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The Maine STEM Education and Workforce Plan 2.0

A Report by the Maine STEM Council

November 2016

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Maine STEM Council

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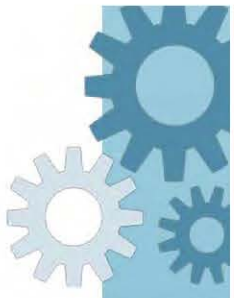


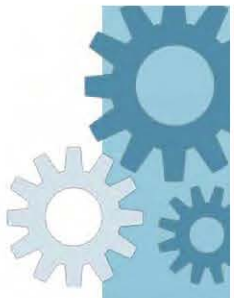


The Maine STEM Education and Workforce Plan 2.0
Executive Summary
Maine STEM Council

Two years have passed since the Maine STEM (Science, Technology, Engineering, and Mathematics) Council issued the Maine STEM Education and Workforce Plan1.0. Progress has been made with many milestones, and some were even achieved. Too few, however, have been accomplished to move Maine forward with the velocity the Council had hoped.

The Plan was written to be bold, to offer some radical though reasonable ideas, and to create the momentum across sectors that is needed to help Maine realize its potential in STEM education and workforce situations. We did not expect each of the milestones would be implemented as written but we did expect a hue and cry from educators, business representatives, administrators, legislators, and others to join in this attempt to develop strategies, initiatives, and methods to enhance STEM education.

Plan 2.0 contains many of the elements of Plan 1.0 but also describes actions to broaden participation and reports on progress made. It is again a call to action, not only by members of the Council but by every resident of Maine. Together, we can create a K-12 education system that excites and prepares all students in STEM; a postsecondary education system that helps Mainers be they recent high school graduates or having graduated fifty years ago to find interesting, meaningful, and productive work; an innovative and creative STEM business community that strives to be profitable and socially responsive; and for-profit and not-for-profit enterprises that work hand in glove.

The Maine STEM Council was established by an act of the Maine Legislature in 2011 and has sixteen members, eleven of whom were appointed by the Governor and five of whom represent major sectors and organizations (see Appendix B). 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 points to immediate actions and to those of longer term that have emerged as a result of analysis and deliberation. The Council intends to use this report to start conversations and stimulate actions at 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.

The overarching charge, 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 goals and numerous milestones that we believe will lead to enhanced STEM education.

This summary identifies the goals and the full report provides a rationale for a set of milestones under each goal.

Goal A. To improve STEM achievement and interest among grades preK-12 students in and out of school.

Goal B. To increase the percentage of students completing postsecondary degrees or certificates in STEM.

Goal C. To better align secondary (including Career and Technical Education [CTE]) and postsecondary training with the state's workforce needs.

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

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

I. Introduction

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

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

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.

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 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 postsecondary 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 three levels of STEM expertise. One level includes the 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 her or his 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 with simple rote information retrieval. In addition to employment, STEM offers fun activities such as beekeeping, robotics, and origami. These two outcomes are necessary to make Maine an attractive, vibrant, exciting state for current and future residents.

II. A Scan of STEM Across the Nation in 2016

With the recent reauthorization of the federal Elementary and Secondary Education Act as the "Every Student Succeeds Act" (ESSA), a major shift is proposed in providing directions for schools. The role of the US Department of Education seems to be reduced as evidenced by the combining of targeted programming such as the Math and Science Partnerships grants made to each state into a general pool of funds and the elimination of requirements such as sanctions through Adequate Yearly Progress measures and reporting of percentages of highly qualified teachers. This in turn provides great opportunity (and challenge) at the state and local level for school operations.

Use of federal ESSA funds for supporting STEM education is not only allowed, it is promoted. States must still adopt challenging academic standards in math, science and reading and states must test students annually in grades 3 8, once in high school in math and reading, and in elementary, middle and high school in science. ESSA allows the state to use federal funding in Title I to integrate engineering and technology concepts in science testing. Title IIA funds can be used to support STEM education, professional development, teacher recruitment and differential pay with a priority for STEM teachers, and to integrate technology into curricula and instruction. Title IIB creates a nationally competitive program for establishing a STEM Master Teacher Corps or providing professional development for STEM. (We urge that Maine apply for this funding stream.) Title IVA is to support student success and academic enrichment and is authorized at $1.65 billion. Each school district will receive at least $10,000 per year for this program and may spend it to provide a well-rounded education including STEM. Funds can be used by districts to expand STEM courses, pay for student participation in STEM competitions, provide hands-on learning opportunities in STEM, integrate classroom-based and informal/out of school STEM, and expand or create STEM specialty schools.

The challenge is that doing any of this requires state and school leadership that values increasing and improving STEM education rather than maintaining the status quo. Funds would have to be allocated differently which is the power of ESSA and change is difficult.

STEM education done well provides students with solid understandings in science, technology, engineering, math and computer science, teaches them how each of these are practiced, and builds on student engagement and creativity. Facility with these subjects has been shown time and time again to allow students to proceed in any number of directions for work or further study.

Proficiency in these subjects is necessary for Maine's economic growth and sustainability. There are simply no 21st century jobs that do not involve STEM.

There is a mountain of reports that support this contention. These include:

- A Nation At Risk, National Council on Excellence in Education
- Rising Above the Gathering Storm, National Research Council
- Prepare and Inspire: K-12 Science, Technology, Engineering, and Math

(STEM) Education for America's Future, PCAST, 2010

- Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering and Math, PCAST, 2012
- Monitoring Progress Toward Successful K-12 STEM Education, National Research Council
- Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics, National Research Council.

III. The Case for Maine Three Years Later

Drawing on these national resources plus pioneering efforts and previous work done in Maine, the STEM Council developed this Plan 2.0 to prepare Maine people for the future economy in STEM fields. Looking across these data sources, the Council has identified five goals:

A. To improve STEM achievement and interest among grades K-12 students in and out of school.
B. To increase the percentage of students completing postsecondary degrees or certificates in STEM.
C. To better align secondary (including CTE) and postsecondary 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 students and minorities, including females, in all fields of STEM education and workforce.

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

Since the issue of Plan 1.0, a new organization, **FocusMaine**, has come on the scene. This group is a largely industry driven one that identified three areas agriculture, aquaculture, and biopharmaceuticals as high potential and having the greatest impact for Maine. FocusMaine acts as a catalyst for the accelerated and sustainable growth and business confidence that energize Maine's economy. Clearly their three "signature industries" are STEM-rich, supporting the need for students who are adept in STEM concepts to contribute to these industries. The Maine Technology Institute has joined this private sector effort led by FocusMaine to strengthen and revitalize opportunity and prosperity in Maine by accelerating the creation of quality jobs within a few select trade sectors that have high growth potential based on global growth projections and Maine's competitive advantages in those sectors according to an MTI press release.

The **University of Maine System** issued a report dated January 26, 2012 that is the latest compendium of STEM education, research and activities in the system. It identifies six system-wide initiatives:

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

This report also details STEM degrees awarded in 2005 2010 by degree and

gender. Overall there has been a very positive and large increase in the five years of up 20.8%. Data was given for STEM degrees in Agriculture & Natural Resources, Biological Sciences, Computer & Information, Engineering, Health Professions, Mathematics and Physical Sciences. Interestingly, STEM education plays a minor role in this report.

This points to an issue between data sources related to STEM. The UMS uses the Classification of Instruction Programs (CIP) and major to categorize STEM data. Thus Computer and Information Sciences and Support Services has four majors under it: Computer and Information Sciences, General; Information Technology; Computer Science; and Computer Software and Media Applications, Other. Once students enter the world of work, labor statistics classify them by Standard Occupation Classifications. There may be no solution to this issue as it transcends two systems.

Research dollars flowing to Maine through the **National Science Foundation** also show levels of effort being devoted to STEM (http://dellweb.bfa.nsf.gov/ AwdLst2/default.asp). Maine is lagging behind its regional neighbors except for VT in total NSF dollars.

State	Awards	FY 2015
ME	76	$26M
VT	33	$12M
NH	124	$36M
MA	1344	$457M
RI	194	$50M

A recent article in **Mainebiz** (May 30, 2016) by Lori Valigra cited the following alarming statistics about federal support (mostly from the US Department of Health and Human Services, National Science Foundation, and the US Department of Defense) to New England universities and colleges in FY2013 and FY2014.

State	2013	2014
ME	$52M	$38M
VT	$80M	$88M
NH	$160M	$161M
MA	$1,606M	$1,713M
RI	$142M	$145M

Maine is the only New England state that did not increase its share of federal support.

The **Three Ring Binder** project was a $30M 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. A bill (LD

1185) was introduced by Representative Norman Higgins in the 127th Legislature to help fund last mile networking. The bill passed overwhelmingly, including an override of a governor's veto, but no funds were appropriated for it. Maine needs to follow through on its initiatives if we want to be an economic player.

Educate Maine issued its report, Education Indicators for Maine 2015, identifying ten indicators:

- Preschool participation
- Preschool access
- Full-day kindergarten
- 4th grade achievement
- 8th grade achievement
- High school achievement
- College-going
- College completion
- College cost & Student debt, and
- Mainers with college degrees.

This report sets goals for each of these for 2019 and gives a data-derived status report. When combined with the actions called for in the Maine STEM Council's Plan 2.0, a great synergy is formed. The Council's Plan provides a plan for reaching the goals identified in the Educate Maine report, while the Educate Maine report cites the status.

The Council's Plan 2.0 makes bold statements and presents innovative ideas for improvement and provides an action plan to accomplish the goals set forth in the Educate Maine report.

The **Maine Economic Growth Council**'s Measures of Growth 2016 report begins by identifying four major themes. These are human capital; investing in education; investing in infrastructure, innovation, and connectivity; and controlling costs. Gold Stars were assigned to areas of exceptional performance and Red Flags indicated "… areas in need of particular attention …" (page 1). Of the twenty-five indicators of Measures of Growth, five Red Flags were given, three of which were indicators in the category Skilled and Educated Workers. These were: Postsecondary Educational Attainment, 4th Grade Reading Scores, and 8th Grade Math Scores. While it is useful to raise the alarm over such areas of concern, the Maine STEM Council Plan 1.0 and now 2.0 have put forth ideas to address these concerns. These ideas are written as milestones or recommendations we do not anticipate that they will necessarily be implemented exactly as written, but we do anticipate that they will result in dialogue and eventual action.

The **Maine Campus Compact** undertook a STEM landscape analysis in 2014 and issued two reports titled *Higher Education and Secondary Schools Coming Together: Strengthening STEM Education Through Collaboration*, one for Secondary Schools and one for Higher Education (http://www.mainecompact.org/vista-stemRes.php). The secondary school respondents stated that the top three challenges facing STEM education were funding, professional development and inadequate links within the K-20 pipeline. The higher education respondents reported that the top challenges were lack of preparation for college level STEM courses, funding and inadequate links within the K-20 pipeline.

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 charge and goals. 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 CTE 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 comprehensive examination of STEM education and workforce issues covers several large arenas including pre-K-12 schooling, CTE, two-year and four-year postsecondary 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 charge with five goals. The charge, 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 have set five goals as:

A. To improve STEM achievement and interest among grades preK-12 students in and out of school.
B. To increase the percentage of students completing postsecondary degrees or certificates in STEM.
C. To better align secondary (including CTE) and postsecondary 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 students and minorities, including females, in all fields of STEM education and workforce.

Milestone Recommendations for Goal A

The first goal of this plan focuses on improving STEM achievement and interest among grades preK-12 students in and out of school. The Maine STEM Council has a number of recommendations and suggestions regarding this goal. 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 (NGSS) 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 fourteen states have already adopted them, as have many districts in Maine. With standards-based proficiency graduation deadlines looming 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 NGSS 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, must work with each other to implement them, and must 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 fictional 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 it now needs to be

mission of all school teachers to ensure that students can read and understand technical literature. This is not a call for science teachers to become reading teachers. It calls for English teachers, for example, to understand the needs and methods of teaching reading in technical subjects. This requires leadership at 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 that could be conducted statewide for efficiency, is the development of a crosswalk between the Maine Learning Results/Common Core, the National Industry CTE standards, and the Next Generation Science Standards. Initiatives that include literacy training for content area teachers in STEM and CTE need to be expanded and made affordable, perhaps through innovative use of federal or local funds.

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 given 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 such as robotics, farming, weaving, or backyard astronomy.

Adults in afterschool and out-of-school programming such as 4-H, Girls and Boys Clubs, 21st Century Community Learning Centers, science centers, nature centers, libraries, and community centers 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 at CTE centers, these groups will provide ideas and feedback to Maine Department of Education 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 give their input, ideas, and feedback. This is a great way for teachers to have voice and perhaps should be a half-time position funded by districts.

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 Bachelor's 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 a 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 problem-solving, learning to program, appropriate use of the internet and reliable websites, 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 Goal B

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

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 doctorates and other advanced degrees. While the STEM Council acknowledges their contributions, the Council also recognizes that another level of knowledge is at the more technical level. Laboratory technicians, welders, medical assistants, electricians, and machinists 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 postsecondary training though not necessarily a Bachelor's 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 owing 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 elsewhere today. Indeed, Maine could become a national leader at the two-year and four-year institution level through development and implementation of a professional learning community that elevates the quality of teaching to equal the importance of academic scholarship.

This is also an opportunity 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 College.

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 regarding 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 postsecondary 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 Goal C

The third goal of this plan focuses on aligning secondary (including CTE) and postsecondary training with the state's workforce needs. The Maine STEM Council has a number of recommendations and suggestions regarding this goal.

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 becoming more of a genre of careers and aspirations. The bottom line is that economic development in the 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 using various modes of media or specific undertakings (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 also an opportunity 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 postsecondary 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 a measure to determine the actual skills and knowledge needed to succeed in Maine business. Examining the options for computer science, for example, reveals that Northern Maine Community College offers an Associate's degree in "Computer Info Systems", the University of Maine at Augusta offers an Associate's degree and a Bachelor's degree in "Computer Information Systems", and a Bachelor's degree in "Computer Information Systems-P". Regarding "Computer Science," the University of Maine at Fort Kent offers an Associate's degree, as does Kennebec Valley Community College; the University of Maine at Orono offers a Bachelor's degree, 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 required, and then providing these specifications to our secondary and postsecondary 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 businesses such as Pratt and Whitney.

Milestone Recommendations for Goal D

The fourth goal 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 goal.

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 sixteen or seventeen years 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 at 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 CTE students in a medical program have toured a morgue remotely, seen the work underway and talked with personnel conducting an autopsy without actually being at the location. This does more directly connect students with real-world lab experiences without exposing them to hazardous situations.

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 the 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 the two sets of groups named above.

This recommendation requires immediate action.

Rationale: Coordination of these groups would promote cost effectiveness as well as clarity of mission. When one group brings in a national speaker on poverty issues, for example, 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 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 grouping engage in numerous studies and initiatives relevant to STEM education and workforce. In many ways, these complement 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 opportunities 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. CTE schools are using National Industry Standards as their curriculum, and alignment with the Maine Learning Results (and NGSS) would facilitate student graduation with proficiency-based diplomas. Secondary and CTE 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 later (at either two-year or four-year level). Finally, CTE 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 other 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 ensuring culturally and spiritually 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, the 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 from sixteen to twenty-six years have at least one internship, apprenticeship, or mentorship for an extended term (longer than forty 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 "externship" 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 becomes 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 and support their activities. The Maine State Science Fair, from which winners advance to the International Science & Engineering 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 Goal E

The addition of these milestones is the major difference between Plan 1.0 and Plan 2.0. The Maine STEM Council recognizes that participation in STEM education and businesses do not represent the population as a whole. Without active participation by currently underrepresented populations, economic growth in STEM fields will continue to be sluggish. The Council has several recommendations and suggestions regarding this goal of broadening participation and opportunities for currently underrepresented populations of low-income, first-generation college students and minorities including females in all fields of STEM education and workforce.

Milestone 1. The Maine STEM Council recommends that groups that support recruiting and retaining STEM majors from low-income, first-generation college students and minority populations share best practices. This recommendation requires immediate action.

Rationale: A number of Maine organizations exist that support students in postsecondary training situations. These groups include Maine College Access Network, Maine Education Opportunity Center, Jobs for Maine Graduates, Maine Educational Talent, Maine GEAR UP, Maine Youth Transition Collaborative, and the MELMAC Education Foundation. Some of these groups may not be involved in this and there may be others. A survey is currently underway from within this community to identify all the players.

It is important to identify these players and once that is done, they should be convened for the sharing of best practices and what works. Postsecondary institutions in the state that are experiencing record growth for example Unity College and the Maine Maritime Academy or that have innovative partnerships such as Bates/Southern Maine Community College or that have specific support structures for such students such as the University of Maine at Machias Machias Initiative for Science and Technology program should be invited to share their strategies. Two-year institutions must be invited to participate.

Two suggestions for improvement are the ability to disaggregate data from low-income, first-generation college students and minority populations, and identifying which organization collects and reports on this data.

Milestone 2. The Maine STEM Council recommends that free community college models be explored. This recommendation requires immediate action.

Rationale: Other states (TN and OR) have proposed free community college tuition for their residents as a way to encourage attendance. As a method of broadening participation and reducing barriers to access for STEM majors, the Council urges that the Maine Department of Education or the EDU Committee of the Legislature charge MEPRI (Maine Education Policy Research Institute) with investigating and analyzing the feasibility of the free community college models in terms of cost and effectiveness.

The Council gave this a high priority but wants to ensure that economic models do not lead to the destruction of community colleges.

Milestone 3. The Maine STEM Council recommends that computer science education be integrated into the K-12 curriculum.

Rationale: As the STEM Council scans the future of STEM in Maine, it is obvious that computer science will impact on work and personal lives. Our youth need to be prepared for their futures with a broad understanding of STEM including computer science. For this to happen, all local educational agencies should at least explore implementing computer science instruction in their K-12 systems. Data should be gathered concerning recruitment and enrollment in the courses (especially at high school). We must take steps to ensure that girls and other underrepresented groups are participating at a rate proportional to their representation in the school population.

The Council gave this a high priority. One suggestion was to add a definition of computer science.

Milestone 4. The Maine STEM Council recommends that the instructional methods of "active learning" be implemented at all University of Maine System, Maine Community College System and Maine Maritime Academy campuses in appropriate STEM courses for undergraduate and teacher education candidates.

Rationale: This is consistent with the Maine STEM Council Plan 1.0, Goal B, milestone 1. One reason for this milestone is the evidence that "teachers tend to teach as they were taught". Since all teacher candidates must have content courses in STEM, by improving the methods by which prospective teachers are taught, we should improve the teaching of STEM in preK-12 schools. There is some data that elementary teachers fulfill their content course requirements in two-year colleges so we must attend to instruction in these institutions as well. A second reason for this milestone is to improve retention of students in STEM majors. Students who are placed in large lecture sections with little interaction with faculty tend to drop out more frequently than in classes that directly and actively engage students.

The Council gave this a high priority. It was noted that effective teaching at introductory levels was key to retaining majors and better preparing teacher candidates.

Milestone 5. The Maine STEM Council recommends that preschool and early

childhood programs be made universally available in Maine.

Rationale: Preschool and early childhood programs have been shown to be effective in helping youth at all levels grow cognitively as well as socially. The research on learning science has also shown that young children are capable of learning to a much higher degree than previously thought. Science is one of the favorite subjects of young children and, with math, can be learned and enjoyed as a family activity.

The Council gave this a high priority but as support at the endorsement level only; no further action is to be taken. We support the work of others in this area specifically the Maine Department of Education (and its $14M grant).

Milestone 6. The Maine STEM Council recommends that the Maine STEM Collaborative creates and implements a plan to increase public awareness of STEM and STEM employment statewide. Their biannual STEM Summit could be a forum for this.

Rationale: The Maine STEM Collaborative, a statewide unincorporated partnership of over 60 individuals from education, research, business, government, and nonprofit sectors that was formed by the Maine Mathematics and Science Alliance in 2007 to help increase the quality of STEM education, student aspirations, and public awareness of STEM education, has led STEM education efforts in Maine with four STEM Summits to date. With such a broad and devoted constituency, the Council believes that the Collaborative is the ideal group to increase public awareness of STEM and STEM employment statewide.

The Maine STEM Summits are now biannual and perhaps another STEM focused event could occur during the intervening years. Council members have suggested a statewide forum on research in out-of-school STEM learning, focused programs taking place in STEM schools, best practices for mentoring and internships, instructional practices at institutions of higher education, the role of teacher leaders and other educational leaders in effective STEM program or supporting STEM education/business endeavors such as Junior Achievement or Jobs for Maine Graduates.

The Council gave this a high priority.

Milestone 7. The Maine STEM Council recommends that the Maine Department of Education provide leadership in meeting with the MACTE, Maine Principals Association, the Maine Curriculum Leaders Association and the Maine School Superintendents Association to facilitate the awarding of graduation credit or proficiency for learning undertaken in CTE centers as a model for non-traditional settings.

Rationale: There was a bill before the 127th Maine Legislature (LD 1627 An Act To Implement Certain Recommendations of the Maine Proficiency Education Council) that may achieve the intent of this milestone. Presently, however, CTE centers must negotiate with sending secondary schools regarding which courses at the CTE will be given which credit at the sending school, if at all.

With proficiency based education and this legislation, such discussions will be facilitated. This milestone calls for convening critical players to make progress on an issue that has plagued CTE for many years.

The Council gave this a high priority.

The following are additional benchmarks under goal E which the Council discussed but determined were not of immediate potential:

1. The Maine STEM Council recommends that local school districts increase the numbers and diversity of students participating in Advanced Placement (AP) and International Baccalaureate programs and promote AP4All.

As an example of current participation rates, in 2015, Maine had twenty-two females take the AP Computer Science test (nine Asian and thirteen white) and one hundred forty-four males (sixteen Asian, four Black, and one hundred eighteen white four were not stated or other). The rates for 2014 were thirteen females (three Asian and ten white) and eighty-six males (one American Indian, fifteen Asian, one Puerto Rican, sixty-seven white and two other) and for 2013 were twenty-five females (eight Asian, one Other Hispanic, and sixteen white), and one hundred thirty-six males (twenty-two Asian and one hundred fourteen white).

2. The Maine STEM Council recommends that local school districts increase dual enrollment courses from high schools to college and from CTE schools to college.

3. The Maine STEM Council recommends that additional supports be provided for K-12 STEM competitions and challenges particularly including students who are from low-income or minority backgrounds.

This is consistent with Goal D, milestone 6. The Maine Mathematics and Science Alliance brought together, for the first time, organizations and people who implement such activities that are judged. A directory of such events was developed and disseminated.

4. The Maine STEM Council recommends that all teacher preparation programs in Maine place student teacher candidates with acknowledged high quality STEM teachers such as Presidential Award recipients, STEM subject Teachers of the Year, and Nationally Board Certified STEM subject teachers.

5. The Maine STEM Council recommends that local educational agencies provide regular and subject-specific professional development opportunities for teachers of STEM subjects.

Ideally these opportunities would occur monthly and would be at no or minimal expense to the teacher. There is a considerable body of evidence that shows effective professional development leads to increased student interest and achievement in STEM.

Goal E focuses on broadening opportunities for currently underrepresented populations of low-income, first-generation college students and minorities, including females, in all fields of STEM education and workforce.

Many of Maine's residents who are seeking postsecondary training fall into the abovementioned categories. 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.

V. Status and Progress Since Plan 1.0

Goal A. To improve STEM achievement and interest among grades pre-K-12 age students in and out of school.

There are five milestones under this goal and actions have been or are being taken on three of them.

The first milestone is the state adoption of the NGSS. A member of the Maine House of Representatives introduced a bill to accomplish this in the 127th Legislature. Many science educators and science leaders testified in favor of this bill and the Education and Cultural Affairs Committee passed it unanimously. It then passed the House and the Senate but was vetoed by Governor LePage. In his veto message, he stated: "While I support the desire to ensure that Maine students are well-equipped with the best science and engineering to prepare them for future careers that demand this vital knowledge, this bill would require that every school in Maine to rewrite its science curriculum to adapt to a new set of standards without allocating a single dollar either to the Department of Education or to the schools that must carry out this significant, time consuming work" (VetoLetters 052215.pdf).

The veto was overridden in the House but sustained in the Senate.

The Council deserves credit for first stating this idea in Plan 1.0 and advocating for its passage.

No progress has been made with milestone 2 (increasing professional development of teachers of math) or milestone 3 (increasing attention to literacy in STEM areas).

Milestone 4 is intended to reach students outside of schools. It urges that out-of-school and afterschool STEM programs be identified and professional development in STEM be provided to afterschool program providers. In Maine, the Maine Afterschool Network (MASN) is the touchstone for these programs. The MASN undertook such a survey. We have been in contact with MASN regarding data from the survey and were told that it is incomplete. However, the Council deserves credit for the implementation of this survey.

The fifth milestone in this goal recommends the development of stakeholder-based content advisory committees, based on the model of CTE

discipline advisory boards, for STEM content areas (including computer science) within the Maine Department of Education. This idea was introduced as a bill before the Legislature's Education and Cultural Affairs Committee but also contained adoption of the NGSS. The bill was withdrawn after noting the overlap with the science standards bill and discussion with personnel in the Maine Department of Education that they would indeed convene such a stakeholder-based advisory group on more of an ephemeral, rather than standing, basis. There was a fear, expressed by a representative of the Department of Education, that these groups would have nothing to do, and that meeting for a meeting's sake would be inefficient.

The sixth milestone was an additional recognition of the value of professional development for teachers and the usefulness of a strong content foundation. No progress was made on this milestone and Maine may slip backwards in this area as a result of the loss of federal funds for Math/Science Partnerships through the US Department of Education. In a typical year, Maine received at least $800,000 in federal funds to be used specifically for professional development of math and science teachers. With the reauthorization of the Elementary and Secondary Education Act as the ESSA (and the discontinuing of the No Child Left Behind Act), these set-aside funds rolled into a general fund. The Council regrets this action by the US Congress.

The final milestone concerns the important content area of computer science and its role in Maine schools. Presently, few students have access to a computer science course and if they are offered one, it is usually as a computer programming class. While programming or coding is a part of computer science, it does not define the field. The milestone the Council recommended was that the Maine Department of Education develop a professional teaching endorsement for computer science, analogous to ones for secondary science or Chinese.

While this milestone has not yet been realized, much work is ongoing with setting the stage for integrating computer science in Maine schools. A national effort is underway to write a K-12 computer science framework and standards are expected to be written at the state or local level.

Some twenty-eight states are promoting a computer science class for all their students and Maine must keep up with this effort.

Goal B. To increase the percentage of students completing postsecondary degrees or certificates in STEM.

Four milestones were promoted to help achieve this goal. The first one focused on improving instruction of undergraduates in the UMaine System, the Maine Community College System and the Maine Maritime Academy (although there is no evidence of the need for remedial instruction or a high dropout rate for freshman classes at Maine Maritime Academy). There is a field of research emerging on the value and impact of what is known as "Active Learning". The University of Maine, Orono campus has one of the leading researchers and practitioners in this methodology. Research results to date indicate that students persist in STEM classes and in

fact increase their taking of STEM classes and student performance after instruction via Active Learning is superior to instruction using traditional methods.

With one of the nation's leaders in this field in Maine, the Council believes it is supported in calling for expansion of this pedagogy through professional development at all University of Maine campuses, as well as those of the Maine Community College System and Maine Maritime Academy. In fact, we believe that Maine could become a national leader in this by expansion of this opportunity to all private higher education institutions in the state as well. Through some type of higher education professional development collaborative, Maine would be addressing this issue systemically as opposed to a campus-by-campus or classroom-by-classroom approach.

The Council deserves credit for continuing to advocate in this area and proposing a systematic solution.

The second milestone pertains to gathering and reporting data on remediation course at all public higher education institutions and citing best practices for overcoming remediation. Further research has revealed that the Maine Legislature has already required all University of Maine System campuses, Maine Community College System campuses and the Maine Maritime Academy to gather and report data and to describe efforts to reduce the need for remediation courses. The latest report (dated 1/1/16) for the University of Maine System (https://staticweb.maine.edu/wp-content/uploads/2016/01/LD-1645-Remediation-Report-2015-FINAL-12-22-15.pdf?565a1d) reveals aggregate data for each of the seven campuses of the University of Maine System in enrollment in remedial courses and student retention (returning to the same university, transferring to another UMS or other university or not enrolled). Almost 3.5 times as many students were enrolled in remedial math (n=209) as in remedial English (n=61) and rates varied widely by campus, from 0 at the University of Maine at Presque Isle to 54.5% at the University of Maine Machias. The report cites numerous initiatives planned and underway although these do not include the citing and sharing of best practices across campuses. Data in the report identify the number of students Maine high schools who matriculate at UMS and the number who enroll in remedial math and English. Unfortunately data are not reported for those schools for which five or fewer students are enrolled in a remedial course and remedial course enrollment data are reported for only nine of one hundred forty-four secondary schools.

In January of 2016, staff at the Maine Education Policy Research Institute prepared a report titled Remedial Course Enrollments and Student Outcomes in Maine's Public Higher Education Institutions (https://usm.maine.edu/sites/default/files/cepare/FinalReport_RemedialCourseReports_Updated_0.pdf). A key statement is made on page 2: "In summary the study concludes that the reports confirm the size of the college readiness challenge in Maine, but do not provide helpful insights to high schools or postsecondary institutions into the sources of the problem or what should be done about it." The recommendations do not call for any examination of postsecondary instructional review or analysis or intervention. And, in view of

several factors including not having comparative data on non-remedial students, the report suggested that the reporting of such data be discontinued. The report, however, does support the Council's suggestion in Plan 1.0 that interventions could take place in the third year of high school/grade 11 to alert the student to the need for remediation and possibly undertake that remediation in secondary school rather than college.

Milestone 3 recommends increasing partnerships between Maine's institutions of higher education and Maine's research and non-profit sector. This is happening organically and notable examples are the collaborations between the Bigelow Laboratory for Ocean Sciences and Colby College and the Jackson Lab with the University of Maine. In addition, the Gulf of Maine Research Institute shares faculty with both UM and USM. And the Maine IDeA of Biomedical Research Excellence (INBRE) is a collaboration of Maine educational and research institutions including Bates College, Bowdoin College, Colby College, College of the Atlantic, The Jackson Laboratory, Southern Maine Community College, the University of Maine, and the Universities of Maine at Farmington, Fort Kent, Machias, and Presque Isle and is led by the Mount Desert Island Biological Laboratory.

While the Council can take little credit for these partnerships, their existence should be roundly acknowledged and loudly proclaimed.

One milestone about which the Council has seen no action taken is that of content literacy that is, the learning of reading strategies in content areas such as math, science and technical subjects in higher education classrooms. This could be occurring and gathering such evidence is problematic. But we believe this is an important issue that is not just a K-12 one.

Goal C. To better align secondary (including CTE) and postsecondary training with the state's workforce needs.

One of the ways to achieve this goal is to create widespread internships and apprenticeships. While these are usually for youth, the Iowa STEM Council has a very successful "externship" program that places teachers in STEM-rich environments.

The Maine STEM Council has made no progress with this milestone.
The second milestone was to increase the awareness of all Maine residents about the vocations and avocations of science, technology, engineering and math. Some efforts are underway by groups such as the Maine STEM Collaborative with its biannual STEM Summit, the Maine State Science Fair, and Maine Robotics competitions. But these have not captured the interest of large numbers of Mainers.

Perhaps serendipitously, the Maine Department of Labor's Center for Workforce Research and Information conducted its second annual Job Vacancy Survey in September of 2015. This correlates well with the Council's third milestone in the goal that recommends such a regular survey. Results from this survey can be found at http://www.maine.gov/labor/cwri/jvs.html. A quick review of these results regarding STEM employment shows that opportunities exist. For example, as a high demand, high wage area, "healthcare

practitioner and technical" leads the need with almost two thousand four hundred vacancies and a median wage of $29.58. "Architecture and engineering" is also notable with one hundred twenty-six vacancies and a median wage of $33.55, as is "Life, physical and social science" with sixty vacancies and a median wage of $25.81.

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

The first milestone under this goal focused on increasing the participation of high school students with Maine's research community. Much work remains to be done here including identifying all the players in Maine's research community and conducting a survey of what is currently underway for such student participation.

Originally we thought that labor laws precluded such programming, but further research has led us to believe otherwise. According to communication with the Maine Department of Labor, youth can be employed at research facilities but must be at least fourteen years of age and have a work permit. Youth with paid jobs must be paid at the current minimum wage of $7.50 per hour. An issue does arise with unpaid internships. Unpaid youth internships must be tied to classroom studies or education credits, that is, the youth would receive class credit for their learning at the facility; otherwise, the internship may require pay.

Business liability needs to be negotiated between the research institute and the insurance company when youth are in unpaid situations. Students may volunteer for any non-profit organization as long as they are not performing hazardous duties.

Milestone 2 (agency collaboration) requires a systemic cultural shift and a possible sharing of power, which may doom it. The value of all of the agencies that impact STEM education even restricted to those dealing mostly with in-school education convening to discuss and share information and coordinate strategy is profound. Bringing together the players named in the original milestone requires a dynamic leader who can forge a vision and plan. There are many issues such a group could address, including reducing the need for remedial courses, aligning curriculum with postsecondary and job demands, strengthening the teaching of science, technology, engineering and math in all Maine schools, and using this report as a jumping-off point for reform.

This milestone also speaks to convening economic development agencies since the interplay of STEM education and economic development is critical to Maine. This probably occurs but we have no data sources on it.

A bold statement made in Plan 1.0 is that these two currently separate arenas should interact on a regular basis. Educators should be informed about economic development opportunities and directions of the state, not necessarily to simply provide "a willing workforce" but to help students and staff understand the link between education and the work world. Business planners need to know the directions schools are taking and the opportunities and constraints they operate under.

Unfortunately, little progress has been made in achieving this milestone.

> **Goal 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.

The Council at its April 2016 meeting accepted milestones for this goal so an assessment of their impact at this time is premature.

VI. Updated 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 with those milestones that the Council has deemed of immediate importance. Another step is to use the repot 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 will be issued on a biannual process in odd years. 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.

In addition, the Council will explore cooperative relationships with other rural states or regions 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 issues that deserve close scrutiny are early childhood education and corporate training provided through the community college system.

This 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 Goals and Milestones

Goal A. To improve STEM achievement and interest among grades preK-12 students in and out of school.

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 to assess access and qualities, 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.

Goal B. To increase the percentage of students completing postsecondary degrees or certificates in STEM.

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.

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.

Goal C. To better align secondary (including Career and Technical Education [CTE]) and postsecondary 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.

Goal 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 the 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 the Maine Department of Education, University of Maine 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 Administrators of Career and Technical Education (MACTE) and Technology and Engineering Educators of Maine Association and other important players.
- Among the Maine Department of Labor, Maine Development Foundation, Maine State Chamber of Commerce, Maine Technology Institute, Coastal Enterprises, and other major economic development focused organizations.
- Between both groups identified above.

Milestone 3. The Maine STEM Council recommends that Maine recruits and retains 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.

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

Milestone 1. The Maine STEM Council recommends that Maine groups that support recruiting and retaining STEM majors from low-income, first-generation college students and minority populations share best practices.

Milestone 2. The Maine STEM Council recommends that free community college models be explored.

Milestone 3. The Maine STEM Council recommends that computer science education be integrated in the K-12 curriculum.

Milestone 4. The Maine STEM Council recommends that the instructional methods of "active learning" be implemented at all University of Maine System campuses, Maine Community College campuses and the Maine Maritime Academy in appropriate STEM courses for undergraduate and teacher education candidates.

Milestone 5. The Maine STEM Council recommends that preschool and early childhood programs be made universally available in Maine.

Milestone 6. The Maine STEM Council recommends that the Maine STEM Collaborative create and implement a plan to increase public awareness of STEM and STEM employment statewide. Their biannual STEM Summit could be a forum for this.

Milestone 7. The Maine STEM Council recommends that the Maine Department of Education provides leadership in meeting with the MACTE, Maine Principals Association, the Maine Curriculum Leaders Association and the Maine School Superintendents Association to facilitate the awarding of graduation credit or proficiency for learning undertaken in CTE centers as a model for non-traditional settings.

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- **Jerry Pieh, Ed.D. (Chair until 2016)**

  Chair, Board of Directors
  Maine School of Science and Mathematics

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  Director
  Mid-Coast School of Technology

- **Diana Allen (Vice Chair starting in 2016)**

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