Governor's Task Force on K-12 STEM Education

Pathways to STEM Excellence: Inspiring Students, Empowering Teachers and Raising Standards

Final Report Released January 2015

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Final Report Released January 2015 to Her Excellency

Margaret Wood Hassan, Governor, State of New Hampshire

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EXECUTIVE SUMMARY

A well-educated and well-informed public, the career prospects of NH's young people and the state's economy depend on high quality science, technology, engineering and math (STEM) education across the state. Most new innovations that are the engines for economic well-being and growth rely on strong STEM foundations and are created at the boundaries where STEM disciplines intersect.

A 2013 NH Employment Security report, *"STEM in New Hampshire: A Labor Demand-Supply Analysis,"* concluded that in New Hampshire workers in STEM occupations[1]

- are more likely to have higher levels of education,
- have the skills and knowledge most in demand, and
- are expected to have very favorable employment opportunities

There are significant opportunities for New Hampshire students who prepare for entry into STEM fields and other careers requiring STEM literacy. New Hampshire companies report that well-paying jobs are available for qualified employees in advanced manufacturing, information technology, financial services, insurance and healthcare. These companies offer a variety of careers as engineers, information technologists, product designers, skilled technicians, data analysts and database managers, to name only a few. In the future, new occupations are expected to emerge offering even more new opportunities, but these will require strong educational programs and high quality preparation of students.

In creating the Task Force, Governor Hassan highlighted that "[t]o help young people develop the skills and innovative thinking needed for jobs that growing businesses are creating here in New Hampshire, we need to come together as a state to ask tough questions about how we can best educate our young people, especially in the STEM fields of science, technology, engineering and math."

[1] NH Employment Security, Economic and Labor Market Information Bureau. *STEM in New Hampshire: A labor demand-supply analysis.* (April 2013). Retrieved from http://www.nhes.nh.gov/elmi/products/documents/stem.pdf

The American Psychological Association (APA) citation style is used throughout this document

About 27 percent of projected STEM job openings are in occupations requiring an associate's degree, and more than half are in occupations requiring at least a bachelor's degree. These percentages are substantially higher than percentages for all occupations.[2] While New Hampshire consistently ranks among the top 10 states in the percentage of associates', bachelors' and graduate degrees, the state is not as well-positioned in the percentage of post-secondary degree holders in STEM. Nationally, New Hampshire ranks 21st and 32nd respectively in the percentage of associates' and bachelors' degrees in STEM. Moreover, it is 49th in the percentage of STEM credentials awarded per STEM employees.[3] To address this gap in STEM degrees, the University System of New Hampshire (USNH) and the Community College System of New Hampshire (CCSNH) have committed to doubling that number by 2025.

The immediate STEM skills gap is being addressed by some innovative collaborative efforts. These include partnerships between community college and university system institutions with individual businesses, such as with Albany Engineered Composites (Rochester), GE Aviation (Hooksett), Dyn (Manchester), BAE Systems (Nashua) and Hypertherm (Lebanon). However, there is a strong need to scale up these efforts and to address the long-term need in the "pipeline" for skilled engineers, scientists and technicians in a range of industries across the state.

The New Hampshire Charitable Foundation's report *Smarter Pathways: Strengthening New Hampshire's STEM Pipeline* identified a significant STEM "pipeline leakage" resulting in lost opportunities for students and an insufficiently STEM-trained workforce.[4] From 4th to 8th grades, the percentage of New Hampshire students scoring proficient, or proficient with distinction, on the 2012 New England Common Assessment Program (NECAP) exam declined significantly.[5] The state's students' scores on both 8th-grade math and science NECAPs were below other New England states. Finally, the report identified that hours spent per week in sciences in grades 1-4 had declined by almost 40 percent since 2004.

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[2] NH Employment Security, Economic and Labor Market Information Bureau. *STEM in New Hampshire: A labor demand-supply analysis.* (April 2013). Retrieved from http://www.nhes.nh.gov/elmi/products/documents/stem.pdf

[3] National Center for Education Statistics. (2012). *Custom download file using 2012-2013 data and Education Commission of the States and the National Center for Higher Education Management Systems*. Retrieved from http://nces.ed.gov

[4] New Hampshire Charitable Foundation. (2014). *Smarter pathways: Strengthening New Hampshire's STEM pipeline*. Concord, NH: Education First.

[5] NECAP tests students in math, science, reading and writing periodically beginning in 3rd grade. Retrieved from http://www.education.nh.gov/instruction/assessment/necap/gle.htm

In the 2012-2013 school year alone, there were 184 vacancies for science and math teachers in New Hampshire schools and only 91 teacher prep candidates qualified for these positions. We are training virtually no teachers at all in physics and the physical sciences, and fewer than half the teachers we need in math.

The NH math and science scores noted above occur in the context of a declining US position in STEM education globally.[6] On the global math survey, administered in 2012 by the Program for International Student Assessment (PISA), 29 countries achieved test scores superior to the United States. The United States was outscored by almost every Asian nation—as well as European countries including Latvia, Britain, Poland, France, Germany and Slovenia. In science, twenty-two countries posted better results than the United States, including Vietnam, Canada and Poland.[7] Between 2000 (when the PISA test was first administered) and 2012, the United States' scores have remained stagnant, while other nations have improved. Thus, while the scores are not New Hampshire specific, the findings are relevant for the state.

Recognizing the need to build the long-term pipeline to help produce a STEM-educated workforce and the benefits of a population that is STEM literate, Governor Hassan in April 2014 issued an executive order creating the STEM K-12 Task Force. In creating the Task Force, Governor Hassan highlighted that . . . *"[t]o help young people develop the skills and innovative thinking needed for jobs that growing businesses are creating here in New Hampshire, we need to come together as a state to ask tough questions about how we can best educate our young people, especially in the STEM fields of science, technology, engineering and math."*[8]

[6] The Program for International Student Assessment (PISA) is an international assessment that measures 15-year-old students' reading, mathematics, and science literacy. Retrieved from http://nces.ed.gov/surveys/pisa/

[7] Layton, L. (Dec. 3, 2013). U.S. students lag around average on international science, math and reading. *Washington Post*. Retrieved from testhttp://www.washingtonpost.com/local/education/us-students-lag-around-average-on-international-science-math-and-reading-test/2013/12/02/2e510f26-5b92-11e3-a49b-90a0e156254b_story.html

[8] State of New Hampshire, Office of the Governor. (2014). *An order establishing the Governor's Task Force on Science, Technology, Engineering and Math Education (Executive Order 2014-01)*. Concord, New Hampshire. Retrieved from http://www.governor.nh.gov/media/news/2014/pr-2014-04-09-stem.htm

The Task Force brought together a diverse group of stakeholders from the education and business communities to make recommendations for modernizing STEM education in New Hampshire's schools. The Task Force has drawn from the strong efforts that had preceded it, including the New Hampshire Charitable Foundation's study of the STEM employment pipeline, the work of the state's Advanced Manufacturing Education Advisory Council, and the NH Business and Industry Association's Strategic Economic Plan. The Task Force focused on student motivation and outcomes, educator preparation and support, and school day curriculum and activities.

How to Best Educate our Young People in STEM Fields

New Hampshire school districts that embrace STEM K-12 education will have the opportunity to inspire and enlighten the state's young people and support strong local economies with skilled graduates. The STEM foundations of math and science, along with technology and engineering, are important complements to arts, humanities and social science. Together these studies form a well-rounded, educated student who will also be a well-informed citizen.

In addition, if young students in the early years of their education are encouraged to practice creativity and hands-on learning within an integrated curriculum, then greater are the chances that more students will gain not only a fluency in STEM, but also embrace STEM as a career. To achieve these goals students need information and support so they can create successful pathways from cradle-to-career.

Progress on STEM K-12 education will also require directly addressing significant inhibitors that cut across the eight Task Force recommendations discussed below. The Task Force report puts forward strategies to overcome the significant barriers in STEM K-12 education. These include the need to: ensure adequate STEM educational resources and opportunities in rural and low income communities; encourage and support girls in STEM; and foster on-going innovation in STEM K-12 education.

The measures of success of the Task Force recommendations and benchmarks to track and assess progress include improved science and math proficiency scores, increased AP STEM course enrollments and SAT math scores, increased student participation in STEM competitions and projects, as well as an increase in the number of STEM majors in NH college and NH graduates entering into STEM careers.

Finally, a statewide commitment to STEM should be made that supports local innovative efforts to inspire New Hampshire students, empower educators, and advance STEM statewide. These efforts must build on the state's strong educational institutions, engineering and technology tradition, and economic strengths. Public funding is essential to support strong and sustained core STEM programs. However, to ramp up innovative practices and to encourage increased external business support, the Task Force recommends establishing a STEM K-12 Education Innovation Fund.

Districts seeking to enhance their students' STEM opportunities can think of STEM K-12 education as a "system" of preparation for students from kindergarten through post-secondary education and then entry into STEM and other successful careers. Today students must be exposed to a holistic, cohesive and applied STEM learning approach to knowledge and its creation; where individual talents of students are nurtured through multiple approaches – not a one-size-fits-all model or approach. These approaches are particularly well-suited to the culture of New Hampshire where individual achievement is embedded deeply in ties to local school, community and work – and now to an increasingly global perspective. In order to realize these aspirations, the Task Force has focused on three objectives: Strengthening Foundations, Inspiring Students, and Empowering Teachers. These objectives provide the framework for the recommendations to follow.

Eight Recommendations to Support Strong STEM Outcomes

I. Strengthening STEM Foundations

Recommendation 1. Math and Coding: Pathways to STEM Success

Expand the options for fulfilling four-year math requirements for all New Hampshire students. Expand from the traditional math calculus track to include options with data and statistical analysis courses and linear algebra suited for a wide variety of STEM-related careers. In addition, coding courses (i.e. logic and programming skills) are important because they teach critical thinking skills and are in high demand by New Hampshire industry. Currently 23 states have already adopted rigorous computer science courses to fulfill basic math or science requirements.

Recommendation 2. Next Generation Science Standards: Hands-on Learning

New Hampshire's Board of Education and local school districts should adopt the Next Generation Science Standards (NGSS). NGSS integrates 21st learning skills such as real world, problem-based learning, and teaches science, engineering and technology while integrating with K-12 Mathematics and English language arts requirements. This recommendation is central to successful implementation of several others in this report.

II. Inspiring Students

Recommendation 3. STEM-Inspirations: Challenges, Competitions and Capstones

Applied STEM learning opportunities, including competitions, should be expanded and incorporated into the curriculum. Age-appropriate STEM-Inspiration sequencing could begin with thematic, problem- and project-based STEM topics in early grades, then move to collaborative, team-based, district-wide STEM competitions in middle school (using FIRST®[9] as a base model program). Finally, students in their junior or senior years of high school should be encouraged to complete a capstone project requiring problem-based research and presentation of results for peer and evaluator review. This applied learning sequence aligns with the NGSS.

Recommendation 4. Early College Academies for STEM: Motivating Advanced Studies

Establish STEM advanced studies leading to a high school diploma and one or two-years of college credit through combination of classroom, research and career experience. The Early College academies would offer two new pathways for New Hampshire students to fulfill their STEM aspirations. The New Hampshire Math and Science Academy (NHMSA) would provide juniors and seniors in high school, who are highly interested in a STEM education, a residential experience allowing them to focus more broadly and deeply in STEM subjects. The NHMSA is designed to prepare students for success in rigorous undergraduate STEM degree programs and high-skill STEM careers.

The New Hampshire Career and Technical Education Schools – affiliated with the NHMSA and in partnership with NH Career and Technical Education (CTE) programs – would provide interested sophomores, juniors and seniors the opportunity to pursue advanced and

[9] FIRST® (For Inspiration and Recognition of Science and Technology) is a 501(c)(3) non-profit that designs a variety of programs to motivate young people to pursue a STEM education and career opportunities.

accelerated application of real-world STEM disciplines and the integration of academics with work and career preparation.

The academies would prepare students for employment, provide opportunities for post-secondary credential and certificate attainment, and act as accelerated pathways to advanced education in applied fields.

Recommendation 5. STEM Career Pathways: Charting Personal Learning Plans

School districts emphasizing STEM competencies can support the development of Personal Learning Plans (PLP), starting in the 7th grade. Personal planning would include interest inventories, career exploration, course advising and job shadowing experiences reflected in a written plan. Students would update their plans each year from the 9th through 11th grades. PLPs can help students make connections between their emerging STEM career ambitions and high school STEM and CTE studies. PLPs would also help all students and their parents understand the relationships of STEM literacy to a student's potential career goals.

Recommendation 6. Girls in STEM: Engaging and Mentoring Girls for STEM Careers

There is broad commitment manifested through activities to support girls in STEM education. These activities, however, are often not coordinated and therefore do not build as much momentum as is required. A governor-appointed advisory council would lead a collaborative effort to attract and support girls in K-12 to discover, explore and pursue STEM-related careers. The council would also track and report on program outcomes, provide mentors, and provide guidance in the development of Personal Learning Plans.

III. Empowering Teachers

Recommendation 7. STEM Learning in the Classroom: Every Day in Different Ways

The goal is to help teachers integrate STEM practices into current mathematics and English language arts curricula. Where possible, a STEM specialist at the school or district level can provide the support teachers need to integrate STEM into the curriculum every day in different ways. Districts committed to STEM literacy can integrate science and math applications into pre-high school education every day in different ways, large and small. Teachers can apply technology and engineering concepts to math and science lessons in team projects, making

STEM relevant and exciting for all students, especially for those who may not be inclined to learn math and science as theory or by rote.

This recommendation addresses three key barriers to STEM education -- the tightly packed K-8 schedule, the need for diverse hands-on learning opportunities and the lack of applied science expertise among teachers in K-8 grades.

Recommendation 8. Teacher Professional Development: Enhancing STEM Excellence:

New Hampshire is fortunate to have outstanding educators across the state. However, the state has a paucity of science and STEM-qualified teachers, especially in the early grades, where most teachers lack specific training in math or science. As expectations rise for STEM education, there is a need to better prepare and resource our teachers.

The New Hampshire Board of Education and Department of Education should reformulate STEM teacher preparation and requirements to include enhanced STEM certificates, endorsements and micro-credentials, as well as pedagogical training that enables STEM professionals to become effective teachers.

Call to Action: Championing STEM K-12 Education and Addressing Barriers

To make progress on these eight recommendations will require strong leadership, enhanced institutional capacity and heightened awareness. Champions will be necessary at the highest level of state government, in educational institutions across the state and in the business community. To ensure the coordinated effort of leaders and institutions, the Task Force supports the recommendation of the NH Charitable Foundation calling for the establishment of a STEM statewide Leadership Coalition.

Finally, the Task Force recommends that the Governor designate 2015 as a “Year of STEM” in which STEM ambassadors from around the state will work together to heighten awareness of the importance of building increased STEM literacy in our K-12 students and creating the framework needed to implement the Task Force recommendations.

RECOMMENDATIONS IN DETAIL

Preface

The Vermont born John Dewey (1859-1952), one of the most prominent persons in educational reform and practice, considered two fundamental elements—schools and civil society—to be major topics needing attention and reconstruction to encourage intelligence and plurality. Dewey asserted that a complete democracy was to be obtained not just by extending voting rights but also by ensuring that there exists a fully formed public opinion**.** To have well informed public opinion Dewey recommended centering the school experience more on children's natural curiosity and less on adult-led lessons from books and advocated a role for teachers in this. For Dewey, education was meant to provide direction for a child's activities by presenting her with interesting questions and the tools she would need to answer them. In one Lab School project, students were asked to consider the role of the textile industry in shaping human history.[10] They examined raw flax, cotton plants, and wool, running each material through a spinning wheel. Through this practice, they learned cotton fiber is more difficult to separate from its plant than flax fiber, which explains why linen and wool clothing predated cotton, why American cotton producers relied so heavily on slave labor, and also why the invention of the cotton mill was such a boon in the economy of the antebellum United States, making slavery less politically viable. [11]

The Task Force seeks to support and inspire modern versions of Dewey's Lab School experience across New Hampshire.

[10] A lab or laboratory school is operated in association with a college or university for the purpose of educational research, experimentation with teacher practices and professional development. John Dewey created the first lab school at the University of Chicago which still operates today. Retrieved from http://www.ucls.uchicago.edu

[11] Goldstein, D. (2014). *The teacher wars: A history of America's most embattled profession*. New York: Doubleday.

Introduction

Recognizing the need to enhance career choices for New Hampshire children as well as build a STEM literate workforce and citizenry, Governor Hassan in April 2014 issued an executive order creating the STEM K-12 Task Force.

The Task Force was charged by Governor Hassan *"[t]o help young people develop the skills and innovative thinking needed for jobs that growing businesses are creating here in New Hampshire, … to ask tough questions about how we can best educate our young people, especially in the STEM fields of science, technology, engineering and math."*[12]

The Task Force brought together a diverse group of stakeholders from the education and business communities to make recommendations for modernizing STEM education in New Hampshire's schools. In particular, the Task Force focused on how to support New Hampshire school districts in preparing students for current and future career opportunities requiring STEM knowledge. Whether students choose a career in STEM or another field, STEM literacy of New Hampshire graduates is at the core of ensuring that NH's residents are well informed and have good career opportunities. To ensure all students have the broadest possible choices and opportunities in the coming years, the Task Force focused on student motivation and outcomes, teacher preparation and support, and school day curriculum and activities.

There are both immediate and long-term opportunities for New Hampshire students in a variety of STEM-related industries. New Hampshire companies report that well-paying jobs are available and the need for qualified employees with STEM-related credentials and skills will continue to grow. The STEM Task Force hopes to inspire and to help guide New Hampshire K-12 education leadership to take advantage of these exciting opportunities for their students.

For example, the *"New Hampshire STEM Pipeline Study"* [13] identified significant opportunities to expand the STEM K-12 education "pipeline" to prepare students for careers and for entry into higher education. The percentage of NH students scoring proficient or better on the 2012 New England Common Assessment Program (NECAP), declined from the 4th to the 8th grades,[14] and the number of STEM-literate students decreased further in the high school years. The report

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[12] State of New Hampshire, Office of the Governor. (2014*). An order establishing the Governor's Task Force on science, technology, engineering and math education*. (Executive Order 2014-01). Concord, NH. Retrieved from http://www.governor.nh.gov/media/news/2014/pr-2014-04-09-stem.htm

[13] New Hampshire Charitable Foundation. (2014). *Smarter pathways: Strengthening New Hampshire's STEM pipeline.* Concord, NH. Education First.

[14] NECAP tests students in math, science, reading and writing periodically beginning in the 3rd grade. New Hampshire Department of Education. Retrieved from www.education.nh.gov/instruction/assessment/necap

also noted that in 2012 the hours spent per week in sciences in grades 1-4 had declined by almost 40 percent since 2004.

In addition, New Hampshire is preparing too few math and science teachers. In the 2012-13 school year alone, there were 184 vacancies for science and math teachers in New Hampshire schools and only 91 teacher prep candidates qualified for these positions. New Hampshire trained virtually no teachers at all in physics and the physical sciences, and fewer than half the teachers needed in math. The Task Force developed recommendations to help the state address key immediate challenges in STEM education as well as provide aspirational goals – recommending policies to help educators to achieve excellence in STEM education over the next quarter century and beyond.

The work of the Task Force is based on the efforts that have preceded it, including the NH STEM Pipeline Study, the work of the state's Advanced Manufacturing Education Advisory Council, and the findings of the NH Business and Industry Association's Strategic Economic Plan.[15] The Task Force focused on student motivation and outcomes, teacher preparation and support, and school day curriculum and activities.

Every student, as well as the local area and state economy, will benefit when a New Hampshire school district commits to enhancing its STEM curriculum. More students will see STEM pathways as a viable career opportunity, and those seeking careers in communications, the arts, humanities, social sciences and other fields will benefit from STEM literacy.

STEM literacy will require a strong humanities and English language arts foundation. The intersection of the liberal arts with STEM education is critical to the innovation economy. As Steve Jobs, co-founder of Apple noted, "[. . .] technology alone is not enough – it's technology married with liberal arts, married with the humanities, that yields us the results [. . .]." And the converse is true. People who love the arts and humanities should endeavor to appreciate science, technology, engineering and math. Otherwise, they will be left as bystanders in an increasingly digital and technology-based world.[16]

STEM literacy will require providing STEM exposure every day and in different ways. This will include delivering STEM courses online and in combination with face-to-face studies, flipped classrooms in which lectures are viewed outside of class, and exposing students to STEM labs and spaces to design and work on STEM projects.

[15] NH Business and Industry Association. (2013). *Strategic economic plan for New Hampshire.* Retrieved from http://www.biaofnh.com/Strategic

[16] Drawn from Isaacson, W. (2014). *The innovators*. New York: Simon & Schuster, pp. 486-487

The Task Force urges parents, teachers and mentors to support students to follow their natural curiosity as they pursue STEM research, applied projects and studies. Encouragement and mentorship will be particularly important for students in rural areas, girls and others who have not been traditionally encouraged in many STEM fields.

We should inspire our schools to provide their students with clear STEM pathways starting in the earliest grades. That means stronger math and science instruction in the early grades. But it also means emphasizing the importance of reading, writing, self-expression and collaboration in making use of those STEM skills.

The Task Force is not recommending a new separate set of tasks for K-12 educators to add to their bulging responsibilities. The STEM literacy framework is already in place in New Hampshire's commitment to personalized learning through competency-based education. Task Force recommendations build on that framework, proposing strategies that enhance support for teachers through professional development in STEM and local approaches to delivering a STEM-infused education.

Stem K-12 Education: Definition

STEM K-12 education is the study of science, technology, engineering, and math as separate subjects and together. Most STEM educators believe that STEM is best taught by exposure to core concepts and theories through *learning by doing.* New Hampshire is already well down this path in its commitment to competency-based learning that includes learning by exploring and experimenting, learning how to ask and answer questions and learning by applying STEM theories to real world problems.

The goal of a STEM education is to prepare all students to become STEM literate in order to be able to effectively engage in a rapidly changing world with a better understanding of science, technology, engineering and mathematics. STEM literacy will enable students to become strong contributors and successful citizens. Some will aspire to be part of the next generation of scientists, inventors, technicians and developers of new theories and solve the many complex problems we face to make New Hampshire a better place to live.

S	*Science* is the study of the natural world, including the laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, or conventions associated with these disciplines.
T	*Technology* is science or knowledge put into practical use as physical tools or embedded in production or social systems. In its ideal it is meant to solve problems or promote individual and social well-being.
E	*Engineering* is the creative application of the tools of science and mathematics to solve challenging problems and help improve the human condition. Engineers determine how things work and find practical uses for scientific discoveries; engineers invent.
M	*Mathematics* is the study of patterns and relationships among quantities, numbers, and shapes. Mathematics includes theoretical mathematics and applied mathematics.[17]

[17] Definition is adapted from California Department of Education. (2014). *Innovate: A blueprint for science, technology, engineering and math in California public education*. Retrieved from http://www.cde.ca.gov/pd/ca/sc/documents/innovate.pdf

The Task Force Recommendations

In grades K-4 in New Hampshire, Task Force recommendations focus on building a strong foundation of basic math and science skills while giving students early experience in hands-on and inquiry-based learning.

In middle school, the focus shifts to giving students an understanding how the many STEM disciplines interact and can be used to answer questions and solve problems.

For high school, the Task Force focused on providing rigorous and challenging learning opportunities that provide deeper explorations of STEM content while encouraging pursuit of open-ended inquiry-based questions.

The Task Force has organized this report for action. Eight detailed recommendations and action steps are presented under three objectives:

I. Strengthening STEM Foundations
II. Inspiring Students
III. Empowering Teachers

We then propose global recommendations to the business community, educators, parents and school board members. And, finally, we propose the mechanisms needed to turn our recommendations into action.

Here are our recommendations.

STRENGTHENING STEM FOUNDATIONS

Recommendation 1. Math and Coding: Pathways for STEM Success

Introduction

The Governor's Executive Order 2014-01 empowered the Task Force on K-12 STEM Education to consider whether new mathematics standards and requirements were needed in order to encourage schools to develop a broader range of applied math courses and thus provide additional pathways to prepare students for future STEM-focused careers.

After the Task Force was formed, the Governor signed into law House Bill 533 establishing a four-year high school mathematics requirement. Although this change will provide additional opportunities to prepare students for a variety of careers, more needs to be done.

For instance, the Task Force agreed that providing a good understanding of math fundamentals was more important than pushing students to advance rapidly through a variety of math courses. In addition, the Task Force articulated math pathways that would offer a broad understanding of mathematical tools that could be applied to a variety of careers.

Finally, the Task Force recommended an increased emphasis on computer coding to enable all students to gain 21st century science and math literacy skills which include problem-solving and logical thinking skills. Currently, 23 states including Wisconsin, Alabama and Maryland have adopted policies allowing computer science courses to satisfy high school graduation requirements for math or science.[18]

Recommendation Overview

This recommendation focuses on creating multiple pathways for high-school students to fulfill the recently approved four-year high school mathematical requirement. Each mathematics pathway includes rigorous, transferable, college-level content that meets the requirements of specific academic programs and careers. Supporting this recommendation requires changing the language describing minimum mathematics requirements for high school graduation. Finally, school districts who wish to enhance logical thinking skills as well as career opportunities for their students in STEM and other careers can do so by introducing coding (i.e. logic and programming) into the curricula for all grades from K-12.

[18] Useful sources include: http://core.org/files/Making_CS_Fundamental.pdf, and Heitin, L. (Feb. 26, 2014). Computer science: Not just an elective anymore. *Education Week*, volume 33 (issue 22). Retrieved from http://www.edweek.org/ew/articles/2014/02/26/22computer_ep.h33.html?qs=coding+adopted+by+states

Recommendation Details

Offer Three Pathways in High-School Mathematics

HB 533 established a four-year- high school mathematics requirement providing that "A pupil may meet this requirement either by satisfactorily completing a minimum of four courses in mathematics or by satisfactorily completing a minimum of three mathematics courses and one non-mathematics content area course in which mathematics knowledge and skills are embedded and applied, as may be approved by the school board."[19]

Over the past decade a common perception among high school and college students has been that they cannot succeed in college calculus without having first done well in high school calculus. As a result, many otherwise talented students give up on a STEM pathway because they did not take calculus in secondary school.

The Task Force recommends adopting the position taken by the National Council of Teachers of Mathematics and the Mathematical Association of America:

> Although calculus can play an important role in secondary school, the ultimate goal of the K–12 mathematics curriculum should not be to get students into and through a course in calculus by 12th grade but to have established the mathematical foundation that will enable students to pursue whatever course of study interests them when they get to college. The college curriculum should offer students an experience that is new and engaging, broadening their understanding of the world of mathematics while strengthening their mastery of tools that they will need if they choose to pursue a mathematically intensive discipline.[20]

If students move too fast through preliminary courses in order to get calculus onto their high school transcripts, they frequently have an inadequate foundation on which to build the mathematical knowledge required for a STEM career. According to Lynn Steen, former president of the Mathematical Association of America (MAA), "It is probably about time that we face facts: Aiming school mathematics for calculus is not an effective strategy to achieve the goal of improving all students' mathematical competence."[21]

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[19] New Hampshire School Boards Association. (2014, May 2). *A brief summary of education issues at the state house*. Retrieved from http://archive.constantcontact.com/fs127/1102189777311/archive/1117255512492.html

[20] Joint Position Statement of the Mathematical Association of America and the National Council of Teachers of Mathematics. (2012). *On the teaching of calculus.* Retrieved from http://www.nctm.org/about/content.aspx?id=32351

[21] Shaughnessy, J. M. (2011*). Endless algebra—The deadly pathway from high school mathematics to college mathematics* [Web log comment]. Retrieved from http://www.nctm.org/about/content.aspx?id=28195

The MAA's Curriculum Renewal across the First Two Year (CRAFTY) report recommends a secondary school mathematics curriculum that facilitates students' transition from high school to college by providing (a) a greater emphasis on modeling; (b) consideration of multivariate topics; (c) an emphasis on computational skills that are useful in other fields; and (d) a strong foundation in units, scaling, and dimensional analysis. These recommendations were based on a thorough examination of the mathematical skills required in various disciplines such as biology, engineering, economics, physical sciences etc.[22]

A New Hampshire high school student typically takes algebra I, algebra II and possibly pre-calculus. In college, this student may be placed again in a pre-calculus course or even in an advanced algebra course. Although repeating these courses in college builds a strong math foundation, many students in this situation feel they are not making progress in their major and this contributes to a high STEM pathways attrition rate.

Providing multiple pathways in high school, however, allows a student to choose a non-calculus pathway that not only prepares them for careers in the health sciences, business or the biological sciences, but also still leaves open the opportunity in college to major in engineering – even if the student was not initially admitted into the program. The advantage of preserving the calculus pathway and creating two alternative pathways is that schools will increase the likelihood that students will graduate college with a STEM degree and compete successfully for a position in the growing New Hampshire STEM workforce.

The Task Force recommends the following three pathways:

1. Students who enroll in a ***calculus pathway*** in secondary school should have demonstrated a thorough understanding of the concepts in algebra, geometry, trigonometry, and coordinate geometry. Additional courses in statistics or coding can be considered part of this pathway as well. Students who are skilled in algebra and analytical or coordinate geometry are much better prepared for calculus. The calculus course offered in secondary school should have the substance of a mainstream college-level course. This is a good pathway for students interested in engineering or the physical sciences.

2. A second pathway focuses on the development of students' ***statistical thinking*** including data science and data visualization. Statistical thinking involves understanding the need for data, the importance of data production, the omnipresence of variability, and decision-making under uncertainty. This pathway is particularly suited for students interested in business, analytics or the biological sciences. However, students on this pathway are still prepared for engineering or computer science in college.

[22] Mathematical Association of America. Retrieved from http://www.maa.org/programs/faculty-and-departments/curriculum-department-guidelines-recommendations/crafty

3. A third pathway includes a solid grounding in ***linear algebra*** integrating algebra and geometry. This pathway introduces students to multivariable problems, providing preparation for many areas of mathematics, computer science, engineering, and economics.

All pathways apply abstract or general math concepts to real-world problems in engineering and the physical and biological sciences. Students in all three pathways will benefit from increased exposure to coding, data visualization and computer science in the math curriculum.

Change the Language for Mathematical Standards

The Task Force recommends new legislation establishing a four credit requirement for mathematics to include the three pathways described above. Furthermore the language for the minimum standards requirements in mathematics for high school graduation could be amended as follows:

Current: Mathematics that encompasses algebra, mathematical modeling, statistics and probability, complex applications of measurement, applied geometry, graphical presentation and interpretation, statistics and data analysis – three credits.

Proposed: Multiple pathways in mathematics that encompass algebra, mathematical modeling, statistics and probability, complex applications of measurement, applied geometry, graphical presentation and interpretation, coding and data analysis – four credits. While students will acquire some basic grounding in these topics, they will be able to emphasize a certain area of mathematics depending upon which pathway they choose.

Integrate Coding into the Curricula

Code (or coding) is the language of the future. Every app, web page and new piece of technology relies on programmers to create it. When teachers help their students learn to code, they help them develop problem-solving and logical thinking skills needed to succeed in 21st century careers. Coding prepares students to understand computational biology (how the genetic code works); mathematical algorithms (instructions for computer programs); computer intelligence; recursion (small computations used repeatedly to solve large problems and many other everyday problems).

Coding should be about teaching logic and bigger concepts, rather than learning a specific language. The math classroom is a natural place to introduce coding concepts to students, even to those not enrolled in a traditional computer science course. Students who use programmable or graphing calculators to solve a quadratic equation are in essence doing coding. Other everyday examples of coding include using logic of loops to teach principles of proofs, writing simple programs to solve a variety of applied math problems, and graphing functions as visual aids in understand important math concepts.

Math curricula can, without major change, be grounded in mathematical questions that one may encounter in the STEM disciplines. A student can formulate the problem, learn to ask the relevant questions and find the data to help solve the problem. While calculating solutions by hand is necessary to fundamental understanding, formulating problem solutions also presents a coding opportunity particularly in solving complex applied math problems and in creating data visualization to better understand the results.

Coding has become a universal language in business. Students who gain knowledge of coding will have numerous career opportunities both within STEM fields and in other careers.

HB 533 allows for one, non-mathematics content area course in which mathematics knowledge and skills are embedded and applied. In addition to integrating coding in the high school math curriculum, high schools could now offer courses in coding, programming, data visualization through graphing etc. in fulfillment of the mathematics graduation requirement.

To build logic and analytical skills, school districts could also consider incorporating lessons available on the web site code.org's *an hour of code*[23] program *in elementary school*, in both science and math units. This could be simple computer science lessons that students engage in with or without a computer.

In *middle school* mathematics, abstract problems in algebra and geometry could be made more relevant through computer coding and game concepts.

In *high school*, core courses that explore computer science and its principles would prepare students for post-secondary experiences.

The Task Force believes that coding need not be undertaken as a major new curriculum requirement but introduced as an additional means of teaching 21st century skills and competencies that are part of the current curriculum. Recognizing that integration of coding into the curriculum may not be possible at all schools, the Task Force recommends that where possible coding be taught independently in other suitable formats.

The Task Force suggests these additional STEM choices for students as a complement to, not a replacement of, the humanities and arts, as it is a diverse education full of a variety of opportunities that will best prepare New Hampshire students for the yet-to-be known challenges of the 21st-century.

[23] Code.org. Retrieved from http://hourofcode.com/us

Action Steps and Timelines

- The New Hampshire legislature should consider new legislation requiring four credits in Math to include three pathways: calculus, statistical thinking and linear algebra. Once this occurs the State Board of Education should reopen the minimum standards for school approval to reflect the new statutory language. (2015)

- School districts seeking to enhance students' access to STEM literacy immediately could adopt:
    - Multiple math pathways allowing students to study the math topics that fit their priorities (2015)
    - Where possible, integrate coding in the math curriculum as a fulfillment of math requirements (2016)

STRENGTHENING STEM FOUNDATIONS

Recommendation 2. Next Generation Science Standards: Hands-on Learning

Introduction

Updated science standards reflecting current research are foundations for preparation of New Hampshire students in STEM subjects and enhanced prospects if they choose a career in STEM or other fields.

New Hampshire's College and Career Ready Science Standards are now nine years old. Over that period, there have been many advances in the fields of science and science education and in the innovation-driven economy. Advances in quantum mechanics, next generation genomics, synthetic biology, molecular dynamics simulations, RNA reprogramming, and precision cosmology, to name a few, will lead to exciting new applications and fields of study.

Updating New Hampshire's College and Career Ready Science Standards to reflect current research will provide the foundation for stimulating student interest and enhancing STEM literacy in the state. The new standards address the full range of college- and career-ready 21st century skills, and are organized in a way that promotes rich application of science principles, practices, or processes. They can connect science topics more easily with other STEM areas and go beyond information transfer and recalling facts to student discovery and deeper knowledge.

New science standards will prepare students for New Hampshire careers that require not only science literacy, but also the ability to think critically and to take an inquiry-based approach to problem solving.

Recommendation Overview

New Hampshire should adopt College and Career Ready Science Standards based on the Next Generation Science Standards (NGSS) because these standards can help students to learn 21st century work and study skills such as critical thinking, and bring together core ideas from math, English language arts, science, engineering and technology in real-world problem solving.

There is a practical benefit to basing New Hampshire College and Career Ready Standards on NGSS as well. For the last 10 years, New Hampshire has shared the costs of its annual science assessments with Vermont, Maine and Rhode Island through the New England Commons Assessment Program (NECAP). In 2016, the NECAP will be eliminated and these states will implement a new assessment consistent with the Next Generation Science Standards. The adoption of standards based on NGSS will allow the state to join other consortium members and draw on a wide array of high quality assessment resources that align with the Next Generation Science Standards.

Recommendation Details

The Next Generation Science Standards, released in April 2013, marked the end of a two-step development process led by a consortium of the National Research Council (NRC),[24] the National Science Teachers Association, and the American Association for the Advancement of Science, and *Achieve*.[25]

The NRC led the first step by developing the framework for K-12 science education based on current science and science learning research.[26] In the second step, managed by *Achieve*, teachers, policy makers, scientists and representatives from higher education and informal science communities from twenty-six states led the development of the NGSS. Their objective was to create an approach that would engage students in scientific and engineering practices by using crosscutting concepts to teach core scientific ideas.

The Task Force recommends that New Hampshire undergo a process leading to the adoption of standards based on the NGSS. The NGSS shifts the focus to instructional practices that create engaging, innovative classroom experiences. The standards are mainly about enhancing instructional vitality at the classroom level, not about dictating required curricula.

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[24] The National Research Council is the operating arm of the National Academy of Sciences and the National Academy of Engineering Retrieved from http://www.nationalacademies.org/nrc/

[25] Achieve is an independent, nonpartisan, nonprofit education reform organization founded in 1996 by a bipartisan group of governors and business leaders. Achieve works with states to raise academic standards and graduation requirements, improve assessments, and strengthen accountability. Retrieved from www.achieve.org

[26] Next Generation Science Standards. (2013). Retrieved from (http://www.nextgenscience.org/final-next-generation-science-standards-released

Action Steps and Timelines

Action steps are estimated to require two-to-three years and four phases, because New Hampshire stakeholders need to be an integral part of the process and the outcome. The following steps are recommended:

- Designate a leadership team at the state level to review the standards in depth and oversee implementation; then create a STEM coordinator position at the state level to manage the process (Phase I)

- Review the standards and recommend any additional expectations important to New Hampshire's success in science education in collaboration with the state's scientific and engineering communities. Review the state's capacity for adoption and implementation, including the development of curricula, instructional practices, and assessments, and develop a vision for how the NGSS will affect students in New Hampshire (Phase II)

- Issue recommendations to the Governor and the State Board of Education including a concise timeline for adoption and financial requirements for implementation. (Phase III)

- Develop materials to support implementation at the school level; communicate with key stakeholders regarding standards, professional development, instructional practices and assessments, and select new assessment providers to align with new standards. (Phase IV)

INSPIRING STUDENTS

Recommendation 3. STEM-Inspirations: Challenges, Competitions, and Capstones

Introduction

According to the New Hampshire Charitable Foundation (NHCF) report on student preparation for STEM careers, New Hampshire students begin to disengage from science and math as they progress through elementary school. Student assessment performance drops significantly between the 4th and 8th grades.[27] Students' natural curiosity about the world can too often be replaced by a perception that science is not interesting, is difficult or is not for everyone. The challenge is to ensure that all students not only become STEM literate, but are also encouraged and supported if they choose to pursue STEM education pathways and careers. Students need to understand that science and math provide an important foundation for understanding the world and also that as they pursue their natural curiosity they can be inspired to invent solutions to the world's many challenging problems.

Recommendation Overview

The Task Force recommends that science and math be taught more as "hands-on" learning from the earliest grades. Science and math and their companions engineering and technology can best be learned by "doing" and not merely by memorizing facts. A sequence of three phases will build a foundation for students to engage fundamental and important concepts in science and math, and add engineering and technology at appropriate levels.

Districts wishing to expand opportunities for STEM learning can offer a sequence of studies appropriate to each grade level. For example, in the early grades technology and engineering topics can be introduced into science and math through thematic, problem- and project-based topics. In middle school, studies might move to collaborative, team-based, district-wide STEM competitions (for example, FIRST® Lego® Leagues). Finally, districts wishing to deepen student learning in areas of special interest should consider capstone projects which are becoming a key demonstration of competency for high school seniors. This approach complements new science standards, the New Hampshire competencies and the use of performance assessments supported by NHDOE.

[27] According to research commissioned by the NHCF, over 50 percent of 4th grade students score with distinction on science assessment, while by the 8th grade that number drops to 31 percent. New Hampshire Charitable Foundation. (2014). *Smarter pathways: Strengthening New Hampshire's STEM pipeline.* Concord, NH: Education First.

The goal of this recommendation is to build a process for students to become STEM literate at different levels of their development, from aware and conversant (able to adapt to changing technology in the workplace, regardless of chosen career) to highly trained scientists and engineers leading the discoveries and inventing the technologies of tomorrow.

Recommendation Details

The Task Force recommends that School Administrative Units (SAUs) or districts seeking to enhance STEM literacy develop a thematic, inquiry-and project-based exploration of a relevant STEM topic in elementary school, ideally in 4th grade. This "challenge" would focus on a broad theme or question around which teachers could provide context and insight. Students would read and discuss stories on the topic, and complete an age-appropriate in-class or at-home project. SAUs and individual schools are particularly encouraged to include developmentally appropriate technology and engineering elements in designing the challenge. Schools might, for example, draw upon the curriculum outlined in the "Engineering is Elementary (EiE)" program from the Museum of Science in Boston.[28]

To provide an opportunity for deeper and broader learning experiences beyond an individual class or school, districts could consider supporting each of their middle schools to form at least one team to engage in a collaborative STEM-related competition or exhibition organized at the district or regional level. FIRST® Lego® League and FIRST® Tech Challenge are New Hampshire-based examples of collaborative, team-based STEM competitions for middle school. For deeper engagement with STEM at the high school level, schools could support teams in district-wide or regional STEM competitions such as FIRST® Robotics or other organized competitions.

However, we recognize that students have a variety of interests. Other subjects such as life sciences, medicine and related fields may offer appealing alternatives. The Task Force recommends that districts work closely with their schools to identify these interests and find appropriate events which encourage students to collaborate in projects that bring exposure to ideas and problem solving in a broader context beyond the school level.

Capstone projects offer an excellent opportunity for students to demonstrate competency-based learning in STEM at the high school level. A capstone requires each student to conduct independent STEM research which might be conducted individually or as part of a group. Results would be presented for peer and evaluator review. Projects will address an open-ended question or hypothesis, and build on material from a range of high school courses. Capstone projects go beyond paper studies to incorporate a laboratory, computational, field study, technology or engineering component. For deeper engagement with STEM content, methodologies, and opportunities, schools might go beyond this foundational level and also include a capstone project in the final year of middle school for each student.

[28] Engineering is Elementary. Developed by the Boston Museum of Science, Boston, MA. Retrieved from http://www.eie.org/

Action Steps and Timelines

- School districts begin to make increased use of STEM-Inspirations (Fall 2015)
- Districts begin to provide curricular support for elementary teachers to develop STEM-based challenges for their students (Fall 2015)
- District wishing to focus on STEM literacy consider providing funding to help support middle school and high school participation in STEM-based competitions (Fall 2015)
- Districts adopting STEM-based competitions recruit local volunteer coaches (Fall 2015)
- A committee of high school science and math teachers and other parties as appropriate develop curricular guidelines for high school STEM capstone projects, including identification or any professional development needed to help support teachers in development of such projects (Fall 2015)
- New Hampshire Community Colleges and other organizations hold STEM-inspiration summits to showcase student STEM challenge projects and capstones with participation by students, teachers, school board members and business community (Spring 2016 and then annually)

INSPIRING STUDENTS

Recommendation 4. Early College Academies: Motivating Advanced Studies

Introduction

As New Hampshire districts enhance their STEM programs, there is an opportunity to support students throughout the state who aspire to become our next generation STEM leaders.

There would be significant benefits if an enhanced environment for comprehensive and coordinated STEM secondary education were available for students across the state. The environment would include advanced STEM application experiences, exposure to STEM careers and STEM early college opportunities. STEM high school courses could be coordinated and supported in a concentrated way, as has been achieved in states and countries with public math and science academies. And advanced and accelerated STEM career pathway opportunities would be available to rural students and young women across the state.

These same advancements should also be available for Career and Technical Education (CTE) students across the state. Many of today's high growth STEM fields, including advanced manufacturing, healthcare, and information technology, require advanced course work beyond

the high school level. CTE students should have opportunities to earn STEM course college credits in high school and to do all their coursework at one location rather than traveling between CTE and district campuses. Finally, CTE students should have STEM internship opportunities and mentors from industry to facilitate pathway from high school into well-paying STEM careers.

Recommendation Overview

The Task Force recommends that New Hampshire create STEM Early College Academies because they will help students aspire to and achieve STEM leadership and accelerated careers. STEM Early College Academies will fuel the STEM academic and career aspirations of young New Hampshire citizens and their families.

The Academies would be free, public high schools for students interested in pursuing a curriculum emphasizing STEM subjects and careers.

> *The New Hampshire Math and Science Academy (NHMSA)* would provide academically talented students interested in advanced STEM study in the 11th and 12th grades with a residential experience allowing them to focus on STEM subjects. It would prepare them for success in rigorous undergraduate STEM degree programs.
>
> *The New Hampshire Career and Technical Education Schools affiliated with the Early College Academies (NH-CTE affiliated with the ECAs)* would provide 10th through12th grade students the opportunity to pursue high growth STEM-focused careers through the integration of academics with business and industry career preparation. The academies would prepare students for well-paying careers and the post-secondary credentials and certificates needed to be successful in those careers.

The STEM Early College Academies would engage in statewide outreach to K-12 students through extracurricular, co-curricular, summer outreach programs, as well as professional development programs for STEM teachers. The ECAs would provide an early exposure to STEM topics for K-5 students and encourage students in grades 6-8 to discover and explore a variety of STEM subjects and careers. In grades 9 and 10 the ECAs would assist students pursuing their choices of STEM careers and recruit them both for the NHMSA and the NH-CTEs affiliated with the ECAs. The ECA outreach and recruitment would pay particular attention to developing the interests of a diverse and broad population including girls and rural students.

Recommendation Details

The New Hampshire Math and Science Academy (NHMSA)

The NHMSA would be a free, college preparatory public high school offering a residential experience for academically prepared 11th and 12th grade students specializing in STEM subjects.

Modeled after the North Carolina School of Math and Science, the Illinois Math and Science Academy, and public math and science academies in several other states,[29] NHMSA would offer students a high school degree as well as skills and competencies designed to foster success in rigorous undergraduate and graduate STEM degree programs. The purpose of the NHMSA will be to educate talented young women and men in 11th and 12th grades, but also to provide outreach programs in STEM to students, teachers, and schools around the state.

While the NHMSA would offer an extensive STEM curriculum including classes for credit at both the secondary and post-secondary level, it would also provide a solid foundation in the arts and humanities expected of any high school graduate seeking entrance into a highly competitive college. The NHMSA would be a public/private partnership among the State of New Hampshire, School Administrative Units (SAUs) or school districts (per student enrolled), with public and private funding sources.

The New Hampshire Career and Technical Education affiliated with the Early College Academies

1. The New Hampshire Career and Technical Education schools affiliated with the New Hampshire Early College Academies (NH-CTE affiliated with the ECAs**)** would be enhanced CTE schools throughout the state. These new schools would be designed for interested students who want to pursue STEM-focused programs integrating academics with career preparation. Students enrolled in a NH-CTE affiliated with the ECAs would earn a high school degree, and a certificate or two-year applied science degree. They would also acquire the skills and competencies needed for success in well-paying, high-potential STEM jobs.

Each NH-CTE affiliated with the ECAs would partner with New Hampshire public high school, the New Hampshire community college system, and New Hampshire STEM-based industry. The NH-CTEs affiliated with the ECAs would be transformed versions of current CTEs in the state and look to similar models in other states including California, Illinois and Massachusetts. The transformation would include on site instructions in math, science and other subjects so that students could do all their coursework on campus.

[29] North Carolina School of Science and Mathematics. (n.d.) Retrieved from http://www.ncssm.edu. Illinois Mathematics and Science Academy. (n.d.) Retrieved from https://www.imsa.edu**.** There are different estimates as to the number of math and science academies in the U.S. There are 90 institutional members in 31 states of the National Consortium for Specialized Secondary Schools of Mathematics, Science and Technology (NCSSSMST). http://ncsss.org

2. Students in the 10th, 11th and 12th grades would attend CTEs full time and be paired with a mentor in the student's chosen STEM field of study. Each student would take a required, semester-long internship in a high growth STEM field in the final year of the program.

3. All CTE program graduates would earn a minimum of 12 college credits—and the CTE student would have the option to earn a professional certificate or associate of science degree at no cost to the student. This recommendation requires that the school provide teachers to be certified to teach college courses or college courses online.

4. The NH-CTEs affiliated with the ECAs could be funded by collaboration between the state, business and industry and private foundations.

5. The Governor would appoint a central statewide advisory board of employers from the high growth STEM sectors to consult on CTE STEM-focused education. This advisory board would bring together business and industry leaders in STEM who may currently serve on existing local CTE boards as well as STEM leaders not currently involved with CTEs.

6. Pilot NH-CTEs affiliated with the ECAs could start soon in regions where there is potential for advanced manufacturing, IT, health care and other STEM-industry participation. All current CTEs would be encouraged to affiliate with the ECAs.

Action Steps and Timelines

- To support the development of the Early College Academies, the Governor appoints two boards of directors: one to develop and oversee the NHMSA and the other to develop and oversee the NH-CTEs affiliated with the ECAs (Fall 2015)
- The STEM Early College Academies aim to open their doors to the first class for NHMSA and pilot schools for NH-CTEs affiliated with the ECAs (Fall 2017)

INSPIRING STUDENTS

Recommendation 5. STEM Career Pathways: Charting Personal Learning Plans

Introduction

Pathways to Prosperity,[30] a national study on the future of career and technical education in the United States, recommends that students explore careers and engage in academic-to-career planning. Depending on their interests, high school students have a number of post-graduation options including a community college, a four-year college, and a special certification for employment High schools play a critical role in helping students understand their options and make more intentional choices for academic and career preparation.

Recommendation Overview

The Task Force recommends career guidance and planning for all New Hampshire students. In grade 6 students would begin to learn about career choices through field trips and job shadowing. In grade 7 students would continue to learn about career choices and develop their first Personal Learning Plans (PLPs), which would be reviewed in the 9th grade, and again in the 10th or 11th grade. Although not all students will choose STEM careers, the Task Force believes career guidance which recognizes the importance of STEM literacy as part of educational preparation will better prepare our students to excel in the careers of their choice. In addition, those students who seek STEM careers will have an opportunity to plan for their specific interests.

This recommendation requires strong partnerships among New Hampshire educators and employers.

Recommendation Details

The Task Force recommends guidance that exposes all students and their parents to an exploration of career pathway options. The process should begin as early as grade 6 because that is when many students develop interests that lead to career choices. In order to nurture these interests, 6th grade students would have the opportunity to learn information technology and computer programming skills. They would also study consumer and family science[31] topics

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[30] Jobs for the Future and the Harvard Graduate School of Education. (2014*). Pathways to prosperity network: A state progress report, 2012-2014. Retrieved from* http://www.jff.org/publications/pathways-prosperity-network-state-progress-report-2012-2014

[31] Topics are designed to help students make healthy choices about well-being, relationships and resources to achieve an optimal quality of life. Studies include research-based knowledge about everyday life, including human development, personal and family finance, housing and interior design, nutrition and wellness, clothing and consumer issues. Retrieved from www.aafcs.org

(such as personal finance and financial planning) and applied technology (such as robotics or automotive technology). Students in the 6th grade would also participate in job shadowing and field trips to NH STEM employers, as well as interact with guest speakers in STEM professions. After exposure and exploration in grade 6, schools would guide their students in grade 7 through their first Personal Learning Plans so students could more intentionally select courses that align with their interests and talents. The Personal Learning Plans would require the support of teachers, counselors, parents, and industry partners.

By grade 9, student Personal Learning Plans would be revisited and the high school course of study aligned with the student's priorities. Students showing an interest in STEM fields aligned to their career interests might consider attending the residential New Hampshire Math and Science Academy associated with the Early College Academies[32] or decide to attend a New Hampshire Career and Technical Education Center (CTE) associated with the Early College Academies. In any case, the student's Personal Learning Plan would be once again reviewed in grade 10 or 11 as educational and career decisions are being made.

STEM career pathways should allow students the opportunity to obtain at least 12 dual enrollment credits (courses that count for both high school and college credits), the opportunity to be mentored by a professional in their chosen career pathway, and the opportunity for an internship during their senior year. Every attempt should be made to pair girls interested in STEM pathways with women mentors as a means for not only more deeply engaging girls, but to illustrate women's success in STEM pathways.

Action Steps and Timelines

- School districts commit to Personal Learning Plans for their Students (Fall 2015)
- Pathway steps as described above are implemented in schools in committed SAUs/districts (Fall 2015/Spring 2016)
- Governor formally recognizes the Personal Learning Plan adopters (Spring 2016)

[32] See recommendation for Early College Academies.

INSPIRING STUDENTS

Recommendation 6. Girls in STEM: Engaging and Mentoring Girls for STEM Careers

Introduction

To improve the STEM workforce pipeline, New Hampshire will require the development of all students, particularly young women. Nationally, only 25 percent of engineers and scientists are women. The latest data from the U.S. Census Bureau's American Community Survey reveal that only about one in four (27 percent) of the computer and mathematical occupations in New Hampshire are held by women, and only one in seven (14 percent) of New Hampshire's architecture and engineering occupations are held by women.[33] Hence, supporting girls and young women in STEM education will be essential to meet the demand for STEM-trained employees in New Hampshire. Moreover, such progress is also important to the women themselves. Women in STEM jobs earn 33 percent more than those in non-STEM occupations and experience a smaller wage gap relative to men than in other fields. In addition, STEM careers offer women the opportunity to engage in entrepreneurship and exciting areas of technological innovation. To realize such outcomes, New Hampshire should commit to increasing the participation and performance of girls in STEM K-12 education.

Nationally, in grade K-5, girls and boys perform equally well in math and science. However, by the time they reach high school, there is a divergence that becomes clear nationally when participation rates of girls in math and sciences drop below those of boys.[34] Much research and discussion surround the causes of this divergence, but one factor remains clear: young women are needed in STEM fields if New Hampshire is to fill the critical shortages in these professions.

Although New Hampshire offers activities for young women interested in STEM, these efforts lack a strong statewide coordinated effort. As a result, many excellent programs do not have the opportunity to build broadly across the state. Moreover, many STEM research and advocacy organizations such as EPSCoR (representing industry, the executive and legislative branches, and higher education in New Hampshire)[35] and STEM NH (a statewide STEM education coalition)[36] address STEM education; however, few are devoted exclusively to the challenges girls face in STEM subjects or to the opportunities girls would benefit from if they were to develop STEM interests.

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[33] New Hampshire Center for Policy Studies. Retrieved from http://www.nhpolicy.org/UploadedFiles/Reports/policynote_women_STEM_Oct2014.pdf

[34] Pollack, E. (2003 October 3). Why there are still so few women in science. *New York Times*. Retrieved from http://www.nytimes.com/2013/10/06/magazine/why-are-there-still-so-few-women-in-science.html?pagewanted=all&_r=0

[35] EPSCoR information retrieved from http://www.epscor.unh.edu

[36] STEM NH Coalition. Retrieved from http://nhepscor.org/stem

There is no centralized vehicle at the state level in New Hampshire so that government policymakers and educators might better understand the factors affecting gender choices for particular STEM careers. Without central leadership, there is limited sustained effort to gather actionable evidence so that barriers to entry for girls and young women into STEM professions might be better understood and addressed. Consequently, the state lacks the comprehensive data that may provide insight into engagement, achievement, academic trajectories, and pre-professional planning for elementary, middle, and high school girls in STEM. While there are general statistics that track STEM course choices and advanced studies by gender, there is little tracking otherwise, given the lack of coordinated efforts to link local, statewide regional and national stakeholders.[37]

Recommendation Overview

The Task Force recommends that Governor Hassan appoint a "Girls in STEM" Advisory Council to create a five-year plan to attract and support girls in grades K-12 to discover and pursue STEM-careers via Personal Learning Plans and mentorships. The Council would serve as a central organizer for activities, such as creating a web portal for organizations supporting girls in STEM, assembling thought leaders from a variety of organizations to discuss collaborative actions and making research available to policymakers, educators and the public so that more informed decisions might be made. Appointment to the Council should represent a broad range of interests, talents and occupations within the STEM fields. The Advisory Council at least in its initial phase, should be co-chaired by a STEM professional woman in business and another in STEM education, and be broadly represented by both men and women familiar with STEM issues.

Recommendation Details

The Governor's Advisory Council to promote Girls in STEM would be a policy advisory and coordinating body to bring together various organizations in a common support of girls in STEM fields.

Council responsibilities would be broad, including the creation of an interactive resource base, one that includes a website to house activities for girls in STEM in New Hampshire, with links to regional and national sources. The initial responsibilities of the Council would be to establish and monitor specific measurable goals. Other activities might include research, as appropriate, as well as supporting existing annual events for girls interested in STEM such as, for example, Aspirations in Computing, which holds annual competitions for girls; Girls in Technology Day

[37] An example of a collaboration for promoting STEM careers to both boys and girls is the Executive Round Table on STEM formed by National 4-H Clubs of America, Boys and Girls Clubs of America, Big Brother/Big Sisters of America, Girl Scouts and YMCAs of America which aims to pool resources to bring more girls and boys into STEM study and eventually into STEM careers. Retrieved from http://www.4-h.org/youthstem/

sponsored by Manchester Community College; Women in Science & Technology events with FIRST®, and the Sonya Kovalevsky Math Day for Girls held at Dartmouth.

In addition, the Advisory Council might consider launching a "2000 STEM Mentors for NH Girls" initiative with a goal of engaging 2000 professional STEM women mentors by the end of five years. This initiative could be linked to the national *One Million Women STEM Mentors* program.[38]

One of the goals of mentoring should be to ensure that girls have adequate advising in New Hampshire middle and high schools about STEM careers, course selections, scholarships and internships. The Council, to provide valuable input into appropriate policymaking, should report annually to the Governor on goals met, initiatives in progress and future plans.

Finally, the Council should reach out to New Hampshire elementary, middle, and high schools to recruit field representatives who would sponsor STEM clubs for girls. These clubs would enable girls to share their interest in STEM throughout the year, while building friendships and providing mutual support for their professional interests.[39] Through the efforts of the Advisory Council, New Hampshire can aspire to increase the engagement of girls in the STEM pipeline as well as serve as a model for other states interested in promoting opportunity for girls in STEM fields.

Action Steps and Timelines

- Establish the Advisory Council and appoint members (Spring 2015)
- Council publishes its strategic five-year plan outlining its mission, vision, goals and metrics; provides a roadmap for its initiatives (Fall 2015)
- Council publishes its first annual report on activities against goals and provides a metrics scorecard for performance (Spring 2016)

[38] Million Women Mentors is a national campaign to mobilize organizations to provide mentors for girls and young women in STEM fields. Retrieved from www.millionwomenmentors.org

[39] The GEMS Club at Dover High School, Dover, New Hampshire, is an excellent example. The club introduces girls to the STEM fields and provides activities relating to STEM careers, such as speakers, field trips, and group activities after school. The club helps girls to build relationships with peers who share similar interests. This club is part of the National Girls Collaborative. Retrieved from http://www.ngcproject.org/program/dover-high-gems-club

EMPOWERING TEACHERS

Recommendation 7. STEM Learning in the Classroom: Every Day in Different Ways

Introduction

The Task Force sees opportunities to engage in deeper STEM-related learning, particularly for K-8 students, within the current competency-based curricula in New Hampshire schools. More importantly, science (a foundation for STEM study) can be restored to its traditional core role alongside reading, writing and math. Teachers can be provided the training, professional development and resources needed to create hands-on, inquiry-based projects that engage students in applying their learning to real world problems as study of engineering and technology requires. Students can be given new opportunities to explore STEM topics that might interest them and fuel a passion for STEM learning.

A strong foundation in math and science is necessary but our schools can go much further toward making our students competitive in the many careers that require advanced math, applied science, technology, and engineering. This recommendation for increased STEM classroom opportunities is designed to provide the consistent and sustained learning that students need.

Recommendation Overview

The Task Force recommends commitment to "day to day" application of science and math in K-8 education. This should include the expansion of hands-on learning in technology, engineering and a wide range of STEM topics. STEM becomes relevant and exciting by "doing and experiencing" more than through memorization and lectures. Introducing technology and engineering to young learners through math and science creates opportunities for applied real world problem solving.

This recommendation attempts to address four key barriers to STEM education: the shortages of hands-on STEM learning opportunities for students; the lack of STEM career and professional expertise among most K-8 teachers; the tightly packed K-8 schedule; and the lack of STEM curriculum materials in some districts.

The Task Force recommends the following to overcome these barriers and achieve our goals:

1. To address tightly packed schedules, teachers could select topics or themes that introduce STEM concepts across all subjects. For example, technical education might be embedded into math and science curricula, and STEM projects embedded into math, history, and English language arts. This would provide students with opportunities to synthesize information and apply it to a common theme. The Task Force recommends that schools and districts be rewarded for implementing this creative approach.

2. To create opportunities for hands-on experimenting and to reach rural populations who lack access to the latest STEM technologies and inventions, the Task Force recommends developing mobile STEM Adventure Labs that would travel to different schools.

3. To supplement and bridge the gap in STEM expertise among teachers, district-wide or statewide speakers bureau of working professionals in STEM could be established, and pre-approved STEM learning programs and materials (onsite and online) be made available to schools on a need-basis.

Recommendation Details

Making Time for STEM

Time in the school day is so limited that few new classes can be introduced. However, with some reorganizing, STEM might be integrated into existing subjects every day. For example, teachers could introduce STEM themes or project-based learning into math, English language arts and science units. STEM labs, discussed below, could be used in math, English, music, art and physical education units as well as for periodic integrated sessions exploring their relationship with STEM. And there should be support for innovative efforts that combine STEM learning with liberal arts fields.[40]

Hands-on Learning Opportunities: Building out the Infrastructure

Mobile STEM Adventure Labs

New Hampshire businesses could partner with the state to develop a fleet of mobile labs giving teachers and students access to STEM related equipment and demonstrations. Some examples might include large telescopes, portable radars, the latest robotic equipment, an inflatable planetarium, a solar array, or a wind turbine. Local districts could also use Mobile STEM Adventure Labs for adult education classes or as part of a community experience such as an "astronomy" night held at local schools. These activities could foster a community spirit of learning about STEM together.

[40]Rhode Island School of Design (RISD). *STEM TO STEAM Initiative*. Retrieved from http://stemtosteam.org/

STEM Labs

Although many New Hampshire K-12 schools have a technology lab, few have STEM labs. A STEM lab differs in that students can explore, design and build rather than more passively use the equipment. For example, students could make weather experiments by assembling simple components to create wind turbine, or use Lego® components to build equipment with movable parts such as trucks, robots and wheel chairs. STEM educators could collectively determine the basic set of components to include in each STEM lab. Most middle schools have science or technology labs that could be converted to STEM labs.

Bridging the STEM Expertise Gap

While some districts will have the funds and staff to create their own unique STEM curriculum resources, many rural districts will find this a challenge. By sharing STEM technology resources at the state or district level, a number of schools could share the costs. The ideas that follow help to bridge the STEM expertise gap and enable rapid implementation:

Pre-packaged STEM Packs

STEM packs would contain the parts for students to design and make things. Examples include a strong wall or small bridge, maple syrup from local trees, a weather station. The instruction guide would show the teacher how the process and instrumentation works and how to show students how to use packs.

STEM Program and Online Resources

Many districts have already successfully piloted online and video resources such as Discovery Streaming™ and PBS Learning Media™ which they might consider sharing with those who have yet to develop those resources. In addition online resources can enhance and supplement STEM curriculum. For example, the Virtual Learning Academy Charter School (VLACS)[41] is an approved curriculum in New Hampshire and therefore eligible for high school credit in home districts. Districts committed to enhancing STEM learning opportunities for their students should consider giving students credits for advanced online classes.

STEM Explorers: Subject Matter Experts

The Task Force recommends creating a STEM Explorers bureau (STEM-EX) where STEM professionals from industry, Career and Technical Education Centers, colleges and universities visit K-12 classrooms to discuss their work. They could lead field trips to their companies or other locations, provide internships and create other forms of local STEM learning.

[41] VLACS is a New Hampshire charter school with headquarters in Exeter, NH. www.vlacs.org

In addition, STEM Explorers could be utilized in New Hampshire's undergraduate and teacher preparation programs to promote interest among students in becoming certified STEM teaching professionals with a STEM endorsement (see Recommendation 8).

STEM-EX professionals would come from diverse STEM fields. Recruiting STEM-EX professionals will require a collaborative effort among New Hampshire organizations such as the University system, the Community College system, the High Technology Council, the NH Business and Education Coalition, the Career and Technical Centers, the NH Business and Industry Association and the STEM Innovation Fund proposed in this report.

STEM professionals would identify an area of expertise and commit to school visits at least twice a year. The Task Force recommends creating a STEM EXplorer online directory searchable by key word for location, subject expertise, grade level preference and activities of interest related to each EXplorer. There would also be capabilities for interactive feedback among teachers, students and EXplorers. Similar to online customer reviews, teachers and STEM EXplorers could access information about school EXplorer programs and speakers. The Task Force also recommends that after one year of service, a STEM volunteer receive recognition from the local district and be eligible for an annual award such as STEM EXplorer of the year presented by the Governor.

Action Steps and Timelines

- School districts provide a plan that outlines their vision in terms of STEM every day (Fall 2015)

- STEM EXplorers volunteer program activated (Fall 2015/Spring 2016)
    - Every grade in every school has a visit from at least one explorer twice a year
    - The DOE builds the web infrastructure to support STEM Explorers, with volunteers in every SAU or district. with the Governor, DOE, and local school districts leading recruitment effort

- The Governor honors NH K-12 schools for creative integration of STEM into the school day (Spring 2016)

- An organized effort led by the DOE creates three pilot hubs or centers providing teachers with access to STEM-packs as well as online and program resources (Spring 2016)

EMPOWERING TEACHERS

Recommendation 8. Teacher Professional Development: Enhancing STEM Excellence

Introduction

If New Hampshire is to prepare future generations of high-quality, highly skilled students, ready to pursue careers in STEM fields, our teachers need to be well supported and prepared. Currently, too few teachers are trained in STEM subjects and inquiry-based teaching. The Task Force identified the need to provide professional development for elementary school teachers who frequently lack the training in science and math, the foundations of early STEM learning.[42] The commitment to STEM teacher excellence requires not only collaboration among teacher preparation programs in New Hampshire colleges and universities, but also new collaborations among teacher education associations, school administrators and industry.

The New Hampshire State Board of Education raised the teaching credentialing requirements for elementary and middle school teachers in 2013, making them competitive with other Northern New England states. While this was a necessary step, it is likely to further exacerbate the state's shortfall in training teachers prepared for science and math. In response, New Hampshire teacher preparation institutions have begun developing deeper subject matter offerings in math and science, and more uniform preparedness for teachers. But these efforts should be accelerated. Training gaps still exists among elementary and middle school teachers who were certified before 2013 as "generalists." Despite the lack of STEM, they are often called upon to introduce science and math concepts to students) at a critical developmental stage.

School districts can play an important role by differentiating recruitment, retention and compensation strategies to increase the numbers of STEM-proficient teachers. Districts can also recruit teachers from the ranks of working STEM professionals, who might be looking to make a career change. Alternative licensure strategies are already available for STEM professionals, and they offer a variety of activities to demonstrate competency in teaching, but they are underutilized.

Recommendation Overview

To take a leadership position in STEM education, New Hampshire needs more STEM classroom leaders. Hence, districts seeking to enhance their students' opportunities to achieve STEM literacy would take a significant step toward that goal by establishing a new "STEM specialist" position comparable to the math specialist positions currently in place in many districts."

[42] New Hampshire Charitable Foundation. (2014). *Smarter pathways: Strengthening New Hampshire's STEM pipeline.* Concord, NH: Education First.

A STEM specialist would assume the role of instructional leader providing guidance and support to reinforce math and science teaching at the K-5 grades, and at grades 6-8 to model how STEM content and practice could be integrated into different curriculum.

To grow the core of STEM-competent teachers, the Task Force recommends that a new teaching endorsement[43] be created and promoted. Although a variety of flexible options is currently available for teachers seeking endorsements (such as those in math and science), they are not well promoted or received. The Department of Education and the Innovation Fund (described in Global Recommendations) should engage in extensive outreach and recruitment to bring teachers into STEM endorsement programs. In addition, since teachers often lack STEM workplace experience, thus affecting their ability to craft effective real-world lessons, it is recommended that the Department of Education partner with the business community to create externships for both teachers in preparation and for practicing teachers.

For STEM professionals who seek a career change to become STEM teachers, the Task Force recommends that the Department of Education, school districts and the Innovation Fund reach out to businesses to actively recruit and train candidates.

To support professional development, districts can accelerate achievement by incorporating STEM competency goals into annual plans. Since STEM teachers should be rewarded and supported in their professional development, the Task Force recommends that teachers who obtain STEM credentials be considered for pay differentials, and that teachers be supported via investment in learning communities, both through online and in-place activities with local and regional organizations.

Finally, to support local efforts in STEM teacher preparation and professional development as well as to organize statewide support efforts, the Task Force recommends appointing a state STEM coordinator.

Recommendation Details

STEM Specialists, Teaching Endorsements and Attracting STEM Professionals to a Teaching Career

The Task Force recommends that a new position called "STEM specialist" be created by the NHDOE. The role would be similar to current math specialists in New Hampshire. The specialist role is essential for organizing STEM teaching efforts at the local and district levels, especially in providing leadership for teachers who are not experienced in either STEM content or the pedagogy of inquiry-based teaching.

[43] A teaching endorsement in K-12 signifies that a teacher has mastered content and pedagogy in a subject and is qualified to teach it at specified grade levels. An endorsement to remain active requires 30 hours of approved professional development in the subject over a three-year period. Retrieved from http://www.education.nh.gov/certification/

STEM specialists would be experienced math or science teachers with advanced credentials in STEM content and pedagogy. As instructional leaders, specialists would provide critical support for STEM teacher professional development, content expertise, and mentoring, curriculum and instruction assistance (especially for new forms of teaching such as theme-based projects, team collaborations and capstones). Specialists would also work collaboratively with other teachers to integrate their lesson plans so that STEM could become part of daily teaching in English language arts and other subjects. The specialists would enable districts to individualize professional development by addressing teachers' specific skill sets in the STEM areas. With the critical shortage of math and science teachers in New Hampshire elementary and middle schools, a STEM specialist is a critical bridge to help teachers achieve STEM competencies.

STEM endorsements for elementary school educators should be created especially for those who have generalist endorsements, but also for science and math teachers who wish to upgrade their skillset and prepare for future leadership positions. Districts seeking to enhance students' STEM literacy could give priority to hiring educators who hold or agree to obtain middle level endorsements. Although professional development for practicing teachers is often difficult due to time and the cost of training, there are alternative methods to achieve endorsements. For example, districts might recognize and reward new skills learned while on the job, through online courses or intensive workshops culminating in an assessment and certificate of completion. The NHDOE and the Innovation Fund should promote these.

The Task Force recommends a focused effort to recruit elementary school teachers and expand and promote available options for teacher preparation, such as low-cost or no-cost in-service professional development programs, intensive short-term institutes, certificate programs, digital badges,[44] and professional learning opportunities that build competency-based assessment into the curriculum.

For STEM professionals transitioning into teaching, one of the most common barriers to retention is the lack of classroom management skills and pedagogy. Thus, the Task Force recommends that these professionals be "fast tracked" to the extent possible to address these needs. NHDOE should identify alternative certification paths that create a viable pathway for STEM professionals into teaching.

It is time to recognize STEM specialists and endorsements with compensation differentials. Negotiating teams for districts should include STEM specialists and teachers with STEM endorsements as eligible for additional compensation in teacher salary schedules. This would be an alternative or in addition to increases in compensation tied to graduate credits. Both STEM

[44] Digital badges are an assessment and credentialing mechanism that is housed and managed online. Badges are designed to make visible and validate learning in both formal and informal settings. MacArthur Foundation at www.macfound.org

specialist and STEM teacher endorsements could be awarded special compensation during this time of critical need, and once the gaps are addressed, continue to be paid a stipend for their expertise.

Externships–Real World Learning

Teachers need a variety of opportunities for professional development in the STEM workplace. These should include paid externships that involve time at STEM workplaces such as, for example, working in advanced manufacturing, in a scientific research lab collaborating on research projects, in an Internet start-up, or as part of a support team in a medical pharmaceutical company. Districts who wish to extend externship opportunities for their teachers should consider partnering with local chambers of commerce, Rotaries and major area employers as, for example, has been the practice by businesses in the Upper Valley of New Hampshire for many years.

Professional Learning Collaborations

To create a sustainable infrastructure that supports the professional development of STEM teachers as well as promotes idea exchanges, the Task Force recommends collaborations among schools, non-profits and businesses, both online and in local and regional locations. Examples of sites and locations include libraries, science museums, corporate learning centers, community centers, and university research facilities such as the STEM Discovery Labs and LESCN centers.[45] Teachers with access to such a diverse mix of participants and programming would benefit from a broad range of ideas that could find their way into the classroom.

Each district might develop its own professional development support effort, but all districts could be connected via an online portal. Regional locations might also house STEM teaching supplies for surrounding schools and provide STEM lab experiences for teachers and students.

Creating a STEM Professional Development Plan at the SAU and District Levels

The Task Force recommends that each school in a district or SAU, especially elementary schools, conduct a needs-assessment of teaching for STEM disciplines. Districts could use the results to work with their schools to set STEM competency goals, and teachers would write their annual professional development plan to achieve those competencies. Districts seeking to focus on STEM literacy could give priority to hiring educators who hold or agree to obtain middle level teaching endorsements.

[45] LESCN (the Local Educator Support Center Network) has five regional locations. In addition, the Southeastern Regional Education Service Center, located in Bedford NH, just showcased a new STEM professional learning collaboration project with the Boston Museum of Science which enables on-the-job training and pedagogy development.

State STEM Coordinator

The Task Force recommends creating a position of state STEM coordinator to organize STEM activities. Responsibilities should include support for district adoption of Next Generation Science Standards, SAU and district STEM implementation plans, and advocacy for K-12 STEM teacher preparation and professional development. The STEM coordinator should report to a leadership committee charged with implementing STEM recommendations. As noted in the New Hampshire Charitable Foundation's STEM Pipeline analysis, "having one organization responsible for this work and one person whose time is dedicated to this task makes all the difference in how fast a joint effort can move."[46]

Action Steps and Timelines

- School districts have STEM Teacher Development Plans with targeted STEM preparation and professional development goals, along with annual reports that would document progress, including teacher STEM professional development gains (Fall 2015)
- Appoint a state-level STEM Coordinator to lead STEM-based efforts including teacher preparation and professional development to be housed in the Department of Education (Fall 2015)
- Professional Standards Board and other regulatory bodies including the State Board of Education through the New Hampshire Department of Education approve the STEM specialist and the STEM teacher endorsement and further articulate criteria for both (Spring 2016)
- Individual districts and negotiations teams recognize STEM specialists and STEM teacher endorsements in salary schedules, and in recognition of critical shortage areas, extend these adjustments to math and science areas, including physics and chemistry (Fall 2016)
- School boards give priority to elementary school job candidates with science and math content endorsements (Fall 2016)

[46] New Hampshire Charitable Foundation. (2014). *Smarter pathways: Strengthening New Hampshire's STEM pipeline.* Concord, NH: Education First.

NEXT STEPS: GLOBAL RECOMMENDATIONS

What Do I Need to Do?[47]

Implementation of the recommendations of the Task Force will require broad stakeholder commitment and engagement. In working together there is an opportunity to modernize STEM education in New Hampshire and position the state as an innovative leader in community-based STEM education. New Hampshire business and industry needs to join together with educational leaders, policymakers, and parents in communities across the Granite State to achieve the STEM prepared workforce needed to support a strong economic future.

TO THE BUSINESS COMMUNITY:

- Businesses have a prime opportunity to partner with local educators to articulate skills requirements needed in the New Hampshire workforce in the future. This means going directly to their local K-12 and post-secondary schools and colleges and helping them identify skills required in the workplace and strategies to meet the skills gap.

- Businesses have an opportunity to think upstream and invest early in talent. This means building strong partnerships with schools and investing in their programs, not only with financial resources, but also with time and talent.

- Business taxes are the backbone of the state's contribution to New Hampshire public education. As investors in the future workforce, businesses have an opportunity to help shape the skillsets they need. A number of New Hampshire businesses are already involved in this effort; they go above and beyond to support education in their local communities. Now is the time for other New Hampshire companies to consider joining these efforts to make strategic investments in K-12 STEM education.

- Business participation can be more than financial. Businesses can make a tremendous contribution by offering their skills at local schools through mentoring students, helping with school projects, assisting teachers in the classroom and providing opportunities for students to job shadow and work as interns. Many students have a limited notion of the variety of exciting careers that are available in New Hampshire, or how to make career choices. Business volunteers can share their real-world experience with young students and mentor them.

- Educators in K-12 nationally continue to request opportunities to gain STEM industry experience so they can connect curriculum to real-world project applications. New

[47] Each of the "voices" was written by Task Force members from the particular stakeholder group. For example, "to the business community," was written by two business representatives on the Task Force.

Hampshire businesses could play a critical role by providing teachers with externship, on- the-job, in-the-lab experiences to fill this critical gap.

To Principals and Superintendents in Grades K-12

- Task Force recommendations are intended to integrate with and enhance the ambitious initiatives in which K-12 administrators are already engaged. This is a time of great change in New Hampshire public education. The STEM Task Force recognizes the challenges administrators face and the commitment that requires. STEM recommendations where possible are designed to integrate with and not disrupt those initiatives.

- By starting discussions now, a comprehensive district or SAU-created STEM plan could be ready by September 2015 for implementation. For those districts who want to ensure that their students are fully prepared for post-secondary education and training – and ready for well-paying jobs – such a plan should include rigorous professional development support and training for teachers, especially in STEM project and inquiry-based instructional methods, as well as integration into current assessment for competency-based learning.

- Parents can be strong partners to drive STEM literacy forward in New Hampshire. For example, if courses such as computer coding or statistics are proposed as replacements or modifications to the curriculum, then if parents are educated as to the benefits of these changes, they can advise their children.

- Educators can collaborate to achieve strategic goals. By working with other schools and with other districts to pool talents as well as share responsibilities and resources, no school or one district will need to bear expensive burdens when cost sharing will produce better results

- Task Force recommendations are an opportunity to correct gaps in our K-12 educational system while recognizing and celebrating the progress that districts have achieved so far.

- Think local – this requires working with local legislators and community leaders to help drive this forward.

To the Higher Education Community

- Higher education institutions can creatively assess and commit strengths and capacities for supporting Task Force recommendations in their areas of service. Higher education leaders can commit resources and talent to help STEM K-12 programs across the state.

- Higher education leaders have an opportunity to partner and to help lead by establishing working groups to support the development of district and SAU STEM

implementation plans. As plans are developed, the University and Community College systems could help to support local and regional collaborations. For example, the Systems might host summits in various regions such as the Seacoast, Lakes, North Country and Upper Valley to bring together local school boards, elected state representatives and various funding agencies to examine how higher education resources might be deployed to support STEM K-12 education.

- Higher education has an important role in helping K-12 curriculum development in areas such as project and inquiry-based education. University teacher preparation and professional development programs, in addition to formal college credit programs, could provide leadership by offering short courses to educators on STEM subjects and to offer continuing education college credit.

- Higher education could harness the tremendous intellectual resources it holds by organizing mentors for K-12 schools and their teachers. University STEM instructors and research scientists could not only mentor K-12 teachers, but also establish formal externships where teachers might work side-by-side with University faculty and researchers on STEM projects and research.

- Higher education could also take a lead role in providing pathway advice to K-12 students, particularly at grades 9-12 where students might learn about career options and the college training available to prepare for those careers.

TO PARENTS

- STEM K-12 education is a "system" of preparation for students from kindergarten to post-secondary education and then to entry into successful careers. The aim is to help every student in New Hampshire become STEM literate, leaving room for career exploration in not only STEM fields but a wide variety of other careers as well. For parents, STEM literacy enables their child to explore different interests and potential careers. And it leaves room for a child's interests and career choices to change over the years – especially as new careers that don't exist today become career choices in five or ten years.

- Parents can be advocates and resources for promoting STEM. Parents can insist on high quality and diverse STEM educational opportunities based on strong foundational knowledge with many opportunities for their children to learn by doing.

- Parents have an opportunity to help their children because their influence is very strong during elementary and high school years; if parents are not familiar with STEM, they will find it difficult to help guide their children. Parents can become advocates; they can ask school principals to prepare an outreach plan for parents such as regular letters home that make the case for STEM education and provides an update on school STEM activities. This information can be presented at Parent Teacher Association and group meetings.

- Parents can reach out to their elected officials and tell them they support rigorous STEM education. STEM educational updates should be available on every school's website.

- Teachers and parents can partner to deliver a positive, supportive message to students about their STEM studies and be vigilant in counteracting the natural inclination for a child to say, "I can't do this." Parent and teachers can say, "Yes you can!"

- When students go from elementary school to middle school, they get their first opportunity to "select" a few courses that may interest them. Knowing this, parents can take this as an opportunity to educate themselves and their child about STEM courses and help them with their selections. Parents need enough advance notice so they can help their child research and ask questions about their choices. Schools can prepare students for these choices by sending out selections one semester in advance.

- When students head to high school they again have the opportunity to select classes. This is the time for key discussions regarding STEM related careers. If new classes such as coding and engineering are proposed, parents can find out why these classes are important. Parents, teachers and principals have an opportunity to collaborate to make the case for STEM-related course offerings.

TO SCHOOL BOARD MEMBERS

- School board members who want to ensure that their students are STEM literate and ready for well-paying careers should focus on developing a STEM education plan for their SAU or district and could use the STEM K-12 Education Task Force report as a resource for the development of that plan.

- School board members after reviewing the Task Force recommendations could consider hosting open forums with education and business leaders, and community members to discuss the Task Force report.

- School board members have an opportunity to take the lead in positioning STEM education as a key component in the policy and budgeting process. This is especially true in the potential development of District STEM strategic implementation plans.

- School board members have the opportunity to embrace local control and create a path that works best for their district. The Task Force recommendations have been crafted to provide a direction and enable local responses.

- Although most school boards will want to know how much a STEM education plan will cost and who will pay for it, the Task Force urges boards to consider how existing resources could be reallocated and to consider this a collaborative effort at the local, state and federal level and between private and public sector – with each doing its part.

TO STUDENTS

- Students are encouraged to explore STEM pathways and learning opportunities.
- Students should discuss their interests with their parents, teachers, and guidance counselor and ask whether a STEM career pathway might be right for them.
- Students should discuss with teachers and administrators and express STEM subject areas that they are interested in exploring.
- Students should be aware that STEM learning can take place in the classroom, while working on assignments, research and applied projects, in internships at businesses, online, and in other ways.

From Recommendations to Action

To be achieved, these Task Force recommendations require building broad awareness of the importance of STEM education and the actions needed to establish New Hampshire as an innovative leader in the field. This effort will require leadership to coordinate advocacy, fundraising and implementation statewide, as well as monitoring outcomes and accountability in meeting STEM educational goals. In addition, this effort will need regionally coordinated educational programming and attention to geographic disparity in the availability of educational resources. Moreover, this effort will require new innovative practices as well as the use of existing resources and capabilities in new ways.

A Year of STEM

Key to moving from recommendations to action will be getting the word out. The Task Force recommends that the Governor designate 2015 as a "Year of STEM" in which STEM Champions from around the state will work together to heighten awareness of the importance of STEM and STEM K-12 Education.

A Year of STEM can focus attention on the opportunities for New Hampshire to turn the Task Force recommendations into actions. The goals of the "Year" are: (a) to call public attention to the importance of STEM and STEM education to the state's future, (b) to draw attention to and gain commitment to the STEM K-12 education recommendations themselves, and (c) to set ambitious achievable milestones for the first year to ensure that the recommendations get traction.

As part of the Year of STEM, the Task Force is calling on business and industry, higher education and K-12 educators, policymakers and parents to join the effort by becoming STEM ambassadors. The role of ambassadors requires a commitment to become educated on STEM and to commit to a minimum number of outreach activities to reach decision-makers and students in New Hampshire. The Task Force calls upon STEM business owners, employees and inventors in New Hampshire to host events to showcase and explain their work. In addition, since news organizations are a vital link to keeping citizens informed, the Task Force calls upon the media to adopt this issue and report on STEM events especially as we approach the 2016 election cycle. The year of STEM would be coordinated by a new leadership coalition described below.

Statewide Leadership

To ensure the coordinated effort of leaders and institutions, the Task Force supports the recommendation of the New Hampshire STEM Pipeline Study calling for the establishment of a statewide STEM Education Leadership Coalition.

The Coalition would advocate for, raise funds for and coordinate the implementation of the STEM K-12 Education Task Force recommendations on a statewide basis. It would monitor and report on the progress towards STEM education goals and help to ensure accountability for outcomes. It would draw on multi-sector interest and the significant business stake in advancing STEM education. A unifying organization would be beneficial to remove overlap, duplication and confusion of efforts.

Going forward a STEM Leadership Coalition will need to identify STEM K-12 education specific goals and benchmarks to be able to assess progress and ensure accountability. In addition to measures such as science and math proficiency scores, AP STEM course enrollments and SAT math scores and other measures should be considered. These could include current and future interest in STEM and STEM careers (as measured in student surveys); student participation in STEM competitions and projects; the number of students who complete CTE STEM academies; the numbers and percentages of students that enter into STEM careers and STEM higher education programs; and the performance of newly certified teachers on Praxis II exam (an exam which measures the content knowledge in math and science, among other subjects, of teacher candidates before licensure). The Task Force recommends that the Coalition adopt the benchmarks and goals of the Task Force report as well as incorporate the existing higher education goal to double the number of STEM graduates in New Hampshire.

STEM Collaboration Hubs: An Engine for Improving Teaching, Delivery and Support

The Task Force believes that the state should support collaboration spaces where groups of STEM professionals can work in partnership with K-12 teachers. These "STEM collaboration hubs" would become regional centers where businesses could explain the skills that are lacking in job seekers and teachers could describe the challenges they have in teaching STEM competencies. Together they would formulate strategies to teach and inspire students in STEM using the best practices in education and the real world examples of STEM businesses. Businesses would have a voice in relaying the STEM skills needed in the workplace, and in turn teachers would gain relevant knowledge in how and why these STEM skills are needed and applied. Hubs would be located regionally and could be co-located at LECSN, USNH or CCSNH facilities, or the CTE early college academies.

In addition to physical facilities, shared space organized by the collaboration hubs should include cyberspace, specifically a common repository and resource website. One of the regional collaboration hubs should take responsibility for a statewide STEM K-12 Education website, for example, a Seacoast hub that might be supported at UNH's Joan and James Leitzel Center. The website would host STEM activities recommended in this report, including registration for STEM EXplorers program (business and industry STEM professionals who volunteer to speak at local schools) and registration for STEM mentors. In addition, it would have an inventory of New Hampshire STEM programs in-school and out-of-school, a searchable database on STEM careers with skillsets and education requirements of different careers, and a portal to access other STEM websites nationally and internationally. The website would be hosted and kept current by the collaboration hubs. It would serve as a central repository for NH STEM K-12 Education activities and will expand as new needs and uses are identified.

Rural STEM Education: Two New Hampshires in STEM Education

Rural school districts will face unique challenges gaining and maintaining momentum in modernizing STEM education. The challenges relate to many things, including low student population density, the need for teachers to travel significant distances for professional development and to share resources and establish partnerships, higher proportions of low income households, fewer STEM businesses, and less funding for local schools. The Task Force encourages rural school districts to be creative with STEM education efforts, utilizing their surroundings and natural resources, combining grade level classes, using online resources, and overlapping personnel to fulfill their STEM requirements. Having access to STEM mobile labs, STEM kits, and resources at the STEM collaboration hubs (see above) will also help rural schools with access and affordability.

A key concern in rural areas is attracting and retaining teachers in STEM fields. STEM teacher recruitment and retention is a problem across the state, but particularly pronounced in rural New Hampshire. Foundation and Federal grants and other funding should be sought to help rural areas provide incentives to STEM educators in rural New Hampshire. Incentives could include a pay differential for those who possess the necessary certifications in STEM. Extending loan forgiveness programs to educators in the STEM field in rural schools could also be helpful. This could include providing additional bonus pay for teachers who teach STEM courses and have demonstrated superior teaching/student growth percentile scores in their yearly performance review.

Once teachers are attracted to rural areas, ensuring their continued professional development and professional networking tends to be challenging. It is not uncommon for teachers in rural areas to need to travel six or more hours round-trip to attend relevant professional development and trainings. The majority of professional development in New Hampshire occurs in the region

between Concord and Manchester. Utilizing existing regional educational hubs and educational centers (as referenced above) can help to address the need for continual professional development for rural educators. The focus can be on supporting the regional educational hubs in rural areas and providing them the resources to attract relevant professional development to these areas throughout the school year as well as summer opportunities to meet the needs of educators in these rural communities and school districts.

It is also hard for schools in rural districts to build sufficient professional capacity in STEM education. Possibilities for schools in rural areas to share, for example, STEM specialist positions should be supported and assisted financially and otherwise. The districts should have the flexibility to employ district-wide personnel that can oversee and assist teachers with implementing STEM into every K-12 classroom.

STEM K-12 Education Innovation Fund

Public investment is essential to support strong and sustained core STEM programs. To ramp up innovative practices and to encourage greater business support, the Task Force recommends establishing the STEM K-12 *Education Innovation Fund* as a program of *The New Hampshire Fund for Public Education*. A collaboration of the New Hampshire Coalition for Business and Education, the New Hampshire Charitable Fund and the New Hampshire Department of Education, The New Hampshire Fund for Public Education will secure a pool of resources dedicated to support innovation in public education.

The STEM K-12 *Education Innovation Fund* would add to public funding of STEM education not replace it. The Fund would support local efforts to implement key initiatives proposed by this Task Force as they are adopted by schools and school districts. For example, the Fund might be used to support new approaches to STEM pedagogy, student engagement in STEM competitions and challenges, STEM professional development for educators, and support for both the expansion and sharing of successful practices in New Hampshire schools.

The *Innovation Fund* would provide an additional – competition based -- resource for New Hampshire educators and K-12 staff. Educators and staff could submit proposals for funding to enhance STEM existing efforts or start new innovative programs. The funds would be used to complement school district funding and to develop projects that would advance the Task Force's statewide STEM strategy

Arts in STEM: The Relevancy of Both

The arts have been integrated into the Task Force's recommendations including STEM-Inspiration activities, STEM Every Day and STEM Early College Academies. The Task Force believes that the arts are an important and vital part of a strong STEM education.

The intersection of the liberal arts with technology and STEM education is critical to the innovation economy. According to a number of US technology company CEOs, the liberal arts help students to manage ambiguity – a key skill in technology where few problems are clearly defined with only one right answer. The CEOs report that arts enable students to see issues from multiple perspectives, an essential element when dealing with complex problems.[48]

STEM and the arts add relevancy to one another. For example, the Corvette Stingray, the 2014 North American Car of the Year, is an engineering marvel and one of the top-performing automobiles on the market. But, it is also aesthetically appealing. The same could be said for new light-weight running shoes, smart phones, tablets and many other products that incorporate good design and function well. These are all examples of engineering and the arts working together, and they all resulted from the same design process engineers use to build the world's most advanced fighter jets, develop new energy solutions, and create targeted therapies for chronic diseases. It is important in K-12 STEM education to engage students in combining technical knowledge and skills with the creativity that leads to innovative ideas.[49]

[48] Heitin, L. (Feb. 26, 2014). Computer science: Not just an elective anymore. *Education Week*, volume 33 (issue 22). Retrieved from www. edweek.org

[49] Bertram, V. (2014, March 25). STEM or STEAM? We're missing the point. *Huffington Post*. Retrieved from http://www.huffingtonpost.com/vince-bertram/stem-of-steam-were-missin_b_5031895.html

CONCLUSION

New Hampshire's economy, a well-educated and well-informed citizenry and the career paths of our young people depend on high quality science, technology, engineering and math education across the state.

The Task Force was charged with helping the state expand and strengthen STEM K-12 education – determining the practices and policies to achieve leadership and excellence. This report puts forward specific recommendations and benchmarks, and a timeframe for action.

The Task Force recommends enhancing efforts in the foundational STEM subjects of math and science. It calls for engaging and supporting students, centering on the school experience, while inspiring students' natural curiosity by posing interesting questions and providing the tools necessary to answer them. This report recommends empowering our educators by investing in professional development to foster new teaching practices and creative application of resources in classrooms and schools. To accomplish these goals, this report provides guidance to New Hampshire leaders as to what each community and each sector needs to do.

The time to act, to organize efforts, to move forward on enhancing STEM K-12 education is now. Too much is at stake. Other nations out-compete our nation in STEM education, other states are expanding their efforts faster than New Hampshire, and the state's STEM workforce pipeline is failing to keep pace with the needs of our employers. If this trend continues the state's economy will not grow as strongly as it could, jobs will continue to go unfilled, and opportunities will be lost for our young people and their communities. To reverse this trend, this report calls for leadership and innovation at the school, district and local levels, statewide mobilization of talent, and resources and commitment by every sector of New Hampshire society. No single person or sector can accomplish this task alone, but through collaboration and investment, New Hampshire can produce the best STEM-competent workforce in the nation and retain its claim as among the best places to live and work.

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GOVERNOR'S TASK FORCE ON K-12 STEM EDUCATION

- Brian Blake, Ed.D., Superintendent of Sanborn Regional School District and President-Elect of the New Hampshire Superintendents Association, representing the New Hampshire School Administrators Association;
- Barbara Couch, Vice President, Corporate Social Responsibility at Hypertherm Inc. and a member of the state's Advanced Manufacturing Education Advisory Council,
- Joyce Craig, Manchester Board of Mayor and Alderman, and mother of three children who attend Manchester public schools;
- Susan D'Agostino, Ph.D., Associate Professor of Mathematics at Southern New Hampshire University, representing New Hampshire's private colleges and universities;
- Ross Gittell (Chair), Ph.D., Chancellor, Community College System of NH; representing the Community College System of New Hampshire;
- Robert Hallowell, member of the Nashua Board of Education and scientific researcher at MIT Lincoln Laboratory;
- Mary Kate Hartwell, District Curriculum Coordinator for Raymond Schools, representing the New Hampshire Science Teachers Association;
- Joseph J. Helble, Ph.D., Dean of the Thayer School of Engineering at Dartmouth College and a Professor of Engineering, representing New Hampshire's private colleges and universities;
- Caroline Herold, Middle Level Teacher at Lurgio Middle School in Bedford, representing the New Hampshire Teachers of Mathematics;
- Jeremy Hitchcock, CEO & Chairman of Dyn, representing New Hampshire's business community;
- Dean Kamen, New Hampshire entrepreneur, President of DEKA Research & Development and Founder of FIRST®, representing New Hampshire's business community;
- Todd Lamarque, Principal at Lancaster Elementary School and former chair of the science department at Gorham Middle High School, representing the New Hampshire Association of School Principals;
- Paul Leather, Deputy Commissioner of the New Hampshire Department of Education, designee of Department of Education Commissioner Virginia Barry;
- Palligarnai Vasudevan, Ph.D., Professor of Chemical Engineering and Senior Vice Provost at UNH, representing the University System of New Hampshire.

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