LEARNING STEM IN MAINE PLACES

Jan Mokros, Co-Director, The Reach Center, MMSA
January 2012

The purpose of this paper is to provide a better understanding of Maine's capability to promote 5th-12th graders' engagement and achievement in STEM during out-of-school hours. The paper will provide a background for the design conference task of constructing "STEM intensives" that make optimal use of Maine's resources and connect these resources with students in ways that make sense.

Introduction and Parameters. In 2009, the National Research Council undertook a significant exploration of how people learn STEM outside of school (2009). The subtitle of this work, "People, Places, and Pursuits," speaks volumes: The focus is on what people do by themselves and in communities to engage in science, where they do it, the nature of their activities, and the impact on the individuals who are involved. The report emphasizes six strands, which are articulated as outcomes for learners. These outcomes have a great deal in common with the Reach Center's goal of engaging promising students in STEM in deep and meaningful ways. According to the report, while it is still difficult to measure impact, there is high potential in informal learning for students to:

1. Experience motivation, excitement, interest, and motivation to learn about phenomena in the natural and physical world.
2. Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.
3. Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.
4. Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena.
5. Participate in scientific activities and learning practices with others, using scientific language and tools.
6. Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science (p. 4).

From kindergarten to their graduation from high school, students spend most of their waking hours outside of school, providing a great potential to expand children's STEM learning through engagement during their 'spare' time. (National Education Commission on Time and Learning, 2005;). Extramural STEM programs are growing in number and depth, and increasingly they are seen as valuable complements to science learning in school. Many examples of scientific exploration can be at least as productive at the more relaxed place that out-of-school time offers (Bevan et al., 2010). Out-of-school learning venues are particularly important for engaging girls, students from low-income families, and students who are most at risk of disengagement in school-based science classes (National Research Council, 2009).

Not surprisingly, students from low-income families have less access to opportunities for structured STEM learning programs outside of school. In Maine, the counties with the highest

poverty rates are overwhelmingly rural, whereas poverty rates in Portland and Bangor are in the low teens. The average poverty rate in Maine is 18%. Maine's rural counties have poverty rates ranging from 20% to 31% (www.datacenterkidscount.org, downloaded December 20, 2011). Thus, many students in such areas have neither access to many out-of-school programs, nor the economic means to participate in the few programs that may be available in their regions.

Nationwide, two key places for out-of-school STEM learning are 1) Science centers (broadly defined to include zoos and aquariums) and 2) afterschool programs. Maine has no large, centralized science centers such as exist in most other states, and has only a handful of small science centers, including two in Portland and one in Orono. The state has four small accredited children's museums, catering to children ages 10 and younger rather than the youth in grades 5-12 that the Reach Center has targeted.

A key function of major science centers, as well as zoos and aquariums, has been as hubs for bringing together the broader community around STEM. Collectively, such centers offer a mind-boggling array of science-rich programs for people of all ages, including science cafes, astronomy clubs, science theater, summer camps—even singles nights focused on current STEM topics. Overall, their missions tend to focus on providing pathways into STEM for youth: Starting in elementary school, science centers engage students through museum visits, then build their interest through special programs such as overnight adventures, school vacation programs, and summer camps. In many cases, these experiences culminate in an Explainer program, through which youth learn to become volunteer educators in the science center. Their work with visitors over months or even years often leads them to develop skills as informal educators as well, while gaining a deeper understanding of science (www.astc.org/resources/youth, downloaded December 21, 2011). Such science center hubs are a key resource in both urbanized and rural states like Iowa and Arkansas, as they engage the community of people who have interests and competency in STEM-related disciplines.

The relative rarity of science centers in Maine leads to important questions to consider: First, what spaces (virtual or physical) and networks might be assembled to function as a science center-equivalent STEM hub in Maine? Second, how can such hubs, when working in concert with one another, engage promising youth on a deeper and sustained level as they move from middle school through high school? Of course, it is also possible that Maine needs a physical hub—like a science center—to bring together STEM places and people.

A second class of structures that serves to bring young people and STEM together is that of afterschool programs, which frequently receive federal and state funding to enrich the learning of lower-income children (http://www2.ed.gov/programs/21stcclc/index.html). Whereas such programs are traditionally seen as ways to keep young people productively engaged in homework and sports activities, rather than being on their own during long absences of parents still at work, they are increasingly seen as a vehicle for immersing students in special activities—such as community service projects and art or STEM programs. (In the area of STEM programs, the Noyce Foundation funds innovative work in this area through 4-H and the Afterschool Alliance, which have thematic focuses on STEM.)

With respect to such comprehensive after school programs in Maine, participation is relatively low: Of 122,000 children in elementary and middle school, fewer than 7,000 participate in general afterschool programs for 30 days or more per year (Maine Afterschool Network). The percentage of participants decreases with age. Most Maine children spend their time with family members after school, although about a quarter of school-aged children currently fend for themselves. As of 2005, there were only two certified after school programs in Maine (www.maineafterschool.net, downloaded December 20, 2011).

A question that we will return to is this: How can Maine capitalize on out-of-school hours in order to spark or deepen interest in STEM? And how can this be accomplished without imposing logistical burdens on parents or caregivers?

What Are Maine's Strengths and Resources, and How Do These Relate to Out-of-School STEM Learning?

Below is a brief description of Maine's out-of-school-time educational programs in STEM-related learning areas. What follows is not a comprehensive review, but rather provides examples of human and institutional resources that could be built upon.

1. Environmental Programs and Centers

Maine's character is integrally tied to the natural environment. On the recreational side, the natural beauty of Maine has made it a mecca for vacationers and campers. Its coastline beckons scientists and visitors alike, and Maine boasts many institutes that conduct research on the ocean and coastline ecology. Consequently and not surprisingly, Maine has an abundance of environmental centers and science specialty camps, many of which focus on the ocean and surrounding environment.

Over 70 programs, most of which involve out-of-school time, are listed in the Maine Environmental Education Association's resource guide (Maine Environmental Education Association, 2007). Some of these programs are substantial networks such as Audubon Society programs; others operate through large centers that focus on the concerns of a particular place (e.g., the Gulf of Maine Research Institute, the Island Institute), while still others are theme-focused programs (e.g., the Ferry Beach Ecology Program). Most of these offer both out-of-school and in-school programs as a way of targeting a large audience. Staff from these programs visit schools, conduct assemblies, host specialized programs at their institutions, and in many cases hold two-day to week-long residential programs that are targeted to overnight visits from Maine schools.

Certain of these programs are thematic, as is the case of GMRI's Cohen Center programs, which host a staggering 10,000 Maine middle school students a year. The Cohen Center's "Lobster: Untold Tales!" includes, "activities modeled on research being conducted by marine scientists along the coast of Maine. Students examine a live lobster's adaptations for defense and migration, take videos of lobsters in a live tank to learn about habitat and behavior, view possible prey under a digital microscope to determine about the diet of a larval lobster, and take a virtual lobstering trip to learn about natural resource issues."" GMRI programs enable students to develop the habits of mind to engage with the environment—specifically the Gulf of Maine

environment—and think critically about new ideas. It is not surprising that GMRI's immersive science experience is the most popular science field trip in Maine, and one that leaves a lasting impression on students in terms of direct encounters with scientific research.

A few environmental centers sustain work with students over longer periods of time. Bigelow Labs, for example, engages promising high school juniors from Maine in a five-day ocean research experience program. The goal of this Keller BLOOM (Bigelow Laboratory Orders of Magnitude) program is to provide Maine students with opportunities to work alongside professional marine scientists in both laboratory and field work, including data collection and analysis. Students also learn about career choices involving marine biology, chemistry, and geology.

On an even longer time scale, Chewonki provides a semester-long program, which focuses on environmental issues and includes rigorous courses in all areas of the high school curriculum. This program is highly competitive, and most of its students go on to selective colleges. However, only 16% of students in Chewonki's program are from Maine, and the vast majority of these are from independent schools. Similarly, the Coastal Studies for Girls program in Freeport Maine enrolls a small number of highly motivated girls each semester to study science and develop leadership skills. This outstanding program has links with and contributes to the TalkingScience blog (a teen science blogging community that operates in conjunction with Science Friday; see www.talkingscience.org). Like Chewonki, the Coastal Studies program offers summer camps. Another similarity is that the programs do not target Maine students as the primary audience. While both programs provide financial aid, the price tag for semester-long programs ($17,500 to $23,000 as of 2011) is prohibitive in a state where the median family income is $45,600 (2009 Census figures).

Certain colleges and most branches of the University of Maine system also offer specialized environmental programs for pre-college students. The EPSCoR program devotes a substantial part of its budget to providing pathways for pre-college students into STEM "sustainability science." Some campuses, notably University of Maine's Darling Marine Center, offer multi-day immersion programs on environmental science (in this case, marine science), for high school students.

2. Citizen Science Initiatives

Citizen science projects, in which ordinary citizens work with scientists to monitor and collect scientific data (often sharing these data through online portals) are proliferating both nationwide and in Maine. Because these projects involve people of all ages in a common scientific pursuit, they are a natural fit for families or school groups. Wendy Almeida, a mother of two in Maine, writes a fascinating blog about her family's experiences with citizen science (see http://raisingmaine.mainetoday.com/blog). Three examples of the projects that the Almeida family has participated in include: 1) **Signs of the Seasons: A Maine Phenology Project** (umaine.edu/signs-of-the-seasons), which focuses on the timing of seasonal changes. The University of Maine Cooperative Extension and Maine Sea Grant coordinate the program in partnership with the U.S. National Phenology Network, U.S. Fish and Wildlife Service, Maine Audubon, climate scientists at the University of Maine ,and several other organizations; 2) **The Invasive Forest Pest Outreach, BugWatchME** (www.albmaine.org), which is conducted by

the Maine Department of Agriculture, which focuses on invasive insects such as the Asian longhorned beetle, which poses a particular threat to Maine; and 3) **The Maine Audubon Wildlife Road Watch** (www.wildlifecrossing.net/maine/map/wildlife), which involves observations of where animals are crossing roads and helps scientists understand habitat fragmentation. What is noteworthy about the Almeida family's experience is that they have put together several related monitoring projects, and in the process truly have become hooked on science. Due to these opportunities, they have become deeply immersed in science—much the way we want Reach Center participants to become immersed. They are also making a difference to scientific research and having an impact on their community.

The Gulf of Maine Research Institute's Vital Signs project takes a school-based approach to citizen science. This program involves middle school students, teachers, and scientists in the collection and analysis of data concerning terrestrial and aquatic invasive species. As in most citizen science projects, data are contributed through a distributed network. In this case, students make use of innovative mapping technologies to show the location and density of their data. On an anecdotal level, GMRI reports that many of the students who participate in its Vital Signs program go on to participate in science and engineering fairs as a result of their involvement in citizen science. It would be valuable to follow students who are involved in this program—as well as other citizen science programs in Maine—to determine the impact on subsequent STEM engagement and interest. On a national level, there is a growing body of research showing that students who participate in citizen science projects are more likely to see science as relevant to their own lives and to become deeply engaged in science (Citizen Science Toolkit Conference, 2007).

Organizations like KIDS Consortium, in conjunction with the Maine Mathematics and Science Alliance, are exploring intriguing ways of linking citizen science projects with service learning (see www.kidsconsortium.org). Many young people care deeply about making a difference in their communities or schools, and they are drawn to projects that involve environmental issues. By immersing students in rigorous investigation of the problem they wish to solve (including collecting and analyzing baseline data), planning and implementing an intervention, then determining the impact of that intervention, students may learn that "making a difference" goes hand in hand with math and science. The Coalition for Science Afterschool (www.afterschoolscience.org) has recently highlighted a couple of national programs that bring together STEM learning with service-learning (December 2011 newsletter).

3. Summer Camps and Programs

Youth from across the country flock to Maine for summer camps. Increasingly, these camps include a programmatic focus on science, technology, engineering, and mathematics. Camps for kids are a Maine specialty, and include academic camps to spark kids' interest in college as well as in STEM. There are many overnight specialty camps: Acadia Institute of Oceanography, for example, offers one- and two-week marine programs for high school students.

As noted above in the discussion of Chewonki and the Coastal Studies Program for Girls, specialty summer camps are usually expensive. However, substantially less expensive STEM specialty camps are increasingly being offered by Maine colleges and universities. There is a dual purpose of these camps: to immerse students in a STEM topic or project, and to acquaint

them with a specific campus and promote their interest in attending college. The University of Maine at Orono's summer camp offerings are especially strong in technology and engineering, as exemplified by programs such as "Innovation Adventure," "Consider Engineering" (for high aptitude students), and CAD camp, which focuses on using computers in design. Some university-based summer camps offer cross-disciplinary approaches to STEM, such as the architecture/engineering camp offered by University of Maine at Augusta, described as follows:

> "Did you know that local Maine engineers are designing photovoltaic fabric which not only becomes the membrane surface, but actually produces electricity from the sun for use by the occupants? Students will design and build their own inventive model interpretation of a pavilion, which will be later constructed using colorful tarp systems." (www.yo.uma.edu, downloaded December 20, 2011).

At the middle school level, a key player in STEM summer camps for the last 15 years has been the Maine School of Science and Mathematics (MSSM). The school offers a long-standing, rigorous, and popular weeklong program that reaches over 400 students per summer with work in a focused STEM topic of the student's choice. In a recent summer, there were 20 topics to choose from, including the physics of projectiles, math behind games, solar car design, programming, origami, mammalian medicine, mapmaking, and the effects of bridge design. MSSM offers the most wide-ranging set of intensive summer STEM experiences anywhere in Maine. Almost all of the campers are from Maine, and the camp serves to acquaint STEM-capable students with MMSM's residential, publicly funded specialty high school (www.mssm.org, downloaded December 20, 2011).

4. Internships

Maine high school students have dozens of STEM-related internships to choose from, in settings ranging from large research institutes to small companies. Some of these internships are open to all comers (Mainers as well as nationwide), while others are targeted at students who live in a particular area and meet a prescribed set of criteria. From the point of view of those offering the internships, a major goal is to develop the scientific/engineering talent that would best address their workforce needs. For students, internships provide opportunities to acquire in-depth knowledge of how science works and how collaborators work together in a scientific environment.

One of the most intensive and selective summer internships for high school students nationwide is offered at Jackson Labs. Three graduates of the summer program have gone on to win Nobel prizes (http://www.jax.org/news/archives/2009/szostak_nobel.html). This long-standing genetics program pays students a stipend and immerses them in research alongside geneticists. They learn research skills, including how to present their findings to an audience of scientists. Dr. Randy Smith, who directs education at JAX, has committed one slot in this competitive program to the winner of the Maine Science Fair.

Like Jackson Labs, the Mount Desert Island Biological Laboratory provides intensive 8-week research internships for selected high school students, who are matched with and work alongside an MDIBL scientist. The goal of this program is for high school students to play an active role in real biological research and plan and conduct their own experiments. Students meet weekly to discuss their projects and interact with guest speakers. The culminating experience involves

presentations to peers and mentors. While the JAX experience typically involves only a few students from Maine, all of the internships at MDIBL are targeted at Maine students.

While it is beyond the scope of this paper to catalog all of the STEM internships in Maine, one noteworthy program is the MERITS scholarship program, which is administered by the Maine Space Grant Consortium. It provides high school juniors intent on majoring in STEM fields with a choice of summer placements in different settings.

> "Since its inception in 1992, MERITS has provided summer and school year opportunities to hundreds of teachers and students at more than 70 businesses and non-profit laboratories across Maine. Participants have worked in a wide variety of research areas including: information technology; semiconductor engineering; electrical engineering; environmental studies; molecular genetics; medical research; estuary and ocean science; marine biology; precision manufacturing; geology and soil science; and analytical chemistry."
> (www.msgc.org/files/MERITSProgramAnnouncement2012.pdf, downloaded December 20, 2011)

MERITS, like the MSSM summer program for younger students, is comprehensive and far-reaching with respect to the diversity of STEM fields that are addressed.

5. Clubs

As discussed above, Maine has relatively few large afterschool programs, but makes up for it with after school clubs at individual high schools, and with one key organization: 4-H. 4-H, which involves a staggering 20,000 Maine students per year in at least one project (https://extension.umaine.edu/4h/youth/), is the major player in Maine's club landscape and is increasingly focused on STEM activities and projects. In addition to the traditional projects involving agriculture and animal science, 4-H students participate in projects involving environmental science and energy as well as technology and engineering (including robotics). Traditional 4-H programs are delivered through community clubs, which are led by volunteers.

Specialized robotics clubs have rapidly gained traction in Maine over the last 10 years; particularly the middle school-oriented FIRST Lego League. There are 60 teams in Maine, ranging in size from 2 to 10 students. Maine Robotics (www.mainerobotics.org) serves as the organizational glue for these clubs and also organizes robot track meets, summer camps, and workshops. These clubs prepare students for statewide robotics competitions, as described below.

6. Contests and Competitions

Maine has witnessed a dramatic increase in engineering competitions among high school students, while is has simultaneously seen a decrease in participation in science fairs. The state's science listserv typically posts two to three announcements concerning state and national engineering competitions *every month.* Competitions in engineering have seen the most substantial growth in the area of robotics. Maine Robotics reports that 1,200 Maine middle and high school students are now participating in robotics competitions each year, mostly at the middle school level. According to Maine FIRST (www.mainefirst.org), ten high school teams—mostly from southern Maine—participated in the 2011 round of competition. These teams typically receive financial and coaching support from Maine companies as they prepare for

competitions, with Fairchild Semiconductor providing major support. Notably, parents and coaches from the community are heavily involved in supporting robotics competitions.

Smaller engineering competitions that are indigenous to Maine include the Maine Windblade Challenge (www.mainewindbladechallenge.com, downloaded December 20, 2011) that is organized by the state's Composites Alliance and researchers at UMaine who are involved in alternative energy. Maine high school students also participate in national online engineering competitions, such as the "Real World Design Challenge" (www.realworlddesignchallenge.org, downloaded December 20, 2011), which pairs teams of students with engineering mentors from companies around the country.

While engineering competitions are on the rise, Maine's more traditional science fairs have been struggling. The statewide science fair nearly died in 2009, but has been resuscitated through a strong commitment from Jackson Labs. In 2010, 140 students from 16 high schools participated (www.mainedoenews.net/2011/05/04/state-science-fair, downloaded December 20, 2011). An increase in these numbers is expected now that participation in Maine's Science Fair confers eligibility to Intel's International Science Fair.

In addition to science fairs, which typically involve research projects, Maine students participate in the Science Olympiad, which fielded twenty teams in 2010. Some schools have been heavily involved in these competitions, while most do not participate at all. Maine's Science Olympiad has been won by Waterville High School every year from 1996 to 2010 (http://www.scioly.org/wiki/Waterville_Senior_High_School, downloaded December 20, 2011).

The major mathematics competition in Maine is the longstanding American Mathematics Competition, which involved 915 elementary/middle school students and 2,130 high school students in the 2010-11 school year (http://www.mmsets.org, downloaded December 20, 2011). Maine students are represented, on a per capita basis, at about the same rate as students from other states. (1.3 million Maine population compared to 30.8 million for U.S.). At the middle school level, the Mathcounts competition involves fewer students, with 18 Maine schools participating in 2010-11. The Mathcounts program offers the option of belonging to a school-based club and participating in competitions. To a large extent, clubs serve to prepare students for competitions.

Why have we seen an increase in engineering competitions with a concomitant drop-off in more traditional science and math competitions? Some speculations: Engineering design challenges are appealing to students because they are collaborative and involve a strong team element, while science and math competitions are more mixed in this regard. Second, a common anxiety for students is identifying a research topic and project for science fairs. On the other hand, the design constraints set by engineering competitions provide a "structured challenge" for students to work with. Note also that when it comes to competitions, it is often not a matter of student choice: If a school has the money and coaches to sponsor a FIRST team, then that may be the primary option for students. If a school has a strong Science Olympiad coach and a history of success (like Waterville's), a student from that school may sign up for the program. Often, involvement in competitions is affected by geography; it is easier to become involved in a team if you are from a

larger school. Competitions that involve online "tests," like the Math Olympiad, do not have as many geographic constraints.

7. Coaches and Mentors

When it comes to athletics and the arts, we find strong "communities of practice" that support middle and high school students in their out-of-school endeavors. In these arenas, there are respected coaches—often professionals or highly skilled amateurs—who guide students as they develop deeper levels of engagement. To some extent, we find this kind of coaching occurring in robotics competitions, where engineering expertise is critical. The role of a 4-H volunteer is in some ways similar, as the volunteer often lends expertise to students who are completing STEM-related projects. However, 4-H volunteers are not required to bring specific content expertise to their volunteer work.

Summer internships provide the greatest access to ongoing mentoring. The programs described above, as well as many others throughout the state, provide intensive mentoring as students conduct their own research. This connection to adults in the field is often one of the most powerful aspects of summer research experiences. Such mentoring work with high school students is an extension of proven programs that pair college science students with researchers at their universities, often through NSF's Research Experience for Undergraduates (REU) program.

Sadly, many STEM professionals in Maine have no meaningful vehicle for mentoring and coaching students—either inside or outside of school. The structure of schools makes it difficult for teachers to work in partnership with STEM professionals. As one highly accomplished medical professional, who had taught in medical schools here and abroad, explained, "It's like schools have an invisible barbed wire fence around them" (personal communication, June 2011). Though this expert had generated significant funding for a science lab at his local high school, he was discouraged from using the lab with students.

Potential mentors, including members of Maine's IEEE chapter and participants in the Senior College at UMaine Augusta, have expressed a strong interest in working with students in STEM fields. Given the fact that Maine has the largest senior population in the country (Callahan, 2007), it appears that retired STEM professionals are a significant and largely underutilized resource. Tapping into networks of STEM professionals—or networks like that of the Senior College, which may include large numbers of STEM professionals—may be a viable strategy for building mentoring relationships with promising STEM students throughout Maine. Virtual communities of mentors, such as MentorNet's (www.mentornet.net) mentoring program for diversity in STEM, is another important resource to explore.

Suggestions and Questions: Improving STEM in Maine Places

We return to the question of how Maine can use its resources to better serve students outside of school with STEM programs that embody the six principles of effective informal learning delineated at the start of this paper. The Reach Center will design experiences that take advantage of out-of-school settings to engage promising students in STEM fields, and that provide increasing depth as students progress through high school.

Below are some provocative statements, potential goals of programming, and questions in this topic. These are intended as discussion starters for the Reach Center's design work. These statements, as well as others that we hope that collaborators will generate, are intended to seed the discussion as we plan Reach Center initiatives.

1. Identify the best of Maine's STEM internships and intensive programs, and encourage them to serve more *Maine* students, including students with limited financial resources. It would be especially attractive to have the "semester away" programs in Maine reserve and subsidize slots for Maine students. These long-standing semester programs have shown strong impact in terms of encouraging more students to pursue STEM in college. They would be more attractive to Maine's students if they were more affordable.

2. Make full use of Maine's seniors and retirees who have had careers in STEM fields. Develop their skills as mentors and coaches through communities of practice (virtual and in-person) specifically designed for mentors. The strong Senior College network, consisting of 17 centers in Maine (http://www.maineseniorcollege.org) and coordinated through the Osher Center for Lifelong Learning at the University of Southern Maine, could be a key resource for developing and deploying mentors. Mentors could be connected with students and parents through clubs, contests, competitions, and summer opportunities, perhaps using the highly successful FIRST program as a model. Provide meaningful and efficient ways of connecting these mentors with students in their own communities and beyond. Finally, figure out how to involve these STEM professionals in more specialized roles in far-reaching 4-H clubs and other traditional clubs that are implementing more STEM programming.

3. As a service to the state that could be provided through the Reach Center, build, maintain, and update an annotated and searchable resource bank of opportunities for out-of-school STEM learning in Maine. A refrain we have heard consistently from educators and recently from the Governor's STEM Council is: "We need an asset map of out of school opportunities." Much of this already exists (see www.mainestem.org), though it is not updated and is spotty because it relies on information from volunteer contributors. While knowing about the resources is an important first step, a more significant contribution would be ensuring that these resources are well utilized on a continuing basis. Helping a student (and her parents and mentor) know what is out there and what matches her interests at a particular point in time and on a continuing basis would be valuable. The Reach Center could help parents, mentors, coaches, teachers, and students themselves use this resource bank to move beyond single "STEM encounters" and develop a pathway of progressively deeper engagement. Local mentors, making use of the resource bank, could help make these opportunities come alive for students.

4. Ensure that students have access to strong out-of-school opportunities *throughout* Maine, not just in the more populated areas. One potential resource to reach students from northern and eastern parts of Maine is the Maine School of Science and Mathematics (see www.mssm.org); another is the Schoodic Education and Research Center in Acadia (see www.sercinstitute.org). While the remote location of these sites is sometimes seen as a liability, it is a strength when it comes to reaching students from all parts of Maine. Education centers like SERC and MSSM could expand upon their growing reputation as STEM camps or retreat centers by becoming hubs

for students who want to engage in science beyond the school day. Weekends and school vacations offer many possibilities for engagement in STEM at these centers.

5. Tie students' STEM experiences outside of school to the state's resources and economic and employment needs. Maine has targeted seven technology clusters that are distinctive specializations in Maine's economy and serve as drivers of the state's economic development (MTI Cluster Report, 2008). These focus on STEM fields, namely biotechnology; composites and advanced materials; environmental technologies; forest products and agriculture; information technology; marine technology and aquaculture; and precision manufacturing. Some of these areas, such as marine and environmental technologies, are well represented in out-of-school education, while others, such as biotechnology and information technology, are relatively neglected. Meanwhile, technology companies in Maine are calling attention to the serious constraints they face due to their inability to find engineers and computer programmers. While STEM education, whether in formal or out-of-school settings, should not be determined solely by the state's economic needs, students will benefit when they see vital connections between STEM experiences and Maine's workforce needs.

6. Finally, start with individual students, and focus on providing a rich and consistent diet of STEM experiences for each student. Dr. Pendred Noyce, a STEM advocate and researcher with a strong interest in out-of-school learning in Maine, has posed a simple yet profound proposal: *Provide at least one exciting, rigorous STEM experience—in or outside of school—every year for every student. Do not leave it to chance.* Providing one meaningful experience per year, Noyce hypothesizes, may be enough to keep students involved in STEM through high school and into college. Currently, about 80% of students in high school indicate they would not take any more than the required number of STEM courses (Microsoft, 2011).

The quality of these annual experiences matters. Perhaps the Reach Center could borrow and broaden the concept of Active Prolonged Engagement (APE) developed at the Exploratorium (Humphrey & Gutwill, 2005). APE guided their design for certain exhibit experiences, but why not apply it to a set of connected out-of-school experiences that take place over a longer time period? Why not make sure there is depth and active engagement in students' involvement in a series of STEM experiences in Maine places over months or even years? The Reach Center could work toward the long-term goal of reaching every promising middle and high school student in Maine with active prolonged engagement in STEM through at least one high-quality experience each year. These experiences would build upon each other.

As this paper has shown, Maine has unique and impressive resources for promoting STEM learning. It is imperative that Maine's students have meaningful, ongoing access to these resources and experiences. We cannot afford to leave STEM learning dependent on chance, financial circumstances, or geography.

References

Bevan, B., Michalchik, V., Bahnot, R., Rauch, N., Remold., Semper, R., Shields, P., (2010) *Out-of-School Time STEM: Building Experience, Building Bridges* [PDF]. Learning and Youth Research and Evaluation Center

(LYREC). Retrieved: http://integratingengineering.org/after_school/Out%20of%20School%20Time%20STEM_NSF%20AYS%20report.pdf

Cornell Lab of Ornithology. (2007) *Citizen Science Toolkit Conference* [PDF] Retrieved: http://www.birds.cornell.edu/citscitoolkit/conference/toolkitconference/proceeding-pdfs/Full%20Proceedings.pdf

Gulf of Maine Research Institute. (2010) *GMRI Celebrates 50,000th Maine Student in LabVenture!* Program. Retrieved: https://www.gmri.org/news/tidings/gmri-celebrates-50000th-maine-student-labventure-program

Harris Interactive. (2010) *STEM Perceptions: Student & Parent Study Parents and Students Weigh in on How to Inspire the Next Generation of Doctors, Scientists, Software Developers and Engineers*. Commissioned by Microsoft Corp. [PDF] Retrieved: https://news.microsoft.com/download/archived/presskits/citizenship/docs/STEMPerceptionsReport.pdf

Humphrey, T., & Gutwill, J. (2005). Fostering Active Prolonged Engagement. San Francisco, CA: The Exploratorium.

Maine Technology Institute. (2008) Maine's Technology Sectors and Clusters: Status and Strategy [PDF]. Retrieved: https://www.mainetechnology.org/wp-content/uploads/2015/06/colgan_cluster_report_2008_full_report_final_040908.pdf

National Education Commision on Time and Learning. (2005.) Prisoners of Time.[PDF] Retrieved https://www.ecs.org/clearinghouse/64/52/6452.pdf

National Research Council. (2009). Learning Science in Informal Environments: People, Places and Pursuits. Washington, DC: The National Academies Press.