College System's seven campuses. These courses, designed to improve the academic backgrounds of students, are usually taught in mathematics and English. Percentages of students taking these non-credit bearing courses are very high at some campuses. The Council suggests that data be

gathered from each campus as to their rate of remediation, the longitudinal effect and, where positive results are found, the sharing of best practices.

It is possible that a mechanism could be established by the third year of high school to determine whether a student will need this remediation. Then low-cost courses could be provided in high school or adult education, saving students the cost of college courses without credit.

Milestone 3. The Maine STEM Council recommends that Maine's institutions of higher education increase the levels of partnerships with research and non-profit organizations in Maine, possibly through credit bearing research and teaching internships.

Rationale: Maine has a richness of scientific organizations such as the Jackson Laboratory, Bigelow Laboratory for Ocean Sciences, Mt. Desert Island Biological Laboratory, Maine Medical Center, and the Foundation for Blood Research. Greater collaboration between these organizations and institutions of higher education including the private colleges should lead to increased student and faculty interest in STEM research and careers.

Milestone 4. Recognizing the critical importance of reading in the content areas, the Maine STEM Council recommends that the content literacy sections of the Maine Learning Results (Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects) be given significant attention in higher education classrooms, particularly with a focus on STEM subjects.

Rationale: An assumption is often made that by the time a student reaches post-secondary training he or she has learned how to read and comprehend written materials in their content field. We believe that providing training in reading in the content areas in colleges and universities for all students will reap benefits in deeper understanding, improve retention of both student interest and students, and provide additional support for learning.

Indeed, instruction in technical reading and writing needs to occur at all grade levels. The Maine Learning Results/Common Core requires this but additional teacher preparation is necessary to accomplish it. Perhaps literacy coaches employed by many school districts may need to increase the emphasis on technical reading and writing.

Milestone Recommendations for Subgoal C

The third subgoal of this plan focuses on aligning secondary (including Career and Technical Education) and post-secondary training with the state's workforce needs. The Maine STEM Council has a number of recommendations and suggestions regarding this subgoal.

Milestone 1. The Maine STEM Council recommends that Maine develop a one-stop clearinghouse for internship, pre-apprenticeship, and apprenticeship opportunities, perhaps building off the Maine State Chamber of Commerce InternHelpMe.com and Educate Maine's efforts. This recommendation requires immediate action.

Rationale: As it now stands, there is no single place for students to learn about internships, pre-apprenticeships, or apprenticeships or for those providing such opportunities to learn about other programs. If Maine is to take full advantage of internships, it is necessary for all Maine residents to have access to the information. Such a clearinghouse could also serve as a nexus to conduct training for those providing internships to maximize the opportunities.

Milestone 2. The Maine STEM Council recommends that all Maine residents know about vocations and avocations in STEM. This recommendation requires immediate action.

Rationale: The terms "STEM" and "STEM education" are probably used in the education world more frequently than in everyday usage. The concept that one 'is good or not good' in math or science may have contributed to the rise of STEM to become more of a genre of careers and aspirations. The bottom line is that economic development in any of the thirteen clusters identified through the Maine Technology Institute is squarely dependent on a populace comfortable and competent in science, mathematics, technology, and engineering, as a process and a body of knowledge.

As an economic driver, the three levels of STEM careers and competencies—research or bench scientists or engineer with a fully professional degree; those who have skills or knowledge but work in more technical roles; and those who use a knowledge of science or math in their everyday lives as productive and informed citizens—are requisite.

Achievement of this milestone could be accomplished through a general information campaign through various modes of media or specific undertaking such as televising the Maine State Science Fair as is currently done for the Maine state basketball tournaments. Robotics competitions, the statewide Skills_USA championship, and many other academic and technical activities need more visibility. Many people do not know about these pockets of great student-focused events.

This is an opportunity as well to reach out to populations underrepresented in STEM fields and areas of study. Maine cannot afford to squander the intellectual resources of all of its residents including females and those with low incomes.

Milestone 3. The Maine STEM Council recommends that a regular survey of Maine's top businesses and economic growth clusters be undertaken to assess their workforce needs in terms of STEM and other skills and knowledge. This recommendation requires immediate action.

Rationale: The Maine Department of Labor has done an excellent job in correlating post-secondary degree attainment with income through its Center for Workforce Research and Information (see http://www.state.me.us/labor/cwri/wdqi/index.html). "Degree", however, may be too blunt of a measure to determine the actual skills and knowledge needed to succeed in Maine business. Examining the options for computer science reveals that Northern Maine Community College offers an Associates degree in "Computer Info Systems," the University of Maine at Augusta offers an Associates degree and a Bachelors degree in "Computer Information Systems" and a Bachelors degree in "Computer Information Systems-P". Regarding "Computer Science," the University of Maine at Fort Kent offers an Associates degree, as does Kennebec Valley Community College; the University of Maine at Orono offers a Bachelors, as does the University of Maine at Farmington; and the University of Southern Maine and Kennebec Valley Community College also offer a certificate.

Inviting leading Maine businesses to a roundtable to identify the skills and knowledge needed and then providing these specifications to our secondary and post-secondary institutions should provide the desired workforce. Perhaps this is already being done but we were unable to uncover much evidence of this effort. One such dialogue is occurring between the Sanford Regional Technical Center and local business such as Pratt and Whitney.

Milestone Recommendations for Subgoal D

The fourth subgoal of this plan focuses on improving conditions across sectors that promote STEM education and careers. The Maine STEM Council has a number of recommendations and suggestions regarding this subgoal.

Milestone 1. The Maine STEM Council recommends that the Legislature consider ways to facilitate high school student participation in scientific endeavors at research institutes through reducing the liability of working at such facilities. This recommendation requires immediate action.

Rationale: One of Maine's unique strengths is its scientific and research capabilities and the motivation of scientific staff to engage in education of high school aged students. Currently, Bigelow Laboratory for Ocean Sciences and the Jackson Laboratory are stymied in their efforts to bring students younger than 16 or 17 into their labs for an authentic, hands-on experience. Sixteen year olds are typically in their third year of high school—just about to miss out on working summers, after school, or school vacations in our premier scientific establishments. This problem was cited by a meeting hosted by the Maine STEM Council for the leaders of the Jackson Lab and Bigelow Lab, but it is the same problem at the Gulf of Maine Research Institute, the Mount Desert Island Biological Laboratory, and college and university labs.

The intent is not to place these youth in hazardous lab or field situations or to have them work overtime; the goal is to have these students work side by side with Maine's scientific establishment, to excite and motivate both parties and to give these students a leg up into possible STEM careers.

At present, we are told the paperwork and insurance requirements limit or prevent such opportunities.

Some activities could be accomplished virtually. For example, some Career and Technical Education students in a medical program have toured a morgue remotely, seeing the work underway and talking with personnel conducting an autopsy without actually being at the location. This is an example of a preliminary mechanism but does more directly connect students with real-world lab experiences.

Milestone 2. The Maine STEM Council recommends that cognizant Maine agencies collaborate on STEM education and workforce issues. For example, there should be regular communication about STEM education and workforce:

- Among the Maine Department of Education, the University of Maine System, the Maine Community College System, the Maine School Superintendents Association, the Maine Principals Association, the Maine Education Association, the Maine Curriculum Leaders Association, the Maine Science Teachers Association, the Association of Teachers of Mathematics in Maine, the Maine Association of Career and Technical Educators, the Technology and Engineering Educators Association of Maine and other important players.
- Among the Maine Department of Labor, Maine Development Foundation, Maine State Chamber of Commerce, Maine Technology Institute, and Coastal Enterprises, Inc. and other major economic development focused organizations.
- Between both groups named above.

This recommendation requires immediate action.

Rationale: Coordination among these groups would promote cost effectiveness as well as clarity of mission. When one group brings in a national speaker on poverty issues and another group brings in one on standards based instruction in another state like North Carolina, any synergy between those two groups is lost and the instructional effort is diffused. The Council is not recommending that, for example, all professional development has to be coordinated between these groups, but it is recommending that these groups better share their strategies and plans to allow for collaboration. This applies far beyond professional development activities.

Similarly, the types of economic development groups identified in the second bullet engage in numerous studies and initiatives relevant to STEM education and workforce. In many ways, these complement in each other, but all too often they occur in isolation, or seem to do so.

In fact, these two groups interrelate in that the 'products' of the first group (students) are given opportunity by the second group. Coordination in workers with needed skills or career trajectories will increase the effectiveness of both the education and the business communities.

Three examples elucidate the power of greater coordination. Career and Technical Education schools are using National Industry Standards as their curriculum and alignment with the Maine Learning Results (and Next Generation Science Standards) would facilitate student graduation with proficiency-based diplomas. Second, Career and Technical Education schools could act as a hub to interface between industry and education both at the high school and adult education levels. These options can be exploratory and cost less than college programs but can lead students to pursue college (either two-year or four-year) later. Finally, Career and Technical Education schools could be more effectively used in the afternoons and evenings for project-based learning. Although needing support for custodial staff, instructional staff, heat, lights, and security, these facilities are well equipped and frequently unused in later hours.

Milestone 3. The Maine STEM Council recommends that Maine recruit and retain talent through development of support systems for individuals and families moving to Maine with the collaboration of the Maine Development Foundation, Maine Department of Labor, and the Maine State Chamber of Commerce. This recommendation requires immediate action.

Rationale: The Maine State Chamber of Commerce and Maine Development Foundation have identified the lack of future workers as a major issue facing Maine. One way to ameliorate this issue is to recruit talent from other states and parts of the world. The transition to life in Maine can be difficult so supports must be put into place to ease this transition. This means culturally and religiously sympathetic structures in places where new populations congregate.

Milestone 4. The Maine STEM Council recommends that all Maine communities have access to technology and education to enable productivity and recreation through completion of efforts to:

- Connect each house to affordable, high-speed Internet.
- Develop affordable, reliable mobile phone zones in all parts of the state.
- Increase connection of University College (distance learning) and digital libraries to workplace needs and community wants.

Rationale: Many jobs can be accomplished remotely via high-speed Internet connections and would take advantage of Maine's high quality of life. However, in too many areas of the state, despite the fiber-optic highway running up the spine of the state, there are communities that cannot easily and affordably access the Internet. This hampers businesses as well as individuals who could locate in Maine. The Three Ring Binder project has provided the backbone but final mile connection is still lacking.

Similarly, mobile phone coverage is spotty and hampers business and education conversations. In some areas, for example near the ends of peninsulas, extended networks are needed if service is even possible; in other areas, for example as one nears the Canadian border, service switches to international rates, sometimes without knowledge of the user.

Better connectivity would allow people to learn new skills in their homes and communities from systems such as University College, to download needed files, and to work in spaces across the state where this is not currently possible.

Milestone 5. The Maine STEM Council recommends that Maine youth aged 16 to 26 have at least one internship, apprenticeship, or mentorship for an extended term (longer than 40 hours), such that:

- High school transcripts note such internship, apprenticeship, or mentorship if accomplished during high school years and they are counted toward proficiency based graduation
- An internship training and evaluation system to use best practices in conducting internships is created
- A network of existing internship, pre-apprenticeship, and apprenticeship opportunities such as Project>Login, USM's Internships and Career Placement, and Maine State Chambers' InternHelpMe.com be coordinated.

Rationale: An internship experience, where a student is placed in an actual workplace for a prolonged period with a supportive supervisor, has been found to be pivotal for that student's entry into the world of work. And there are best practices for mentors. Combining the two would be a unique undertaking.

The Iowa STEM Council has implemented an "Ex-ternship" program for STEM teachers. Their reasoning is that the multiplier effect one gets by having a teacher have this real-world experience and then relate that to their one hundred or so students is more cost effective than a student internship program. Both should be investigated.

Milestone 6. The Maine STEM Council recommends that Maine become the "State of Innovation" through supporting creative, collaborative and problem solving activities such as:

- Regular, high quality opportunities such as the Maine State Science Fair and CTE Auto Skills Competition.
- Regular, high quality challenges such as Maine FIRST Robotics, VEX Robotics, Skills-USA competitions and the Maine Wind Blade Challenge.
- STEM activities such as CAD Camp and the Acadia Night Sky Festival.

Rationale: For those students who thrive on competitions and challenges, Maine must be better prepared to offer these and support their activities. The Maine State Science Fair, from which winners go on to the International Science Fair, has a handful of participating schools and students. It is possible that the Maine Wind

Blade Challenge will not occur this year due to lack of support. In other states, these challenges and competitions approach the zeal of sporting events, yet we are struggling to get participants. If we can shift the mindset for those outside of Maine to view Maine as the "State of Innovation" through active support and dissemination of these activities, the impact in the business world will be profound.

Milestone Recommendations for Subgoal E

The fifth subgoal of this plan focuses on broadening opportunities for currently underrepresented populations of low-income, first-generation college and minorities , including females, in all fields of STEM education and workforce.

Many of Maine's residents seeking post-secondary training are low-income, first-generation college attendees, and minority students including females. The reasons these populations are underrepresented are numerous and include a shortage of mentors, lack of access to qualified STEM teachers, lack of encouragement to tackle challenging subjects, and lack of acceptance from coworkers and supervisors.

Solutions require personal, collective, and organizational actions. An example of a personal action is to not use solely male pronouns when referring to highly skilled people. An example of a collective action is to make sure that photographs from robotics competitions show a variety of children. Messages are sent when these simple actions are not taken.

The Maine STEM Council has not yet determined milestones for this subgoal and as one of its next steps will be identifying models for inclusion across the state.

V. Next Steps for the Maine STEM Council

There are several immediate next steps for the Council. One is to use this report as a starting point to cause actions to be taken, particularly on those milestones that the Council has deemed of immediate importance. It also is to be used to create discussion across the state and across organizations and sectors.

Council members intend to bring this report to their professional networks for analysis and to add ideas of their own. We also will brief members of the executive and legislative branches of Maine government.

A major undertaking will be the development of a dashboard of indicators to define final goals and measure progress toward those goals. The dashboard will show status on selected goals and issued on a biannual process in odd years, starting in 2015. As modeled by this report, the dashboard will take into account the measures other groups have identified as important and are monitoring as well. But the STEM Council's dashboard of indicators will be much more action oriented and of a finer grain size.

In addition, the Council will explore cooperative relationships with other rural states or as region to seek major funding to bring about some of the ideas presented in this report. At the very least, regional cooperation will provide a forum for sharing similar actions in other states and surface new models of collaboration. We are already in discussion with the STEM council directors in Massachusetts and Vermont, and we are represented on the Board of Directors of the National Alliance of State Science and Math Coalitions. Together we will approach national or private funders.

Finally, we will continue to scan the nation for models and actions that will help Maine move forward in STEM education and workforce issues. Two that deserve close scrutiny are early childhood education and corporate training provided through the community college system.

The report is our first step – and we intend to make it as significant as the first ones taken on the moon, "for all of Maine's residents.

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Appendices

Appendix A **Maine's Subgoals and Milestones**

Appendix B **Preliminary Indicators Identified for 2012-2013, Iowa STEM Monitoring Project, 2012-2013 Summary Report**

Appendix C **MA STEM Plan 2.0: Expanding the Pipeline for All**

Appendix D **Members of the Maine STEM Council**

Appendix A. Maine's Subgoals and Milestones

Subgoal	Milestone	Description	
		Short Term/Immediate Impact	**Long Term**
A. To improve STEM achievement and interest among grades K-12 age students.	1	The Maine STEM Council recommends that Maine adopt the Next Generation Science Standards as soon as possible.	
	2	The Maine STEM Council recommends that certified teachers in the K-12 system who teach mathematics be required to pass a three-credit course in current mathematics content and pedagogy as part of the six-credit educator recertification process. Similar requirements should be considered for teachers of science, technology, and engineering.	
	3	Recognizing the critical importance of reading in the content areas, the Maine STEM Council recommends that the content literacy sections of the Maine Learning Results (Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects) be given significant attention in grades K-12 classrooms, particularly with a focus on STEM subjects.	
	4	The Maine STEM Council recommends that out of school and after school STEM programs across the state be catalogued and that program providers be provided with opportunities for professional development in STEM content knowledge, pedagogy, and positive youth development.	
	5	The Maine STEM Council recommends that the Maine Department of Education develop stakeholder-based content advisory committees in STEM (including computer science) content areas. The Maine Department of Education, with input from the stakeholder-based content advisory committees, should develop and actualize implementation plans for STEM subjects.	

Subgoal	Milestone	Description	
		Short Term/Immediate Impact	**Long Term**
	6		The Maine STEM Council recommends that incentives be provided to new and existing teachers of STEM subjects who are accredited in their content area at the Bachelors and beyond levels. Incentives include tuition reimbursement or additional stipends.
	7		The Maine STEM Council recommends that the Maine Department of Education, with the guidance of a stakeholder-based content advisory committee, develop a professional teaching endorsement for teaching computer science.
B. To increase the percentage of students completing post-secondary degrees or certificates in STEM.	1	The Maine STEM Council recommends that University of Maine System and the Maine Community College System initiate or expand system-wide professional development in research-based best classroom practices for instructors of STEM courses.	
	2	The Maine STEM Council recommends that the Maine Department of Education gather and report data on remediation courses in STEM subjects at all public higher education institutions and cite best practices for overcoming remediation.	
	3		The Maine STEM Council recommends that Maine's institutions of higher education increase the levels of partnerships with research and non-profit organizations in Maine, possibly through credit bearing research and teaching internships.
	4		Recognizing the critical importance of reading in the content areas, the Maine STEM Council recommends that the content literacy sections of the Maine Learning Results (Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects) be given significant attention in higher education classrooms, particularly with a focus on

Subgoal	Milestone	Description	
		Short Term/Immediate Impact	**Long Term**
			STEM subjects.
C. To better align secondary (including CTE) and post-secondary training with the state's workforce needs.	1	The Maine STEM Council recommends that Maine develop a one-stop clearinghouse for internship opportunities, perhaps building off the Maine State Chamber of Commerce InternHelpMe.com and Educate Maine's efforts.	
	2	The Maine STEM Council recommends that all Maine residents know about vocations and avocations in STEM.	
	3	The Maine STEM Council recommends that a regular survey of Maine's top businesses and economic growth clusters be undertaken to assess their workforce needs in terms of STEM and other skills and knowledge.	
D. To create conditions across sectors in the state that promote STEM education and careers.	1	The Maine STEM Council recommends that the Legislature consider ways to facilitate high school student participation in scientific endeavors at research labs through reducing liability of working in laboratories.	
	2	The Maine STEM Council recommends that cognizant Maine agencies collaborate on STEM education and workforce issues. For example, there should be regular communication channels about STEM education and workforce issues: • Among Maine Department of Education, University of Maine System, Maine Community College System, Maine School Superintendents Association, Maine Principals Association, Maine Education Association, Maine Curriculum Leaders Association, Maine Science Teachers Association, Association of Teachers of Mathematics In Maine, Maine Association of Career and Technical Educators, Technology and Engineering Educators Association of Maine and other important	

Subgoal	Milestone	Description	
		Short Term/Immediate Impact	**Long Term**
		players. • Among Maine Department of Labor, Maine Development Foundation, Maine State Chamber, Maine Technology Institute, Coastal Enterprises, and other major economic development focused organizations. • Between both groups identified above.	
	3	The Maine STEM Council recommends that Maine recruit and retain talent though development of support systems for individuals and families moving to Maine, with the collaboration of the Maine Development Foundation and the Maine State Chamber of Commerce.	
	4		The Maine STEM Council recommends that all Maine communities have access to technology and education to enable productivity and recreation through completion of efforts to; • Connect affordable, high speed Internet to each house • Develop affordable, reliable mobile phone zones in all parts of the state • Increase connection of University College (distance learning) to workplace needs and community wants
	5		The Maine STEM Council recommends that Maine youth aged 16 to 26 have at least one internship, apprenticeship or mentorship for an extended (longer than one month) term, such that: • High school transcripts note such internships if accomplished during high school years • An internship training and evaluation program – to use best practices in

Subgoal	Milestone	Description	
		Short Term/Immediate Impact	**Long Term**
			conducting internships – is created • A network of existing internship opportunities – e.g. Project Log>in, USM's Internships and Career Placement, Maine State Chambers InternHelpMe.com be coordinated
	6		The Maine STEM Council recommends that Maine become the "State of Innovation" through supporting creative, collaborative and problem solving activities such as: • Regular, high quality opportunities such as the Maine State Science Fair and CTE Auto Skills Competition. • Regular, high quality challenges such as Maine FIRST Robotics, VEX Robotics, Skills-USA competitions and the Maine Wind Blade Challenge. • STEM activities such as CAD Camp and the Acadia Night Sky Festival.
E. To broaden opportunities for currently underrepresented populations such as low-income, first-generation college and minorities, including females, in all fields of STEM education and workforce.		Milestones are to be developed	

Subgoal A Additional ideas that surfaced during Maine STEM Council deliberations:

1. Each student in grades K through 12 should have at least one out-of-school STEM experience or Extended Learning Opportunity per year that is student-driven. The intent is not that these be an additional burden upon the school system but that we encourage, promote, and support out-of-school as well as in-school STEM learning.

2. The Maine STEM Council recommends that the legislature and Maine Department of Education consider adding a computer science requirement for high school graduation. Despite most every student carrying a computer (cellphone) that has more computing power than the Apollo 11 mission that landed on the moon, our students are remarkably naïve about computer science. It has been said that youth today can 'read computers' but they cannot 'write computers'—referring to reading and writing English as a necessary part of learning.

3. Each student must demonstrate proficiency in the Maine Learning Results Guiding Principles through STEM subjects. The current proficiency based graduation law mandates that students demonstrate proficiency in the eight content areas of the Maine Learning Results plus the Guiding Principles. But demonstrating the Guiding Principles (for example, being an effective communicator or problem solver) through the STEM subjects makes it a much more authentic experience.

4. The Maine Department of Education should capitalize on the expertise of high quality educators and students (e.g. Principal of the Year, Teacher of the Year, Nationally Board Certified teachers, National Youth Science Camp alumni, Presidential Awardees for Excellence in Science and Math Teaching) by, for example, placing them on stakeholder task forces and program reviews of teacher preparation programs.

Appendix B. Preliminary Indicators Identified for 2012-2013, Iowa STEM Monitoring Project, 2012-2013 Summary Report

	Ind.	Description	Data source(s)
STEM Achievement and Interest among K-12 Students	1	Iowa student achievement in mathematics and science	Iowa Testing Programs (ITP)
	2	Iowa student achievement on NAEP mathematics and science tests	National Center for Education Statistics (NCES)
	3	Number of students taking the ACT and average scores in mathematics/science	ACT
	4	Number of students taking STEM Advanced Placement tests and average scores	College Board
	5	Predicted ACT scores among 1Oth grade ACT-Plan test-takers	ACT
	6	Percentage of ACT test-takers interested in majoring in a STEM area in college	ACT
	7	Percentage of Iowa 8th graders interested in STEM careers and educational paths	I Have a Plan Iowa
	8	Number/Percentage of K -12 students interested in STEM topic areas	Iowa Testing Programs (ITP)
STEM Preparation of K-12 Students	9	Number of current Iowa teachers with licensure in STEM-related subjects	Iowa Department of Education (DOE)
	10	Number of current Iowa teachers with endorsement to teach STEM-related subjects	Iowa DOE
	11	Number of beginning teachers recommended for licensure/endorsement in STEM-related subjects	Iowa DOE
	12	Teacher retention in STEM-related subjects	Iowa DOE
	13	Enrollment in STEM-related courses in high school	Iowa DOE
STEM College Completions	14	Number of college students who complete degrees in individual STEM majors (AA, BA, other)	NCES
	15	Number of college students who complete graduate degrees in individual STEM majors	NCES
STEM Employment	16	Percent of Iowans in workforce employed in STEM occupations	Iowa Workforce Development (IWD)
	17	Job vacancy rates in STEM occupational areas	IWD
	18	STEM workforce readiness	IWD

Appendix C. MA STEM Plan 2.0: Expanding the Pipeline for All

Goal	Benchmark	Metrics	
		Current	Recommended
1. Increase student interest in STEM areas	Increase interest in STEM college majors among college-going MA public school graduates from 35% in 2009 to 45% by 2016	• Continue to use the SAT registration questionnaire to capture students' interest in majors.	• Use PSAT-SAT matched data to look at changes in interest as students get closer to leaving the K-12 system. • Use available labor market data to evaluate trends in future employment areas. • Add an MCAS survey question to capture student interest across the state at multiple points of time. • Use existing or assist in the development of a common student interest survey tool in order to compare impact on student interest across various programs.
2. Increase student achievement among all PreK-12 students in order to prepare graduates to be civically and college and/or career ready.	Increase the percentage of all students who score proficient or advanced on the MCAS mathematics and science and technology/engineering assessments by 20 point by 2016	• Use MCAS achievement data. • Collect SAT data measuring course enrollment for science and mathematics classes. • Obtain student-level course enrollment data that are reported to DESE by schools. • Obtain school-level information about course offerings that are reported to DESE and merged with course enrollment data. • Analyze disaggregated data looking at improvement of similar sub-groups at different types of schools.	• Survey instructors of freshman STEM-related courses at the 29 public higher education campuses about the quality of their skills, practices, and content knowledge of incoming students. • Collect state-level K-12 assessment data.

Goal	Benchmark	Metrics	
		Current	Recommended
3. Increase the percentage of skilled educators who teach PreK-16 STEM classes.	Increase the number/percentage of STEM classes led by skilled educators from PreK-16 by 2016	• Use MA Educator Effectiveness tools to measure K-12 teacher impact on instruction. • Collect MTEL data. • Collect professional development hours data from the Educator Licensure and Recruitment database that is managed by DESE. • Use data from DHE's Vision Project annual reports for higher education retention data.	• Update and use the Status of Educator Workforce report from MA Department of Higher Education to determine the quality of STEM teacher preparation. • Use Quality Rating and Improvement System (QRIS) data to assess implementation of STEM in early education and Out-of-School time programs.
4. Increase the percentage of students completing post-secondary degrees or certificates in STEM subjects.	Increase the percentage of students who complete STEM-related post-secondary degrees and certificates at public and private institutions by 50% from 2008 to 2016	• Continue to have UMass Donahue Institute update the Integrated Postsecondary Education Data System (IPEDS). • Collect Joint DESE-DHE data on dual-enrollment student credits issued.	• Analyze DHE data to determine increase of students transferring from community colleges to four-year institutions and the number of credits that transferred over in STEM courses. • Track number of public high school students who choose to stay in Massachusetts and major in STEM compared to student who attend school out-of-state. • Analyze data of students who choose to enter/leave a STEM major. • Disaggregate data of current post-secondary students to compare those who graduated from a Massachusetts high school vs. non-Massachusetts high school.

Goal	Benchmark	Metrics	
		Current	Recommended
5. STEM degrees and certificate attainment will be aligned with corresponding opportunity in STEM-related fields to match the state's workforce needs for a STEM talent pipeline	No less than 50% of degrees (associate's, bachelor's, and Ph.D.) and certificates earned will provide transferrable knowledge, skills, and work habits for entry into STEM-enabled occupations, ensuring the supply of talent will meet demands of the Massachusetts economy	• Compare the mix of STEM degrees and certificates earned (IPEDS) to the mix of STEM occupations in college labor market jobs (BLS Occupational Employment Statistics) and to the mix of job openings posted online (HWOL). Look at participation rates in internships, co-op, practicum, or clinical experience opportunities for students, disaggregated by fields of study, gender, and race, through National Survey of Student Engagement (NSSE) data. • Use college NSSE data to track relative score on deep learning scale by major field for New England compared to the nation. (Deep Learning Scale questions are included in the Appendix.)	• Analyze data on economic outcomes from non-degree certificates completed in STEM fields. • Begin to collect STEM career and vocational education program completion rates at career and technology high schools and comprehensive high schools across the state in a unified way. • Use apprenticeship completion data for STEM trades.

Appendix D. Members of the Maine STEM Council

- **Jerry Pieh, Ed.D. (Chair)**

  Chair
  Maine School of Science and Mathematics

- **Mark Kostin, Ed.D. (Vice-Chair)**

  Senior Associate
  Great Schools Partnership, Inc.

- **Tom Keller, Ed.D. (Executive Director, Ex-Officio member)**

  Co-Director
  Maine Mathematics and Science Alliance

- **Diana Allen**

  Grade 7 Life/Environmental Science Teacher
  Sanford Junior High School

- **Carolyn Arline**

  High School Mathematics Teacher
  Richmond Middle/High School

- **William Belcher**

  Technology Development Engineering Manager
  Texas Instruments

- **Anita Bernhardt**

  Director, Standards and Instructional Support
  Designee of the Commissioner, Maine Department of Education

- **Chris Boudreau**

  Director, Center for Workforce Research & Information
  Designee of the Commissioner, Maine Department of Labor

- **Sharon Eggleston**

  Retired Senior Project Engineer
  Lockheed Martin

- **Kathy Englehart**

  Math and Science Department Chair, Kennebec Valley Community College
  Designee of the President, Maine Community College System

- **Elizabeth Fisher**

  Director
  Mid-Coast School of Technology

- **Karen Horton, P.E.**

  Mechanical Engineering Technology, University of Maine
  Designee of the Chancellor, University of Maine System

- **Ed Liu, M.D.**

  President and CEO
  Jackson Laboratory (designee Tom Litwin, VP for Education)

- **Susan McKay, Ph.D.**

  Director
  Maine Research in STEM Education (RiSE) Center

- **Jan Mokros, Ph.D.**

  Co-Director
  Maine Mathematics and Science Alliance

- **Steven Pound, Ph.D. (resigned November 1)**

  Associate Director of Workforce Development
  Cianbro Companies

- **Paul Wlodkowski, Ph.D.**

  Professor of Engineering, Maine Maritime Academy
  Designee of the President, Maine Maritime Academy