Alaska S.T.E.M.: Education and the Economy

Report on the Need for Improved Science, Technology, Engineering and Mathematics Education in Alaska

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November 2010

SpringBoard
A program of the Juneau Economic Development Council

JEDC Juneau Economic Development Council

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Executive Summary

There is growing concern nationwide that we are not adequately preparing students, teachers, and practitioners in the areas of science, technology, engineering, and mathematics (S.T.E.M.). A majority of secondary school students are not proficient in math and science, and many are taught by teachers lacking adequate subject knowledge. S.T.E.M. education (and competitiveness) issues have received much attention in recent years. Several high-profile publications have been written and have catalyzed rigorous conversation among leaders in education, business, industry and politics. Many of these conversations have led to the conclusion that there is a need for reform in our science and math education systems to include S.T.E.M.

What is S.T.E.M. and S.T.E.M. Education?

S.T.E.M. is an acronym for **S**cience, **T**echnology, **E**ngineering and **M**athematics. These four content areas are, as a group, crucial to our nation's economic competiveness and our youth's ability to succeed in the 21st century. There is a need to reform our education system so that future generations have adequate access to the global economy; with appropriate reform, they will find success throughout the 21st century and beyond.

First, it is important to distinguish between what S.T.E.M. education is and what it is not:

S.T.E.M. EDUCATION IS . . .	S.T.E.M. EDUCATION IS NOT . . .
• an interdisciplinary approach to learning that is rigorous and links student learning with real world challenges. • an approach that emphasizes process and design with a goal to develop problem solvers and critical thinkers. • a teaching method used to create a learning environment that promotes discovery, exploration, and problem solving. • a move to drive S.T.E.M. literacy into the classrooms for ALL students.	• a new name for the traditional approaches to teaching science and mathematics that rely primarily on lecture, worksheets, and cookbook-style labs. • the grafting of technology and engineering onto traditional science & math curriculua. • an emphasis on solution and replication of factual information. • a movement to educate only the best and the brightest. • simply more math & science classes.

Why is S.T.E.M. Education so Important?

Compared with students in other nations, U.S. students working with math and science are mediocre at best. Furthermore, held as a world leader in scientific innovation, the U.S. is not a leader in the number of students graduating with a S.T.E.M. degree. The U.S. ranks 20th among all nations in the proportion of 24-year-olds who earn degrees in natural science or engineering. In a recent international assessment of 15-year-old students, the U.S. ranked 28th in math literacy and 21st in science literacy. This and other data supporting the need to "fix the leak" in the S.T.E.M. school-to-career pipeline is mounting. It is time to look carefully at the cold, hard facts and proactively create a plan of action that will reignite our competitiveness as a nation.

The Facts:

1. Fewer than 15% of high school graduates take enough math and science to pursue scientific or technical degrees in college.
2. By 2018, computer and mathematical science occupations are projected to provide almost 785,700 new jobs.
3. Eight of the ten top jobs in 2010 require some form of specialized S.T.E.M. education.
4. It is predicted that over the next decade the amount of new technology introduced into the U.S. economy will equal that of the last 50 years.
5. Only 20% of the current workforce possesses the skills needed for 60% of new jobs created in the early 21st century.
6. It is estimated that by 2018 some 90% of occupations will be middle- or high-skill, with most of these jobs requiring a S.T.E.M. education and more than a high school diploma.
7. American companies have to outsource in order to stay competitive. They also need to import labor. Since 1999 over 300,000 temporary, non-immigrant, and skilled computer workers from abroad have arrived in the U.S. due to the shortage of skilled labor in the U.S.
8. "Between 2010 and 2020, the United States will experience a major talent meltdown," according to at least one analysis (Edward Gordon, "The Global Talent Crisis").
9. The U.S. is facing dismal graduation rates at both the high school and college levels. Only about seven in ten students finish high school with a diploma, while less than 60% of students who enter a four-year college receive a degree within six years.
10. Today's learner will have 10-14 jobs by age 38, creating a need to be a flexible problem solver.

Despite these compelling facts, little reform has occurred in our schools. As Willard Daggett, President of the International Center for Leadership in Education, once stated, "The rate of change has been phenomenal and will become even faster. Yet, even with all these changes, if Rip Van Winkle woke up today, he would be comfortable in most American classrooms." There remains a profound gap between the knowledge and skills most students learn in school and the knowledge and skills they need for typical 21st century careers.

More change is possible. Student success is directly related to quality of teaching. Bottom line, teachers make the difference. The U.S. is facing a critical shortage of S.T.E.M. teachers both in the current workforce and the in the candidate pool for potential teachers. It is estimated that by 2015, our nation will need an additional 280,000 new mathematics and science teachers. A looming teacher shortage, combined with the need to seriously update the skills of the current workforce, indicates a drastic need for teacher professional development in our Kindergarten through 12th grade (K-12) systems.

K-12 S.T.E.M. Education: What Should It Look Like?

What should education in the 21st century look like – especially an education that includes S.T.E.M.? Many of the best practices that would support a quality 21st century S.T.E.M. classroom have already been well documented by numerous educational

researchers. Programs created across the U.S. have implemented components of these best practices. Yet, there is not a specific curriculum or program that can be called S.T.E.M. Simply put, S.T.E.M. is a method of delivery that utilizes an array of best practice research in teaching and learning with an integrated approach to teaching science, technology, engineering, and mathematics. A framework for S.T.E.M. education has been developed by the author and utilizes a research-based set of components grounded in a constructivist view of learning and teaching. In the *S.T.E.M. Literacy Framework*, there are seven individual aspects – each one essential to the development of high-quality S.T.E.M. education at any level. Each component has one or more elements to describe it. The components within the *Framework* connect to one another and are designed to spiral and increase in rigor over time as a student progresses. The *Framework* may be used for many purposes, but its full value can be realized as the foundation for conversations among leaders as they seek to enhance S.T.E.M. education. The seven components are:

1. Basic knowledge and skills
2. S.T.E.M. skills for all students
3. All students graduate prepared for college and career
4. 21st century content
5. Purposeful design and inquiry
6. An early start in S.T.E.M.
7. High quality professional development

What are Barriers to Implementing S.T.E.M. Education?

There are five major barriers to implementing successful K-12 S.T.E.M. education discussed here. An awareness of these challenges can help leaders guide S.T.E.M. reform in their region:

1. Increasing awareness of S.T.E.M.;
2. S.T.E.M. is not another new reform effort;
3. Creating collective action – working collaboratively;
4. Creating the classroom learning environment;
5. Student and parent attitudes.

Career & Technical Education and S.T.E.M. Education

Career & Technical Education (CTE) can provide at least part of the solution. S.T.E.M. education and CTE programming are grounded in a set of complementary, and sometimes overlapping, best practices. One clear and intentional difference between CTE programming and S.T.E.M. education is that CTE is an *organized set of courses* at the high school level that leads to a deeper understanding of what it takes to be successful in a S.T.E.M.-related career.

S.T.E.M. education, on the other hand, focuses on educating all students K-12. The goal of S.T.E.M. education is to ensure that students gain the mathematics, science, technology and engineering literacy necessary to succeed in life beyond high school. Leaders can utilize the successful history of CTE as a model in developing successful S.T.E.M. education programs at all levels.

Further Direction Recommendations – Relating S.T.E.M. to Alaska

This section begins the process of bringing home the need for Alaska to consider how S.T.E.M. education reform is vital to our future – economically and educationally. Five recommendations have been developed for any leader or group of leaders to consider as they reform S.T.E.M. education in the state of Alaska.

The future well-being of Alaska and its citizens depends on *how well we educate our children and youth*. If Alaska wants to keep pace throughout the new century, it is imperative that we provide our youth with a proper S.T.E.M.-based education. These are huge challenges and great opportunities. The following five recommendations are suggested as ways to achieve success in the face of these challenges:

Recommendation 1: Conduct a comprehensive needs assessment to determine Alaska's projected need for a S.T.E.M.-educated workforce and to highlight shortcomings in our education systems.

Recommendation 2: Develop a comprehensive multi-year public awareness campaign focused on the importance of S.T.E.M. education to prepare all students for future jobs and opportunities, as well as foster innovation for the state's future economic success. Key to this will be developing community-based and statewide partnerships to improve S.T.E.M. education.

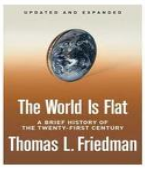
Recommendation 3: Expand and improve opportunities for students to take high-quality mathematics, science and S.T.E.M. courses as part of regular coursework as well as beyond the school day or year. Programs should start at an early age and continue throughout middle and high school, and be aligned with the expectations of postsecondary education and the workplace. Develop systems for qualitative evaluation and dissemination of this data.

Recommendation 4: Invest in teachers through high-quality, sustainable professional development in mathematics, science and S.T.E.M. education and literacy.

Recommendation 5: Develop meaningful and sustainable collaborations among K-12 schools, business, industry, and postsecondary institutions to align expected outcome competencies for college and career. Strengthening partnerships between these entities will provide Alaska with a blueprint to ensure students are prepared for work and/or postsecondary education upon graduation from high school.

What is S.T.E.M. and S.T.E.M. Education?

***S.T.E.M.**: **S**cience, **T**echnology, **E**ngineering and **M**athematics*



S.T.E.M. is a relatively new term that is growing in importance. It has become a popular acronym, particularly among advocates, government officials and educators. It is most often used in relation to the U.S.'s economic competitiveness and the related need for education programs that support future generations' aptitude in key subject areas. Among the most recent and relevant publications on S.T.E.M. education and competitiveness is *Rising Above the Gathering Storm* from the National Academies Press. Complementing this analysis is Thomas Friedman's book *The World is Flat*.[1]

S.T.E.M. is critical to America's economy, national security, and global leadership in research and innovation. There is a growing consensus that America's workforce needs to have a solid foundation in S.T.E.M. education to be successful in today's global economy. S.T.E.M. education can prepare all of America's students for the challenges and career opportunities of the 21st century.

Among occupations that the National Science Foundation includes under S.T.E.M. are:		
- Engineering - Psychology - Biological Sciences - Physical Sciences	- Economics & other Natural & Social/Behavioral Sciences - Mathematics - Computer Sciences	- Agricultural Sciences - Earth Sciences - Atmospheric & Ocean Sciences

Others have identified *any* occupation that uses math, science and technology.

What is S.T.E.M. Education?

S.T.E.M. education is not simply a new name for the traditional approach to teaching science and mathematics. Nor is it just the grafting of "technology" and "engineering" onto standard science and math curricula. Instead, S.T.E.M. is an approach to teaching that is greater than the sum of its parts – it is a "meta-discipline."

S.T.E.M. represents a new frontier in education by removing traditional barriers between disciplines and integrating them into a cohesive curriculum. Each of the four content areas is essential and does not stand alone; each adds a specific relevance and purpose. Real-world problems are presented as part of the curriculum and students are challenged to apply each of the four content areas seamlessly. Indeed, S.T.E.M. is the new frontier.

> *"S.T.E.M. Education is a process for teaching and learning that offers students opportunities to make sense of the world and take charge of their learning, rather than learning isolated bits and pieces of content."*
>
> -Idaho S.T.E.M. Project
> http://www.sde.idaho.gov/site/iSTEM/

S.T.E.M. is not intended to be a new standalone subject area with a new set of licensure regulations for teachers. Given the amount of content within each of the four subject

areas, it is hard to imagine a new teaching/licensure program that could prepare current or new teachers with the sufficient science, mathematics, engineering and technology expertise to teach all content effectively. S.T.E.M. education is about redesigning the infrastructure, principles and methods of instruction within conventional science and mathematics programs so that engineering and technology are presented as real-world outlets for traditional subjects.

Engineering and technology put emphasis on the *process* and *design* of solutions instead of the solutions themselves – the familiar approach to math and science. The emphasis on process and design allows students to explore math and science in a more personalized context, while helping them to develop the critical thinking skills that can be applied to all facets of their academic and work futures. Engineering is the method that students use for discovery, exploration, and problem solving. The technology component allows for a deeper understanding within the other three parts of S.T.E.M., allowing students to apply what they have learned – for example, specialized and professional applications like GPS, computer assisted drafting, and computer animation. The knowledge gained from these separate but integrated subject areas is greater than the sum of its parts.

S.T.E.M. Literacy for All: The goal of S.T.E.M. education is for all students to graduate from high school with the essential S.T.E.M. competencies necessary to succeed in postsecondary education and work, whether they specialize in S.T.E.M. fields or not.

In summary, S.T.E.M. education is a process that offers all students an opportunity to make sense of the world holistically, rather than in bits and pieces. S.T.E.M. education removes traditional barriers and integrates separate subject areas into a cohesive teaching and learning paradigm. As stated by Janice Morrison, "S.T.E.M. education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise."[2]

S.T.E.M. initiatives have been established throughout the U.S., including many here in Alaska, as a means of promoting education in these crucial subject areas so that students will be prepared to study and work effectively throughout the next century.

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Why is S.T.E.M. education important?

Staying Competitive with New Ways of Thinking

The United States isn't number one anymore. We're not even number two. In fact, the U.S. doesn't even make the top 10 list in science or math literacy among 15-year-olds worldwide.[3] Instead, the U.S. ranks 21st in science literacy among the survey's 30 participating countries, all part of the Organization for Economic Cooperation and Development - the wealthiest and most technologically advanced nations in the world. The U.S. fares even worse in math literacy, ranking 25th in the same group of 30 countries.

Fewer than 15% of high school graduates have enough math and science to pursue scientific/technical degrees in college. *TIMMS Report - 2007*

Students fare well in grade school; fourth grade students in the U.S. seem to be comparable to other students in the world. By middle school, American students begin to fall behind in math and science.[4] By the end of high school, fewer than 15% of high school graduates have enough math and science to pursue scientific or technical degrees in college.[5]

By 2018, computer & mathematical science occupations are projected to add 785,700 new jobs. *Bureau of Labor & Statistics - 2010*

Maintaining America's scientific and technological leadership is critical to staying competitive in the global marketplace. By 2018, computer and mathematical science occupations are projected to provide almost 785,700 new jobs. As a group, these occupations are expected to grow at more than twice the average pace for all occupations. The need for science, engineering and technical training has increased 51% over the past three years alone - emphasizing the need for a S.T.E.M. curriculum throughout America.[6]

The U.S. is under-investing and under-performing in S.T.E.M.-related fields. For example, over $440 billion dollars are being invested in China over the next ten years for renewable energy; South Korea has committed $85 billion dollars over the next five years. By comparison, the U.S. invests between $6-12 billion annually in renewable energy.[7] Lack of investment in S.T.E.M. education is also a concern. A number of recent studies show that the U.S. lags behind many of its economic competitors in higher education. According to *Rising Above the Gathering Storm*, only 15% of American undergraduates received their degrees in natural science or engineering in 2004, while in China a full 50% of students received their undergraduate degrees in those subjects.[8] American students are trailing behind their foreign counterparts in post-graduate S.T.E.M. education as well; in 2004, 56% of engineering Ph.D.s in the U.S. were awarded to foreign-born students. If this trend continues, more than 90% of all scientists and engineers in the world will be from Asia.[9]

US Department of Labor Top Jobs 2010

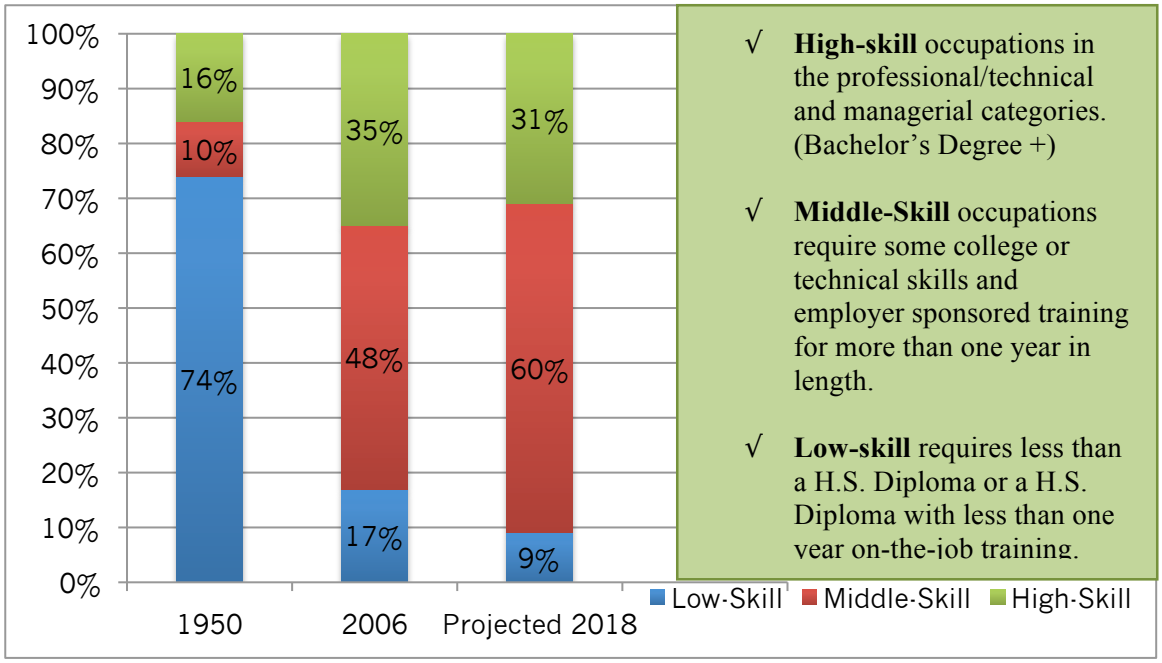
1. Actuary
2. Software Engineer
3. Computer Systems Analyst
4. Biologist
5. Historian
6. Mathematician
7. Paralegal Assistant
8. Statistician
9. Accountant
10. Dental Hygienist

S.T.E.M. skills are vital to this generation as well as future generations of job seekers. Eight of the ten top jobs in 2010 require some form of specialized S.T.E.M. education - all but historian and paralegal.[10] More than 75% of U.S. jobs will require workers with S.T.E.M.

skills by 2018.[11] Demand for these jobs has been triggered by an ever-changing workplace full of new technologies and of greater complexity and sophistication.

New Job Skills in a New Economy

The United States' education-to-employment system needs to be rebuilt. Already, 62% of all U.S. jobs require high levels of skill – most of these require S.T.E.M.-related skills.[12] It is predicted that over the next decade the amount of new technology introduced into the U.S. economy will equal that of the last 50 years.[13] This is and will continue to be an unprecedented acceleration from low-skill jobs to jobs requiring more complex knowledge. Many of these jobs are and will continue to be S.T.E.M.-related. In 1950, 74% of jobs were low-skill; just over 50 years later, only 17% of jobs are low-skill (see definitions and chart below).[14]



Only 20% of the current workforce possesses the skills needed for 60% of new jobs likely to be created in the early 21st century.[15] "Knowledge work" is replacing low-end, low-wage jobs. It is estimated that by 2018 some 90% of occupations will be middle- or high-skill, with most of these jobs requiring a S.T.E.M. education.[16] Additionally, some of these jobs will be taken by professionals educated outside the U.S.

Many American companies feel the need to outsource in order to stay competitive. Historically, so-called blue-collar jobs have been most impacted by outsourcing. However, a recent University of California study finds that 14 million white-collar jobs within the U.S. are vulnerable to being outsourced.[17] These days, it is clear that no S.T.E.M.-related job in the U.S. is safe from being outsourced. Future workers – students – are affected as well. Outsourcing has led to record unemployment in S.T.E.M.-related fields and, as a result, there has been a major drop in university enrollments in scientific, technical, engineering, and mathematical fields of study.[1817] In short, outsourcing S.T.E.M. jobs has had a negative effect on both professionals and students in the U.S.

Many companies also bring skilled labor into the U.S. In 1999, Congress passed legislation to permit the entry of computer workers into the country. Since that time over 300,000 temporary, non-immigrant, and skilled computer workers from abroad have arrived in the U.S. due to the shortage of skilled labor.[19] This trend continues today; however, importing labor is no longer limited to computer workers. It has expanded to other S.T.E.M.-related jobs including advanced technological production, design and management, and engineering. The U.S. has failed to invest adequate long-term resources to educate its youth, leaving them unprepared to work in this and the next wave of emerging S.T.E.M.-based jobs and forcing companies to look elsewhere for skilled professionals and laborers.

> *"Education is one of the most effective ways for individuals, communities, states, and the country to improve our social and economic future."*
>
> -Patrick M. Callan, President
> National Center for Public & Higher Education

The new world economy presents us with both a short- and long-term S.T.E.M. problem, especially when it comes to educating future S.T.E.M. professionals. "Without drastic talent-creation change between 2010 and 2020, the U.S. will experience a major talent meltdown," states Edward Gordon, a business trend consultant.[2019] There will be millions of middle- and high-skill jobs left vacant. The inability to find qualified workers will devastate the U.S. economy. Businesses will leave the U.S., searching for S.T.E.M. talent elsewhere. To prevent chronic imbalance and a true economic catastrophe, the U.S. needs to reinvent its education system to include S.T.E.M. instruction.

Playing Catch-Up

During most of the 20th century the U.S. had the most educated workforce in the world. This advantage is eroding. Trend data suggests that if patterns continue, the portion of U.S. workers with high school diplomas and college degrees will decrease and the personal income of Americans will decline over the next 15 years. Only about seven in ten students finish high school with a diploma. Similar issues with graduation rates are also evident at the college level. Less than 60% of first-year students entering a four-year college receive a degree within six years.[21] This trend is more profound among minority and low-income students. These statistics combined with the retirement of the baby-boomers – the most highly-educated generation in U.S. history – is causing an economic ripple that has the potential to devastate the U.S. economy. A decrease in the average education level of U.S. workers places them at a major competitive disadvantage, rendering them unable to compete for the high-skilled jobs in demand both now and over time.

Aligning rigorous and relevant K-12 S.T.E.M. education requirements with the expectations of postsecondary education and the workplace is essential to reestablishing the U.S.'s ability to educate future professionals. Fewer than half of all high school graduates are ready for introductory-level math and science in college. This is likely because less than 41% of high school graduates meet or exceed the ACT college readiness benchmark in mathematics and a mere 26% meet or exceed the science benchmark (ACT provides curriculum-based measures of college readiness).[22]

Key to building a "S.T.E.M. education pipeline" is student course selection and course rigor. Students who are successful in S.T.E.M. fields beyond high school must not only take the right number of courses in high school, but also the right kind of courses. ACT conducted a survey of U.S. high schools and found that only 56% of students reported taking the recommended core curriculum for college-bound students: four years of English and three years each of math (algebra or higher), science and social studies.[23] Students who choose not to or are unable to finish algebra 1 before 9th grade – which is needed for them to proceed to high school geometry, algebra 2, trigonometry, pre-calculus, and calculus – effectively shut themselves out of careers in S.T.E.M.[24] This calls for a focused investment in middle school and early high school mathematics programs so that students have a strong foundation as they move forward.

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> -Willard Daggett
> President
> International Center
> For Leadership in Education

The U.S. needs an education system that prepares its students to be nimble in a dynamic and evolutionary workplace. The U.S. Department of Labor estimates that today's learner will have 10-14 jobs by age 38.[256] Furthermore, students will have *new* options for work; many of the jobs currently being filled weren't in demand just a handful of years ago. Indeed, the job market is fast-paced and will be even more so in the future.

There remains a profound gap between the knowledge and skills most students learn in school and the knowledge and skills they need in typical 21st century workplaces. Employers citing skills critical to success in the 21st century workforce include the following:

- √ a combination of basic knowledge and applied skills, with applied skills trumping basic skills as the top five most important for any level of education;
- √ professionalism/work ethic, teamwork/collaboration, and oral communications, which are rated the three most important applied skills;
- √ and creativity/innovation, which is projected to increase in importance for future workforce entrants.[26]

> • 84% of employers say that K-12 schools are not preparing students for the workplace.
> • 74% of students say they feel unprepared for college/career and that requiring more math & science would help.
>
> Peter D. Hart
> Research Associates

Students and employers both agree that there is a lack of preparedness for S.T.E.M.-based careers. A staggering 84% of employers surveyed by Peter D. Hart Research Associates stated that K-12 schools are not adequately preparing students for the workplace. Meanwhile, 74% of students surveyed stated that they felt unprepared for both college and the workplace and that they believe requiring more math and science would help with college and workforce preparation. [27]

Teachers Make the Difference

The most direct route to improving student achievement is to have better teaching. The U.S. is facing a shortage of S.T.E.M. teachers both in the current teaching workforce and the in the candidate pool for potential teachers. By 2015, our nation will need an additional 280,000 new mathematics and science teachers.[28] There is a drastic need for teacher professional development to answer this growing demand for mathematics and science teachers.

In addition, it is critical to bolster the capabilities of the current teaching workforce. More than one in four high school mathematics teachers and nearly one in five high school science teachers lack even a minor in their main teaching field.[29] This is a significant disparity. A recent review of the research on teacher quality conducted over the last 20 years revealed that, among those who teach math and science, having a major in the subject taught has a significant positive impact on student achievement. As a recent report by the National Commission on Mathematics and Science Teaching for the 21st Century makes clear, the existing workforce isn't the only concern. More than 12% of all new hires enter the classroom without any formal training; another 14% start work without meeting the teaching standards for their state. Regrettably, about 56% of students taking physical science in high school are taught by teachers who lack expertise, as are 26% of those taking mathematics. In high poverty and rural areas these statistics are profoundly worse – where students have less than a 50% chance of getting a science or mathematics teacher who holds both a license and a degree in the subject being taught.[30]

If we are to stop the so-called leak in the S.T.E.M. school-to-workplace pipeline, a good place to start is the quality and availability of qualified, S.T.E.M.-educated teachers. An improved workforce of teachers will lead to an improved pool of future S.T.E.M. professionals who are ready for work and/or career.

K-12 S.T.E.M. Education: What Should It Look Like?

Education for the 21st Century

Most Americans still adhere to a 20th century paradigm of education – one that honors the memorization of facts over creative critical thinking skills. As a result, American schools have not kept pace with changes in education worldwide, which directly impacts our nation's capacity to maintain our global leadership in science and technology. K-12 education reforms need to provide all of America's youth with the skills necessary to compete in the 21st century and beyond. This vision of reform focuses on S.T.E.M. literacy skills, which give students the capacity to create, design, adapt, innovate, and think critically to solve complex challenges in real world contexts. The goal of S.T.E.M. education is for all students to graduate from high school with the essential S.T.E.M. competencies necessary to succeed in postsecondary education and work, whether they specialize in S.T.E.M. fields or not.

S.T.E.M. education will take us out of the 20th century and into the 21st century. Schools that embrace S.T.E.M. education will inspire all students, not just the brightest and best, to succeed in a challenging and shifting employment environment (projections show that S.T.E.M.-related occupations are expected to grow more than twice as fast as the average rate for all occupations).[31] S.T.E.M.-focused schools will expect students to complete a rigorous, college- and career-preparatory curriculum, including a four-year high school course of study with an intense, applied focus on science, technology, engineering and mathematics preparation.

This vision for K-12 S.T.E.M. reform is not impossible to implement. As discussed earlier, many of the best practices for implementing K-12 S.T.E.M. education have already been well documented by education researchers. A number of programs created and implemented in schools across the U.S. have shown promising results. The problem is that these programs and practices have not been fully developed nor have they been brought to scale. S.T.E.M. education is an opportunity to do both.

A Framework for Developing S.T.E.M. Literacy Skills, K-12

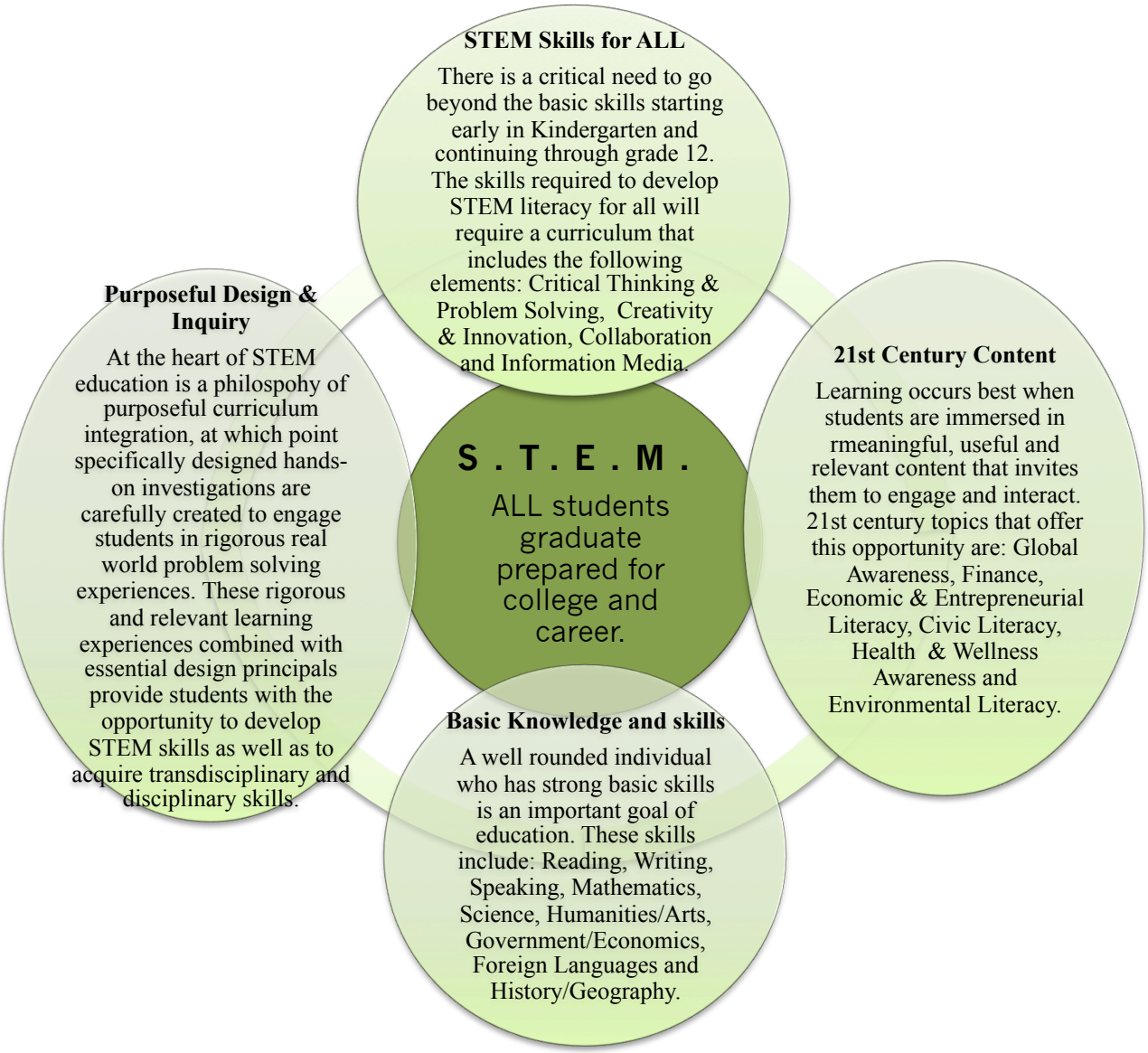
S.T.E.M. education is not a program or a curriculum; it is a method of delivery that seamlessly and purposefully ties the four content areas of science, technology, engineering, and mathematics. The *Framework* illustrated below demonstrates how the components essential to create S.T.E.M.-literate students work as a process with the aim of readying all students for life beyond high school. This *Framework* came out of a synthesis of the current research on S.T.E.M. education, brain-based learning, best practice research for K-12 education, and readings on 21st century skills. It is a structure from which leaders can begin the development and implementation process for a high-quality K-12 S.T.E.M. program in their state or community.

Essential to the framework are two overarching elements: (a) the implementation of high-quality professional development and teacher training; and (b) an early start for students, beginning as early as kindergarten and continuing through high school. The other elements of the framework are revisited each year as students progress. (See

visual for *A Framework for Developing S.T.E.M. Literacy Skills, K-12* on the following page.)

A Framework for Developing S.T.E.M. Literacy Skills, K-12

High Quality Professional Development & An Early Start Beginning in Kindergarten and Continuing through Grade 12 is foundational to the Framework.



Framework Elements

1. All Students Graduate Prepared for a Career and/or College: At the core of this framework is the goal of improving standards that build toward college- and career-readiness. Strengthening instruction in science, technology, engineering and mathematics, as well as in key basic skills like reading, writing, listening, and speaking, is

crucial. The No Child Left Behind Act of 2002 is currently being reauthorized by the Obama administration; first drafts of the legislation have clear expectations outlining how states and local schools will be accountable for assuring that all students graduate prepared for college and/or a career.[32] The developing plan recognizes a need for American schools to prepare all of our youth with 21st century knowledge and skills – specifically highlighting S.T.E.M. skills. The plan asks states to align their academic standards with college and workplace expectations. These same expectations have been voiced repeatedly by employers, college admissions officers, and parents and students as highlighted in numerous surveys.[33]

2. S.T.E.M. Skills for All Students: As much as students need to learn basic academic content, they will be required to have the skills and knowledge expected by S.T.E.M. curricula. Learning and thinking skills developed within S.T.E.M. education are comprised of: [26][34]

- Critical Thinking and Problem Solving
- Communication
- Creativity and Innovation
- Collaboration
- Information and Media Literacy
- Contextual Learning

3. Purposeful Design and Inquiry: S.T.E.M. education removes the traditional barriers between subject areas and integrates them into one cohesive means of teaching and learning. Best practice methods in education that promote the S.T.E.M. skills mentioned in #2 above include:

Curriculum, Instruction & Assessment
- Alignment with National Science, Math and Technology Standards
- Hands-on and inquiry-centered real world experiences
- Backward design
- Integrated curriculum
- Project-based learning/solving real world problems
- Applied learning experiences
- Team teaching
- Periodic progress/benchmark assessment

Design Principals
- Connect students with mentors or S.T.E.M. role models
- Job shadowing/internships
- State of-the-art technology and equipment utilized
- Equity based education/high expectations for all learners
- Supportive and committed leadership (system and building)
- Ongoing support from community partners
- Consistent, yet flexible frameworks for program implementation

4. 21st Century Content: Several significant emerging content areas are critical to success in communities and workplaces and will serve as platforms for curricula that develop *S.T.E.M. skills for all students* (see #2 above). The following content areas typically are not emphasized in schools today:[35]

- Global awareness

- Financial, economic, business and entrepreneurial literacy
- Civic literacy
- Health and wellness awareness
- Environmental literacy

5. Basic Knowledge and Skills: There is and always will be a need for a "well rounded" individual who has strong basic skills in various areas.[36] Yet, it is crucial to build on these basic skills to focus on the higher-level skills needed in the 21st century. Either way, the basics are a strong foundation for all students. Basic skill/content areas include:

- Reading, Writing, Listening, and Speaking
- Mathematics
- Science
- Government/Economics
- Humanities/Arts
- Foreign Languages
- History/Geography

6. An Early Start in S.T.E.M.: The earlier children are exposed to S.T.E.M. concepts, the more likely they are to be comfortable with them later in life.

- S.T.E.M. core concepts and ideas should be included in kindergarten education and continued through to 12th grade
- Improving the extent and quality of elementary school S.T.E.M. education should become a priority

7. High Quality Professional Development: Maintaining consistent, sustained and targeted teacher training and support is essential. Training and support models the approach that teachers will be expected to use in the classroom.

- Ongoing training and support for up to five years
- A school culture that supports and honors inquiry-based teaching and learning
- Teacher mentors
- After school and/or summer programs that teach challenging S.T.E.M. content through hands-on, inquiry-centered experiences
- Access to scientists and engineers
- Postsecondary partnerships

Career & Technical Education and other Best Practice Examples for Developing S.T.E.M. Education

CTE can provide at least part of the solution – fixing the leak in the S.T.E.M. education pipeline. CTE is a high school program and, as such, its impact is focused. CTE is an organized set of courses that leads to a deeper understanding of what it takes to be successful in a particular career. S.T.E.M. careers are only one of sixteen categories within CTE programming nationwide. Other categories include health care and architecture and construction.

As discussed earlier, S.T.E.M. education and CTE programming are grounded in a set of complementary, and sometimes overlapping, best practices. While S.T.E.M. education focuses on educating all students from K-12, CTE programming focuses on the students who choose to study S.T.E.M. while in high school.

CTE is and has been on the radar in Alaska for some time. The Alaska Department of Education & Early Development defines CTE as "an organized education program that offers a sequence of courses, providing individuals with the academic knowledge and skills needed to prepare for future education and careers in emerging occupations."[37] This definition implies the importance of developing career readiness programs. Many CTE programs are aligned with universities and colleges whereby students who successfully complete these courses can earn college credit. These existing CTE programs can provide a strong platform for developing at least some components needed for a solid S.T.E.M. education framework that reaches out to all students.

A unique and defining characteristic of CTE is that courses are taught using a hands-on approach. For example, students in building trades programs learn to read blueprints and understand the international code of conventions. Students in medical assisting programs learn medical terminology and how to calculate drug dosages. Students in digital media programs build websites as part of their class experience. The hands-on approach used by CTE programs strengthens student understanding and helps attract more individuals to particular careers; this approach is also an important component to successful S.T.E.M. education program design. Many experts believe that expanding and strengthening CTE programs will augment the response to S.T.E.M. education challenges.

CTE courses offer students the opportunity to learn by doing. Students in medical assisting programs learn medical terminology and how to calculate drug dosages. Students in digital media programs build websites as part of their class experience.

S.T.E.M. education advocates deeply believe that like CTE programming, *quality* S.T.E.M. must have an integrated approach to the curriculum.

In addition to having a hands-on teaching methodology, CTE has long been a leader in the integration of high-level-academics and technology in high school curricula. Examples include courses in health care, engineering principles and construction management. These courses have always contained rich science, math, and technology components. S.T.E.M. education advocates deeply believe that like CTE programming, *quality* S.T.E.M. must have an integrated approach.

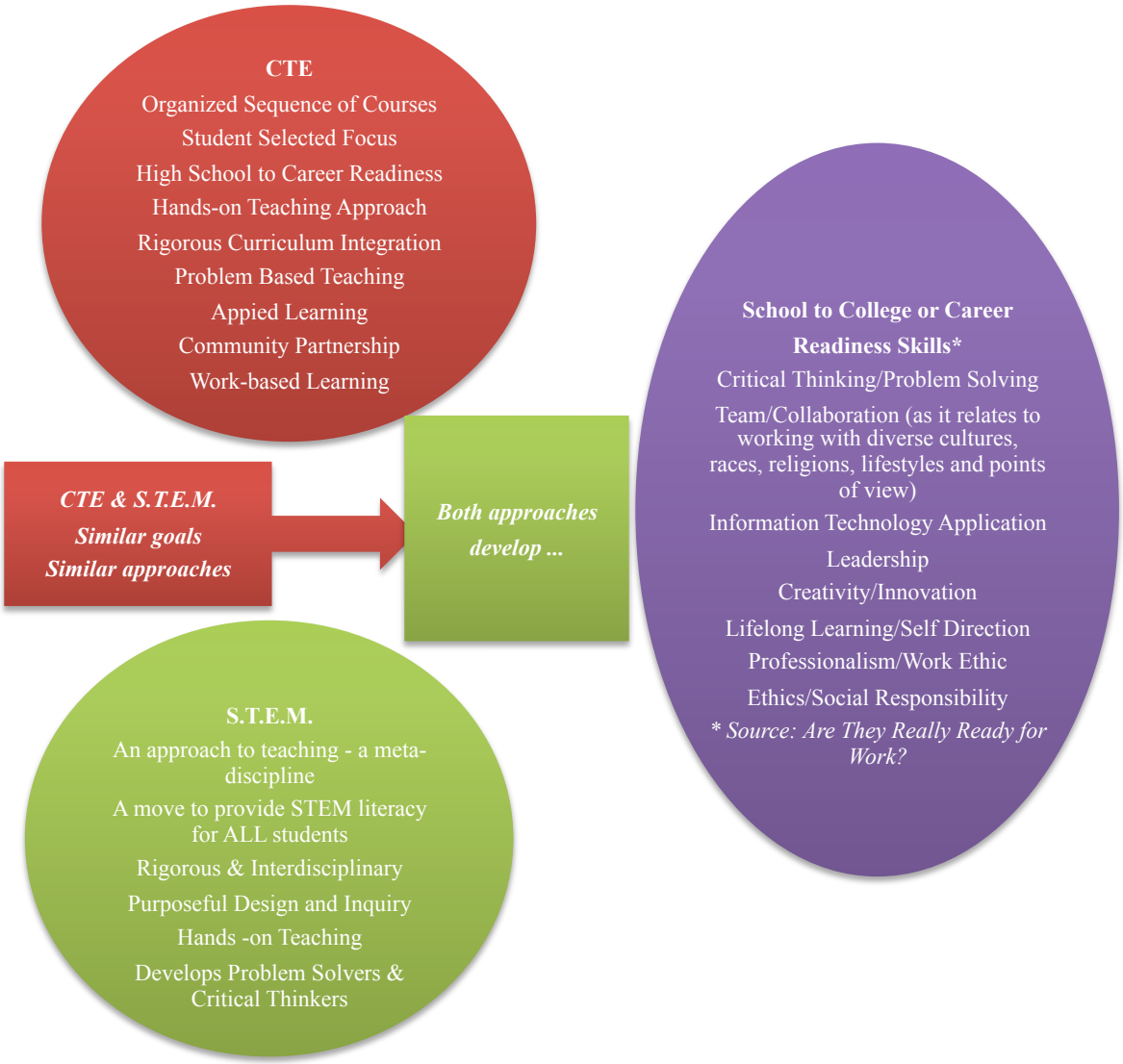
The S.T.E.M. component of CTE programming has already influenced many new ventures in high school education nationwide. During the last decade, many innovative and S.T.E.M.-intensive programs have been launched or expanded in schools across the nation. A model that has become familiar is that of academies and small learning communities. Well-designed, S.T.E.M.-focused academies provide students with a rigorous and well-rounded education with outstanding science, technology, engineering and mathematics instruction. Often, these academies are focused on career clusters associated with typical CTE programs, such as: Architecture and construction, S.T.E.M., Health Care, Engineering, Information Technology and Mathematics. In their curricula, academies and strong CTE programs focus on career education and work experience. Academies, when using best practices, are good examples of how CTE and S.T.E.M. can and do directly connect.

CTE programs have worked successfully to blend essential components: hands-on learning, rigorous curriculum, problem-based teaching, teacher-as-facilitator, applied learning and guest instruction from professionals in the community. All of these components are best practices mentioned by experts in both CTE and S.T.E.M. education. CTE programs are also not about taking more classes in math, science or technology, but rather about taking an *organized sequence of courses.* They offer students a deeper understanding of S.T.E.M. career paths. CTE programs help to build interest in S.T.E.M. and S.T.E.M.-related careers at the high school level, by making math and science content more relevant and tangible to students through content integration and applied learning techniques. The best CTE programs also include active career exploration and career advising. This ensures that students better understand the breadth of careers that have a relationship with S.T.E.M. and the varied pathways that can lead to those careers. It also keeps students enthusiastic about S.T.E.M. careers by clearly defining what it takes to prepare for particular S.T.E.M.-related career paths. For example, courses like aviation and aerospace, information technology, and simulation and robotics expose students to curricula and careers they may have never even imagined otherwise.

Embedded within quality CTE programs are the support services necessary to help all students gain an opportunity to pursue these rigorous courses and careers. These services include mentors, career and technical student organizations, and work-based learning opportunities, such as job shadowing and internships.

CTE programming, along with some educational ventures like the academies discussed above, offers a set of best practices that can and should be utilized in developing and implementing K-12 S.T.E.M. curricula.

The diagram on the following page illustrates the similarities between goals and approaches utilized by quality CTE and S.T.E.M. education programs.


CTE
Organized Sequence of Courses
Student Selected Focus
High School to Career Readiness
Hands-on Teaching Approach
Rigorous Curriculum Integration
Problem Based Teaching
Appied Learning
Community Partnership
Work-based Learning
CTE & S.T.E.M.
Similar goals
Similar approaches
Both approaches develop ...
School to College or Career Readiness Skills*
Critical Thinking/Problem Solving
Team/Collaboration (as it relates to working with diverse cultures, races, religions, lifestyles and points of view)
Information Technology Application
Leadership
Creativity/Innovation
Lifelong Learning/Self Direction
Professionalism/Work Ethic
Ethics/Social Responsibility
* Source: Are They Really Ready for Work?
S.T.E.M.
An approach to teaching - a meta-discipline
A move to provide STEM literacy for ALL students
Rigorous & Interdisciplinary
Purposeful Design and Inquiry
Hands -on Teaching
Develops Problem Solvers & Critical Thinkers

What Are Barriers to S.T.E.M. Education?

> *"There must be no barriers for freedom of inquiry. There is no place for dogma in science. The scientist is free, and must be free to ask any question, to doubt any assertion, to seek for any evidence, to correct any errors."*
>
> -J. Robert Oppenheimer ~ American Theoretical Physicist

Every state in the nation has begun to embrace the importance of S.T.E.M. education, with many state-level initiatives arising in recent years. Success has been as varied as the initiatives themselves. As these initiatives have moved forward, barriers impeding progress in implementing a S.T.E.M. educational framework have been identified. Any lack of success comes from many possible sources. In some cases it is a lack of vision or awareness of the issues surrounding S.T.E.M.; in others it is a lack of policy or funding. In addition to these more generic issues, developers need to address local issues and conditions.

Becoming aware of these challenges and addressing them early can prevent or reduce delays or even derailment, and can assure the attainment of systemic and sustainable S.T.E.M. education. Therefore, identifying and understanding possible barriers is the first step in successfully implementing a statewide K-12 S.T.E.M. education framework. Some of the challenges states and communities have come up against in developing a K-12 S.T.E.M. agenda:

Barrier 1 – Increasing Awareness: S.T.E.M. is Essential

Promoting a S.T.E.M. education agenda is vital. As stated earlier, the U.S. is not number one anymore; but it can be again. Both the general public and stakeholder groups must understand that the mission of improving K-12 S.T.E.M. education for all students is not merely important, it is extraordinarily pressing, and the success or failure of the S.T.E.M. mission will have lasting consequences for America's economic and social well-being and, more specifically, the well-being of individual states.

Communicating this importance and immediacy is imperative, as is raising awareness of the underlying reasons for the need for reform. Efforts to improve S.T.E.M. education have proven futile in many states partially because of a failure to create an organized, systemic plan to inform the general public and the closest stakeholders about the importance of S.T.E.M. education reform. If government officials or school district administrators are unaware of the critical linkages between S.T.E.M. education and a sustainable future for America, then restructuring an educational system to address S.T.E.M. issues is impossible. When people realize that K-12 S.T.E.M. education reform can increase the likelihood of all students having success in the transition from school to work and/or college, the S.T.E.M. agenda is in a position to bring about essential changes. This awareness forms the essential first step in building and sustaining public support for K-12 S.T.E.M. education redesign that will help secure our economic future.

Barrier 2 – S.T.E.M. is the Most Relevant Education Reform Effort

There are skeptics who ask, "How is this S.T.E.M. education movement different from past educational reform efforts?" Only in recent years has research indicated that a strong education in S.T.E.M. for all students benefits our states and nation. In the past, S.T.E.M. education initiatives have focused just on those students seeking specialized careers in science or engineering. Today's S.T.E.M. education efforts, however, are for all students: the essential S.T.E.M. competencies give students the tools to succeed in postsecondary education and work, whether they specialize in S.T.E.M. fields or not.

> Economic and technological factors are visibly changing the job market, creating a broad awareness among Americans that their children need more and better education – an education that includes S.T.E.M.

The American education reform movement is still with us today; efforts to reform the educational system have been underway since the mid-twentieth century. Now, as we step into the 21st century, there seems to be an even greater interest in reforming our schools. Why is education reform still alive? One reason is the fundamentally changed nature of the economy in the information age. Growing numbers of employers call for better educated, more highly skilled workers, claiming that there are good jobs with career prospects going unfilled because there is a shortage of adequately prepared young people. As intelligent machines take over a growing array of routine business functions, the work left for persons involves increasingly less programmable tasks: those in which surprise and variability must be accommodated, where only someone with adaptive intelligence can make the evaluations and decisions needed. These economic and technological factors are visibly changing the job market, creating a broad awareness among Americans that their children need more and better education – an education that includes S.T.E.M.

Barrier 3 – Creating Collective Action – Working Collaboratively

> People who work together will win, whether it be against complex football defenses, or the problems of modern society.
>
> -Vince Lombardi

Collective action is the pursuit of a goal or set of goals by more than one organization or individual. In the case of developing a S.T.E.M. agenda, this means more than one group who has created a S.T.E.M. initiative is working to drive S.T.E.M. education forward. We live in a world where cooperation among diverse groups and organizations is essential to the successful deployment of large and sustainable efforts such as K-12 S.T.E.M. education reform. Collective action can be used as a tool to leverage the power of individual groups and initiatives currently working to improve S.T.E.M. education.

Clay Shirky, an expert on collective action, states that strong, long lasting results come from collaborative work where effort on the part of those taking action creates such synergy that decision-makers take notice. There are many tools and strategies available today to create collective action groups. One strategy is the creation of a coalition or alliance. A coalition/alliance is an association of individuals and groups that generally share a common set of values and objectives. These individuals or groups cooperate in joint action; each acts in their own self-interest while joining forces for a common cause.

Barrier 4 – Creating the Classroom Learning Environment

In addition to general public and policy barriers, there are challenges in S.T.E.M. education reform at the classroom level of implementation, including:

- Expectations of content coverage: If teachers feel they must cover too much material, they may forgo research-based methods that are geared toward engaged learning and offer an opportunity for deep understanding.
- Lack of teacher time: Teachers are sometimes too busy with large teaching loads or class sizes to have time to learn about and integrate new techniques (at the high school level, teachers can have up to 180 students on a given day, and at the elementary level, class loads can exceed 25 students in one room with at least five or six different content areas to be taught).
- Teaching norms of the school: Implementation is much more difficult if traditional methods are the norm and there are no local or school-based role models to follow or to be supportive. If there are role models, consistent support and advice are within reach; teachers will succeed in changing their teaching practices followed by gains in student achievement.
- Student resistance: Teachers are often met with resistance from students when they implement new teaching strategies; often, students are not prepared to think critically, communicate inventive ideas or collaborate on projects.
- Classroom size and room layout: Schools are often designed for lecture-style teaching and learning; many classrooms are small, sometimes having just enough room for desks. These cramped conditions make using best-practice methods that focus on hands-on learning, discussion groups, and inquiry hard if not impossible.
- Time structure: The school day is 'chopped up' in blocks for different subject areas, often leaving no more than 50 minutes to do a lesson. Additionally, at the elementary school level, schools - especially low-performing schools - often spend extra time focusing on remedial reading and don't provide adequate time for learning S.T.E.M.-related skills.
- Skills for teachers: As stated in an earlier section, the most direct route to improving S.T.E.M. education is through quality teaching and teachers who are qualified to teach math, science and S.T.E.M. classes. As discussed, the U.S. is facing a teacher shortage, most critically with S.T.E.M. teachers. Additionally, many of the current teaching staff across the U.S. lack the proper credentials to teach math or science. Finally, all teachers need S.T.E.M. professional development as the basis to improve and advance the character of science, technology, engineering and mathematics teaching regardless of grade level or subject area.
- Unintended consequences of NCLB: Less quality and quantity of math and science is being taught, K-12. The No Child Left Behind act (NCLB) is working precisely as designed. This is great in part, but not entirely. Recent studies by a University of Maryland professor and the Thomas B. Fordham Institute found that some unintended consequences of NCLB have occurred – ones that are worrisome for America's future competiveness. First, NCLB is narrowing the curriculum taught by limiting the time that school districts spend on non-tested subjects. In a report from the Center on Education Policy, 44% of school districts reported cutting time from subjects, including science, in order to devote more time to teaching remedial math and reading. Additionally, there are declines in teaching higher-order thinking, in the amount of time spent on complex assignments such as project-based learning, and in the actual

amount of rigorous content in the curriculum. This same professor found that these declines were attributed to the pressure teachers were feeling to "teach to the test."[38]

Barrier 5 – Student and Parent Attitudes

There are societal and cultural beliefs that mathematics, science, engineering, and technology are not for everyone. It is okay to say, "I'm no good at math (or science)," while it's not okay to say, "I am not a good reader."

Parents…

Many Americans believe that S.T.E.M. subjects, collectively and individually, are for only the bright and gifted students. Parents with kids between the ages of 5 and 18, in a survey conducted in 2009 by Penn, Schoen and Berland Associates, report that the topics of math and science are harder to discuss than drug abuse.[39] Additionally, it was also reported that while more than 50% of parents ranked math and science subjects as the most critical to their children's future success, they struggle talking to their kids about these subjects. The main reason cited for this difficulty is their own lack of understanding of these subjects. While parents recognize the importance of math and science, they are unable to engage with their children around them, due to limited understanding and scarcity of resources. Parents are not sure how to help their kids make the best choices, including taking math and science (S.T.E.M.) courses so they are prepared to succeed.

Parents recognize the importance of math and science education but are not sure how to support their child in these subjects.
Students' attitudes toward math and science and the related S.T.E.M. skills but lack an understanding about of them and the careers associated with S.T.E.M..
Penn, Schoen & Berland Associates - 2009

Students…

Student attitudes also play a significant role. According to a recent survey about teen attitudes toward S.T.E.M., students exhibit a renewed openness toward pursuing S.T.E.M. professions and show more interest in developing marketable S.T.E.M. skills. However, the survey also indicated that youths' lack of understanding of S.T.E.M. creates a serious obstacle. "Nearly two-thirds of teens indicated that they may be discouraged from pursuing a career in S.T.E.M. because they do not know anyone who works in these fields (31%) or understand what people in these fields do (28%)."[38]

Summary Remarks

Overcoming these barriers and developing a strong K-12 S.T.E.M. education for all students requires a multi-layered approach that includes input from government, school district, business, and industry leaders, as well as practitioners from the school and community. These constituent groups must collectively plan and develop strategies to address the barriers mentioned above; issues particular to each region, district, and school; and any other barrier they may face. These issues should be addressed at every level, especially the state level, to ensure consistent implementation of S.T.E.M. education policies and to increase the likelihood of successfully implementing quality K-12 S.T.E.M. education for all students.

Existing Programs that Support S.T.E.M. Education: Pacific Northwest & Alaska

> "*A thousand points of light is a wonderful thing. However, it is still dark on a starry night, and it takes a single blazing sun to make a bright day.*"
> - Terry C. Wallace, Jr., Los Alamos National Laboratory

Within the U.S., the volume of S.T.E.M. information and the number of initiatives is extensive. Each state is actively applying S.T.E.M. principles, from University research to stronger math and science standards and business/industry workforce development, and every state has something to showcase for strengthening their economy through S.T.E.M. education. The richness of programming and information, and partnerships among programs, industry, business and institutions, have strengthened S.T.E.M. progress. However, the majority of the work appears fragmented within most states and results aren't what they could be through more effective collaboration; there are many stars but no sun.

This section takes a closer look at efforts within those states "close to home." Hawaii and Washington, with their development of statewide S.T.E.M. coalitions, are especially effective case studies. (As a side note, California is just embarking on a concerted statewide effort of coalition building that will be worth watching.)

Washington and Hawaii's success in connecting individual initiatives and stakeholder groups forecasts a successful outcome for similar efforts elsewhere. In 2005, Hawaii formed a statewide alliance among the *Honolulu Advertiser*, the Maui Economic Development Board, Women in Technology Project and *isisHawaii*. Founders of the alliance recognized that it is necessary to unite in order to leverage individual strengths and align missions. Their primary intent was to improve the S.T.E.M. education-to-workforce pipeline throughout the state. A year later they began to see evidence of their work paying off. To document their progress and sustain dialogue regarding S.T.E.M. practices throughout the state, a S.T.E.M. newspaper tabloid entitled *S.T.E.M. Hawaii* was developed. *S.T.E.M. Hawaii* is still used as a forum for S.T.E.M. development in Hawaii.

Washington also emerges as a leader with its effort to create a statewide S.T.E.M. plan. This is not surprising, given the number of resources available in this state. According to Knoster and Villa, the following are crucial for the development of a S.T.E.M. plan: vision, skills, incentives, resources and action plan. Washington state has many of these key ingredients. *Partnership for Learning* is leading the charge in Washington. Like the Hawaiian alliance, this organization recognizes that many stakeholder organizations with S.T.E.M. initiatives could be stronger if they worked in unison. The mission of *Partnership for Learning* is to help fill the existing gap for promising practices not fully scaled or integrated into an overall S.T.E.M. framework. There are other statewide initiatives in Washington as well; however, it is not apparent what, if any, connection they have to the *Partnership for Learning*'s work. LASER (Leadership Assistance for Science Education Reform), for example, is another organization with a statewide focus in Washington. LASER is a set of ten statewide alliances supporting school districts with training and technical support. Each statewide alliance is comprised of members from various educational and scientific institutions (e.g., Office of Public Instruction, Institute for Systems Biology and Pacific Science Center). A third organization is the Washington

State S.T.E.M. Education Foundation (WSSEF). WSSEF was created to build a statewide network "to share their stories and best practices for enrichment of the entire educational system." Washington state department of education also commissioned an agency to produce a document containing the state activities related to S.T.E.M., no matter how big or small. In August of 2008, Clark College and the Southwest Washington Workforce Development Council published a document outlining work in the Southwestern portion of the state as well. The work of these states should be considered as Alaska moves forward in their own S.T.E.M. education work.

Alaska's S.T.E.M. activity is occurring at the university level, within pockets at the high school level, in private organizations, in economic development councils and through workforce development efforts. There are also many more efforts that do not necessarily connect themselves directly with S.T.E.M. Alaska does not have a statewide mission or overall framework for S.T.E.M. education. These connections could easily be made if statewide S.T.E.M. coalition building were the goal. There are good things happening, nonetheless; S.T.E.M. initiatives are reaching K-12 education and workforce development programs. Some noteworthy initiatives are described below. These efforts should be used as models to move S.T.E.M. development forward throughout Alaska. They are each important parts of an overall framework that can help the state bring S.T.E.M. practices to full-scale implementation.

1. *Alaska Native Science & Engineering Program (ANSEP)* - ANSEP, housed at UAF, is a strong and ever-growing program, just recently accepting $4.4 million from the Rasmuson Foundation to create the Herbert P. Schroeder Endowment. The funds provide a bright future for this S.T.E.M. initiative. ANSEP works with a range of students, from freshman year of high school to those finishing graduate school. The goal is to increase university recruitment and retention rates through hands-on high school outreach programs, summer programming, focused and supportive academic learning communities, student cohorts and internships. ANSEP proudly points out that in May 2008, the University of Alaska graduated the largest number of Alaska Native engineering and science students in its history.

2. *Alaska Process Industry Careers Consortium, University of Alaska Anchorage, AK Department of Education and Early Development and AK Department of Labor form Partnership* – On November 17, 2009 these united partners signed an Engineering Academics Memorandum of Understanding. The plan is to develop and support access to engineering academies for public high school students in Alaska. The initiative hopes to build a pipeline of qualified Alaskans to enter S.T.E.M. career fields.

3. *Avant-Garde Learning Foundation* – an Alaska non-profit focused on transforming education and helping schools improve science education in Alaska—and, in turn, helping students succeed. This science initiative is funded by Shell Oil and includes partnerships with the National Science Resource Center and other Alaska-based science organizations. Since the inception of this initiative numerous school districts have been supported with teacher training and systemic systems support for quality research-based science programming.

4. *Anchorage, Juneau, Palmer, Soldotna High Schools using Project Lead the Way (PLTW)* **-** Project lead the way is a national educational program that promotes science and engineering for middle and high school students. PLTW utilizes a project-based learning philosophy where students engage in hands-on, real-world projects and discover how the skills they learn are applied in everyday life. PLTW's primary goal is to increase the number of students who pursue or graduate with degrees in engineering and engineering technology. PLTW is also committed to providing leadership for the continuous improvement and innovation in S.T.E.M. programs. One of its major hallmarks is its commitment to teacher and counselor professional development.

5. *Juneau Economic Development Council (JEDC)* – JEDC has taken an important leadership role both regionally and statewide to promote S.T.E.M. K-12 education beyond the school day and school year. JEDC provides numerous S.T.E.M.-related programs to Alaska's youth. SpringBoard, a statewide partnership with the US Department of Defense, has helped JEDC bring to the state of Alaska valuable resources that work to promote new businesses and to diversify the economy. These funds have been utilized to provide statewide programs such as First LEGO League. First LEGO League competitions are held throughout the U.S., including Alaska, for students grades K–12. JEDC has also organized numerous other S.T.E.M.-related events that provide an active, hands-on learning approach for both our youth and our educators alike. Some of the programs offered to date include: summer programs for students in middle and high school, *Girls Rock Science!*, and teacher/professional development programs such as SeaPerch and CryoConn. Each year new and improved programs have been developed to meet the current needs of schools and districts.

In summary, statewide S.T.E.M. initiatives consist of literally thousands of programs spread across dozens of agencies in basically every state. Programs do not seem know about one another nor do they consistently communicate with each other causing a lack of forward systemic movement. Additionally, some of the initiatives do not have sufficient resources to move forward. Finally, not all initiatives possess a defined action plan. Despite these shortcomings, each state has successes or *pockets of excellence*. These pockets of excellence are essential however to the development of new initiatives. They provide evidence of programmatic or organizational adaptability necessary for success. They also provide a resource to develop efficiencies and opportunities as a means to enhance S.T.E.M. education. States that have been most successful in moving entire school systems and states forward have employed statewide strategies such as alliance/coalition development.

Future Direction Recommendations - Alaska

The future well-being of Alaska and its citizens depends on *how well we educate our children and youth*. The global economy, the fast pace of technological innovation, and the need for a highly skilled workforce demand that we prepare our youth with advanced thinking, reasoning, and problem solving skills.

The 21st century economy requires more from the average worker. More than ever, knowledge and skills in S.T.E.M. are linked to economic and professional success. No longer will basic arithmetic and a familiarity with a few scientific facts be enough to get ahead – and stay ahead – either in college or in the workplace. Basic skills, while still important, will not be enough for students or young professionals to become productive and informed citizens – whether in Alaska or elsewhere in the U.S.

If Alaska is to keep pace, it is imperative that we provide for our youth a proper S.T.E.M.-based education. These are huge challenges that provide great opportunity. Following are five recommendations to achieve success in the face of these challenges.

Recommendation 1

(A) Conduct a comprehensive needs assessment to determine Alaska's projected need for a S.T.E.M.-educated workforce versus postsecondary and workplace expectations. (B) Highlight the gaps that exist in these areas.

CONFRONTING REALITY

Policymakers and state residents do not have access to important information about the courses students take in high school, as well as 8th graders' performance in writing and science, because the state declined to participate in the national survey and assessments.

Measuring Up: The National Report Card on Higher Education[40]

Recommendation 2

Develop a comprehensive multi-year public awareness campaign focused on the importance of S.T.E.M. education to prepare all students for future jobs and opportunities, as well as to foster innovation for the state's future economic success. Key to this will be the development of community-based and statewide partnerships to improve S.T.E.M. education.

CONFRONTING REALITY

Research has shown that a powerful predictor of whether high school students will graduate and earn a college degree is the rigor of the high school curriculum they complete. Advanced Placement (AP) exams are one indicator of rigor in a high school curriculum. Indicative statistics showing rigor or lack thereof include:

- 9% of Alaska's students took an AP exam.
  American Diploma Project Network January 2008[41]
- 45% of Alaska's high school graduating students go to college, and about 7% graduate from college within six years.

NCHEMS Information Center for Higher Education Policy Making and Analysis[42]

- 75% of University of Alaska's incoming freshmen are not prepared to do college-level math and English (science data not available).

  University of Alaska Research Summary – May 2008[43]

Recommendation 3

Expand and improve opportunities for students to take high-quality mathematics, science and S.T.E.M. courses as part of regular coursework and provide other opportunities beyond the school day or year. Programs should start at an early age and continue throughout middle and high school and be aligned with the expectations of postsecondary education and the workplace. Develop systems for qualitative evaluation and the dissemination of this data.

CONFRONTING REALITY

- The State of Alaska requires two years of math and science. Local standards vary and can exceed the state's requirement, but cannot be less. Additionally, few of Alaska's high schools require higher-level technology and engineering courses or offer them as electives.

  Department of Education Website: http://www.eed.state.ak.us/ [44]

- Few of Alaska's high school graduates are ready for first year college math and science. 44% are ready for college level Math and 28% are prepared for science courses.

  ACT 2009 Profile Report for the state of Alaska[45]

Recommendation 4

Invest in current and future teachers through high quality and sustainable professional development in math and science education as well as in S.T.E.M. literacy.

Teacher quality is the single most important factor influencing gains in student achievement – an influence greater than race, poverty, parents' education, or any other factor associated with learning.[46] It is imperative that Alaska improves the quality of math, science and S.T.E.M. teaching, and that it attracts and retains an adequate supply of high quality teachers in both urban and rural areas.

CONFRONTING REALITY

- Research confirms that an effective teacher has the single greatest effect on improving student performance. Conversely, the impact of having three ineffective teachers in a row can be devastating to a student's subsequent achievement.

  W.L. Sanders and J.C. Rivers[47]

- Teacher Quality Indicators for Alaska:
  - 15% of Alaska's middle-level science teachers and 20% of math teachers are certified in that content area
  - 16% of high school chemistry teachers earned main certification in chemistry
  - 44% of high school math teachers have their main certification in math

  Alaska K-12 S.T.E.M. Ed. Report Card 2010, www.S.T.E.M.edcoalition.org[48]

Recommendation 5

Develop meaningful and sustainable collaborations between K–12 schools, business, industry, and postsecondary institutions to align expectations. Strengthening partnerships between these entities will provide Alaska with strong network that ensures students are prepared for work and/or college upon high school graduation.

Cooperation can enhance Alaska's prosperity and help businesses meet both immediate and long-term needs, while the ultimate beneficiaries of these alliances are the students—for whom collaboration means improved career opportunities and a stable state economy.

CONFRONTING REALITY

- Alaska's employment is projected to grow by 14% between now and 2016. This is an increase of nearly 44,000 jobs, most requiring S.T.E.M. skills.

  Alaska Economic Trends: "2006-2016 Occupational Forecast", January 2009 [49]

- 20% of Alaska's wage and salary workers are non-residents who commute to work in Alaska in a variety of occupations, including engineering, healthcare and information technology.

  Alaska Economic Trends: "2006-2016 Occupational Forecast"[50] *& January 2009. Alaska's Strategic State Plan 2007-2009* [51]

- By 2016, 61% of Alaska's jobs will require middle- and high-level S.T.E.M. skills. More than a high school diploma is needed to compete for these jobs.

  Alaska Economic Trends: "2006-2016 Occupational Forecast", January 2009[52]

- Alaska's high school graduation rates and college attendance rates are among the lowest in the nation – and even lower percentages pursue S.T.E.M.-related careers.

  ACT's 2006 report: Developing the S.T.E.M. Education Pipeline[53]*, American Diploma Project Network January 2008*[54]*, University of Alaska Research Summary 2008*[55] *& NCHEMS Information Center for Higher Education Policy Making and Analysis*[56]

- Per capita income of U.S. workers is projected to decline IF education doesn't improve. If current trends continue, the proportion of workers with high school diplomas and college degrees will decrease and the per capita personal income of Americans will decline over the next fifteen years.

  Issue Paper from the Secretary of Education's Commission on the Future of Higher Education [57]

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Thanks to the Department of Defense for support of the SpringBoard program of the Juneau Economic Development Council. The views and information expressed in this report do not necessarily reflect those of the Department of Defense and are the responsibility of the Juneau Economic Development Council and our consultant.