



INNOVATE

A Blueprint for Science, Technology, Engineering, and Mathematics in California Public Education

A report by State Superintendent of Public Instruction Tom Torlakson's STEM Task Force

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CALIFORNIA
DEPARTMENT OF
EDUCATION

TOM TORLAKSON
STATE SUPERINTENDENT OF PUBLIC INSTRUCTION

Fellow Californians:

One of my first acts as State Superintendent of Public Instruction was to convene a team of teachers, parents, and business, labor, and community leaders to candidly assess where we are, set ambitious goals about where we want to be, and describe in some detail a shared vision for how to get there. That team worked together and created *A Blueprint for Great Schools*. The recommendations from that report led to a closer look at key concerns facing California public education: civic education, educator excellence, education technology, schools of the future, and science, technology, engineering, and mathematics (STEM).

Assemblywoman Susan Bonilla and I convened California's first STEM Task Force for kindergarten through grade twelve. The 54-member task force brought together classroom teachers, district and school administrators, leading academics, the state's business community, and legislative representatives. To lead this effort, I chose two authorities on STEM education: Dr. Herb Brunkhorst, chair of the department of science, mathematics, and technology education at California State University, San Bernardino; and Dr. Susan Hackwood, a professor of electrical engineering at the University of California, Riverside, and executive director of the California Council on Science and Technology.

We charged them with three tasks. First, explore the status of STEM education in curriculum, instructional practices, professional learning, student testing, existing resources, and community and business partnerships. Second, assess the state's future needs. Third, recommend a blueprint on how to improve teaching, learning, and access to STEM-related courses and careers for students in kindergarten through grade twelve.

The report provides readers with the opportunity to consider the recommendations and take action to put in place a cohesive STEM education system that produces exceptional results and exceptional students. The recommendations are intended for all students, not for a select few. Implementation of the recommendations must address English learners and students with special needs, including academically advanced students.

As with *A Blueprint for Great Schools*, the recommendations of the STEM Task Force are sobering. They reflect how diminished resources, difficult circumstances, and shifting policy choices over the years have diminished the opportunities for all students at all grade levels to benefit from science, technology, and engineering education.

The introduction to the report includes the task force's definition of STEM education and the difficulties the task force faced in defining STEM education. Faced with the same dilemma as others who have tried to define STEM education, the task force decided that the definition was not as important as providing the guiding principles or characteristics that would distinguish STEM education in California from STEM education in other states.

There is also cause for great hope and optimism for STEM education. Many sound strategies are proposed in the report and hold great promise for our students, educators, and schools—including ones that have already proven effective in California. Some areas need further study, discussion, and debate and would require, in some cases, changes in law to carry out. Others merely need nurturing and support to achieve lasting results.

The recommendations of the task force are invigorating and inspiring. Some may take longer to accomplish than others. But together, they offer a vision of what STEM education can be in California.

This report was not written to sit on a shelf. It is imperative that it become a plan of action, unifying us with focus and purpose. We must invest our very best thinking, our very best efforts, and—above all—our very best people in improving the quality and level of STEM education in California public schools. We need to do so for the future of our students, their schools, and the economic future of California.

A STEM education is not only about the future, it is about today. Over the past 10 years, growth in jobs involving STEM fields was three times greater than that of non-STEM occupations. STEM jobs are expected to continue to grow at a faster rate than others in the coming decade. STEM-related industries are a major economic component of California's economy. It is important that California's students have access to courses that prepare them for postsecondary education and careers in STEM. Students and teachers in the twenty-first century must have the skills and abilities today to succeed.

Sincerely,

A handwritten signature in black ink that reads "Tom Torlakson". The signature is written in a cursive, flowing style.

Tom Torlakson
State Superintendent of Public Instruction

A Message from Assemblywoman Susan Bonilla

Dear Colleagues,

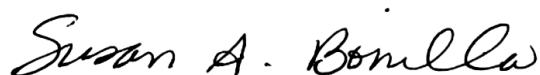
Thank you very much for your time, work, and willingness to share ideas to create *Innovate: A Blueprint for Science, Technology, Engineering, and Mathematics Education in California Public Education*.

I would like to commend State Superintendent of Public Instruction Tom Torlakson for his leadership in ensuring the success of all California students. From his work on bringing together teachers, students, parents, and labor and business leaders to create *A Blueprint for Great Schools* to spearheading the STEM Task Force, Tom is doing an incredible job of bringing all available resources to our students.

When the STEM Task Force convened on May 24, 2012, it was quite an honor to participate in discussions and conversations with task force members. The following report demonstrates the commitment, partnership, and great collaboration of the task force members. My Select Committee on Increasing the Integration of Science, Technology, Engineering and Math in Education in California K–14 Schools will carry on your efforts and continue to work with all of you to ensure the successful integration of STEM curriculum in every school in California.

The STEM Task Force report and its recommendations can become the catalyst for greater partnerships for student success. Together, we will strengthen California's position as the global leader for creating the technological products, systems, and services that will sustain our health, security, and economic prosperity.

Sincerely,

A handwritten signature in black ink that reads "Susan A. Bonilla". The signature is written in a cursive style with a small dot above the letter 'i' in "Bonilla".

Susan A. Bonilla
Assemblywoman, 14th District of California

EXECUTIVE SUMMARY

STEM EDUCATION IN CALIFORNIA

To be successful, California's efforts to improve schools and raise student achievement must include advancing our students' understanding of STEM: science, technology, engineering, and mathematics. Through STEM education, students learn to become problem solvers, innovators, creators, and collaborators and go on to fill the critical pipeline of engineers, scientists, and innovators so essential to the future of California and the nation. Recognizing both the urgency of the state's need to improve support for STEM teaching and learning and the unprecedented opportunities emerging from the current renaissance in public education, the STEM Task Force calls upon policy makers, business leaders, philanthropists, educators, and all Californians to take the actions necessary to realize this future vision:

California leads the world in STEM education, inspiring and preparing all of its students to seize the opportunities of the global society through innovation, inquiry, collaboration, and creative problem solving.

Fortunately, as this report is being written, California is in the midst of significant, positive educational change that has the potential for supporting major advances in STEM education, including: the implementation of the Common Core State Standards (CCSS), the forthcoming implementation of the Next Generation Science Standards (NGSS), the transition to a student assessment system aligned with the new content standards, the new Career Technical Education standards, and the innovation made possible through the implementation of the Local Control Funding Formula (LCFF). Taken together, these efforts provide a unique and unparalleled opportunity to enhance STEM education in California. When considered in conjunction with the accelerating demands for a skilled STEM workforce in our state and the nation, the economic and social imperatives for providing high-quality STEM education become self-evident.

STEM education includes four specific disciplines—science, technology, engineering, and mathematics—in an interdisciplinary and applied approach. But STEM is far more than this and is best viewed in terms of its attributes, which transcend the four disciplines. STEM teaches and trains students to engage in critical thinking, inquiry, problem solving, collaboration, and what is often referred to in engineering as design thinking. These stand out as skills that all students, workers, and Californians will need to be successful in college, career, and life.

As a core requirement for careers in some of the fastest-growing industries, STEM is closely linked with our nation's economic strength in the global economy. Scientists, technologists, engineers, and mathematicians are largely responsible for creating the products, systems, and services that support our health, security, economic prosperity, and quality of life. To ensure that the nation and, more specifically, California, continue to fill the demand for technically skilled workers and innovators in all fields of work, California must embrace STEM teaching and assessment practices, curriculum, and policies that expand STEM opportunities for all California students.

THE STEM TASK FORCE: PRIMARY RECOMMENDATIONS

The California STEM Task Force was charged by California State Superintendent of Public Instruction (SSPI) Tom Torlakson and Assemblywoman Susan Bonilla with drafting a new vision and direction for STEM education in the state, paying particular attention to remedying issues of access to high-quality learning experiences and professional STEM workforce needs. The task force, made up of teachers and administrators from K-12 and higher education as well as leaders of partner organizations, explored the current status of STEM education, assessed the state's future needs, and developed recommendations for improving teaching, learning, and access to STEM-related courses and careers for K-12 students.¹ This report details the results of the task force's work and calls upon California's policy makers and educators to ensure the realization of seven strategic action areas:

1. **Public Awareness:** Create a broad-based campaign to convey the importance of STEM education and ensure the availability of sufficient resources and public support to realize the vision for STEM education in the state.
2. **Resources:** Increase resources for STEM learning from all stakeholders (government, business, communities) through additional and reallocated government funding, in-kind support, multi-sector participation, philanthropy, and innovative public/private partnerships.
3. **Access:** Make access to high-quality STEM experiences and programs universal to all K-12 students through a variety of opportunities in school, expanded learning, and community partnerships through informal, formal, and digital pathways.
4. **Framework:** Establish a K-12 STEM framework for teaching and learning that identifies the sequence of STEM knowledge, skills, and attitudes toward developing college, career, and life readiness skills and that aligns with the CCSS, NGSS, and associated curriculum frameworks.
5. **Professional Learning:** Adopt policies and standards for quality STEM professional learning, development, and training to guide support systems at the state, regional, and local levels.
6. **Assessment and Accountability:** Integrate STEM into assessment and accountability systems in a cohesive, meaningful, and innovative fashion, taking advantage of the entire suite of assessment tools available to, and under development by, the state and LEAs at this time.
7. **Guarantee the Availability of High-quality STEM Educational Materials and Resources:** Ensure that state, regional, and local STEM programs can identify and access excellent learning resources.²

Supporting students' development of key STEM competencies is central to our state's future economic and social vitality, contributing to innovation, economic development, and competitiveness in the global economy. Perhaps more importantly, the STEM competencies of active problem solving, open inquiry, experimentation, collaboration, and dialogue help ensure an open and just society. California has long been recognized as a leader in STEM innovation, and it is now time for California to lead the nation in advancing STEM education. To do so, we must rapidly mobilize the necessary statewide political and social will to make high-quality STEM education for all students a reality.

1. STEM EDUCATION IN THE UNITED STATES AND IN CALIFORNIA: THE CONTEXT

“STEM is gaining increasing attention and support at both federal and state levels, for a number of reasons. First, the nation needs to increase the number of experts in STEM fields to drive innovation and keep the country competitive in the global economy. ‘If America is going to compete for the jobs and industries of tomorrow, we need to make sure our children are getting the best education possible,’ said President Obama recently. Second, the U.S. needs STEM-literate citizens who are knowledgeable enough in STEM subjects to understand, assess, and interpret basic data reported in the news and make informed choices in the marketplace. Third, the U.S. Department of Commerce reports that business and industry do not have enough candidates to fill key jobs in STEM fields, and they are resorting to hiring candidates from other countries to fill these positions” (White House Office of the Press Secretary, 2012).

1.1 DEFINING STEM EDUCATION

In the 1990’s the National Science Foundation united science, technology, engineering, and mathematics and created the STEM acronym—a strategic decision made by scientists, technologists, engineers, and mathematicians to combine forces and create a stronger political voice. STEM education, however, is much more than a convenient integration of science, technology, engineering, and mathematics; it is an interdisciplinary and applied approach that is coupled with real-world, problem-based learning. STEM education integrates the four disciplines through cohesive and active teaching and learning approaches. We now understand that these subjects cannot and should not be taught in isolation, just as they do not exist in isolation in the real world or the workforce.

The Four STEM Disciplines Described

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, and conventions associated with these disciplines. Science is both a body of knowledge that has been accumulated over time and a process—scientific inquiry—that generates new knowledge. Knowledge from science informs the engineering design process.

Technology, while not a discipline in the strictest sense, comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves. Throughout history, humans have created technology to satisfy their wants and needs. Much of modern technology is a product of science and engineering, and technological tools are used in both fields.

Engineering is both a body of knowledge—about the design and creation of human-made products—and a process for solving problems. This process is design under constraint. One constraint in engineering design is the laws of nature, or science. Other constraints include time, money, available materials, ergonomics, environmental regulations, manufacturability, and reparability. Engineering utilizes concepts from science and mathematics as well as technological tools.

Mathematics is the study of patterns and relationships among quantities, numbers, and space. Unlike in science, where empirical evidence is sought to warrant or overthrow claims, claims in mathematics are warranted through logical arguments based on foundational assumptions. The logical arguments themselves

are part of mathematics along with the claims. As in science, knowledge in mathematics continues to grow, but unlike in science, knowledge in mathematics is not overturned, unless the foundational assumptions are transformed. Specific conceptual categories of K-12 mathematics include numbers and arithmetic, algebra, functions, geometry, and statistics and probability. Mathematics is used in science, engineering and technology.

Source: Adapted from National Academy of Engineering and National Research Council, 2009.

STEM Further Defined by Competencies

While the STEM disciplines above define categories of knowledge, STEM is equally defined by learning strategies and competencies. It is strongly associated with skills, abilities, work interests, and work values (Carnevale, Melton, and Smith, 2011). Skills include foundational content skills, such as mathematics; processing skills, such as critical thinking and self-awareness; and problem solving skills, such as evaluating options and implementing solutions. Abilities are defined as enduring personal attributes that influence performance at work, such as creativity, innovation, reasoning, and oral and written communication. Work values are individual preferences for work outcomes, such as recognition, responsibility, or advancement. Work interests are defined as individual preferences for work environments such as environments that are artistic, enterprising, or conventional. There is a growing demand for these competencies throughout today's economy beyond the traditional STEM occupations, highlighting the importance of implementing a broad STEM strategy across K-12 education in America (Carnevale et al., 2011).

Moreover, readiness for a career in STEM is more than skills, abilities, work interests, and work values. It is a convergence of these with self-knowledge, adaptability, and a commitment to lifelong learning that make students ready to "*achieve a fulfilling, financially-secure and successful career*" in an "*ever-changing global economy*" (Career Readiness Partner Council, n.d.).

Defining STEM Education for California

One of the first assignments the STEM Task Force undertook was the development of a definition of STEM education for California. Many educators know what STEM stands for, but few may have thought much about what it means (Gerlach, 2012). A definition proposed by Tsupros, Kohler, and Hallinen (2009) refers to STEM as an interdisciplinary approach to learning in which rigorous academic concepts are coupled with real-world lessons. Students apply science, technology, engineering, and mathematics in contexts that connect school, community, industry, and the global enterprise, enabling the development of STEM literacy and, with it, the ability to compete in the new economy. At the K-12 levels, STEM has focused, to date, on science and mathematics; technology and engineering have not been prominent in the curriculum. At the undergraduate level, STEM education has focused on the knowledge, skills, and aptitudes in the fields of science, technology, engineering, and mathematics. In the career and technical education field, it has focused on workforce development issues. Research has also demonstrated a strong correlation between success in the arts and success in STEM. A major challenge of the task force was, therefore, to begin to clarify what the STEM acronym actually means for K-12 educational policies, programs, and practices in the state of California.

In an attempt to capture the spirit of both the education and workforce communities, the task force developed the following definition:

K-12 STEM education encompasses the processes of critical thinking, analysis, and collaboration in which students integrate the processes and concepts in real world contexts of science, technology, engineering, and mathematics, fostering the development of STEM skills and competencies for college, career, and life.

STEM Literacy

Rodger Bybee's seminal article, *Advancing STEM Education: A 2020 Vision*, clearly articulated the basis for STEM education planning, noting, "Now is the time to move beyond the slogan and make STEM literacy for all students an educational priority" (Bybee, 2010, p. 31).

In keeping with Bybee's vision, several policy, government, and educational groups have worked to identify specific goals for STEM education. These include the National Research Council Committee on Highly Successful School or Programs for K-12 STEM Education, 2011; The California Space Education and Workforce Institute, 2011; The Alliance for Regional Collaborations to Heighten Educational Success, 2008; and the California STEM Learning Network, 2013. Generally, these goals have been divided into either **educational goals**, such as increasing the STEM proficiency of all students, or **workforce goals**, such as expanding the number of students entering postsecondary education and the STEM workforce. Both sets of goals are intended to enhance the global competitiveness of the U.S. economy and help Californians achieve economic security.

A number of professional organizations in STEM have developed working definitions of STEM literacy in each of their content areas, while acknowledging the integrated and interrelated nature of STEM education. The National Governors Association, the College Board, Achieve, Inc., and STEM professional organizations have recommended ways to demonstrate the connections between STEM domains:

- **Scientifically literate** students use scientific knowledge not only in physics, chemistry, biological sciences, and earth/space sciences to understand the natural world, but they also understand the scientific need for existing and new technologies, how new advances in scientific understanding can be engineered, and how mathematics is used to articulate and solve problems.
- **Technologically literate** students understand that technology is the innovation with or manipulation of our natural resources to help create and satisfy human needs and also to learn how to obtain, utilize, and manage technological tools to solve science, mathematics, and engineering problems.
- **Students who are literate in engineering** understand how past, present, and future technologies are developed through the engineering design process to solve problems. They also see how science and mathematics are used in the creation of these technologies.
- **Mathematically literate** students not only know how to analyze, reason, and communicate ideas effectively; they can also mathematically pose, model, formulate, solve, and interpret questions and solutions in science, technology, and engineering.

Through problem/project-based learning situations, students weave together and communicate their understanding of STEM concepts. Concepts that were once taught in isolation become tangible and relevant to their daily lives. Integrated approaches to K-12 STEM education in the context of real-world issues can enhance motivation for learning and improve student interest, achievement, and persistence. These outcomes have the potential to increase the number of students who consider pursuing a STEM-related field.

1.2. STEM IN SOCIETY

The future needs of global business and industry are evolving dramatically. According to the U.S. Bureau of Statistics (2013), STEM jobs are expected to grow over the next five years by 21.4 percent (versus 10.4 percent growth in the overall job market). Even students who do not seize the STEM jobs of the future will be asked to evaluate and vote on complex issues that require strong scientific competence. They will also be consumers of ever more-sophisticated technologies.

The growth of jobs in California requiring STEM proficiency is on the rise. In California in 2012, there were approximately five people searching for every available job. Meanwhile, there were 1.5 STEM jobs available for every job seeker (Change the Equation, 2012). Workers with STEM skills are scarce across the entire economy and too many workers lack the competencies necessary for success in the current and future labor market (Carnevale, Smith, and Strohl, 2010). By 2018, it has been estimated that 92 percent of traditional STEM jobs will require at least some postsecondary education and training. Close to two-thirds of STEM job openings will require bachelor's degrees or above (65 percent). By 2018, the remaining roughly 35 percent of the STEM workforce will consist of those with sub-baccalaureate training, including 1 million associate in arts degrees, 745,000 certificates in related fields, and 760,000 industry-based certifications (Carnevale et al., 2010).

While the demand is growing, research has clearly established that students in the United States are not adequately prepared for these jobs and responsibilities. Data from the Programme for International Student Assessment, collected by Organisation for Economic Co-operation and Development, confirms that students in the United States are less proficient in science than many of their worldwide counterparts.³ In an international exam given to 15 year-old students, the United States performed below average in mathematics in 2012 and ranked twenty-sixth out of thirty-four countries. The United States ranked seventeenth in reading and twenty-first in science. While the U.S. spends more per student than most countries, this does not translate into better performance. The U.S. also has a below-average share of top performers. Students in the United States have particular weaknesses in performing mathematics tasks with higher cognitive demands, such as taking real-world situations, translating them into mathematical terms, and interpreting mathematical aspects of real-world problems (Organisation for Economic Co-operation and Development, 2012).

As a result of these weaknesses, California employers often rely on foreign-born workers to fill available STEM jobs. Foreign-born workers account for 17 percent of all United States STEM workers, compared with 12 percent in the labor force as a whole (Carnevale, Rose, and Hanson, 2012).

According to an annual report by American College Testing (ACT), the college admissions testing company, more female high school test takers indicate an interest in STEM careers than their male counterparts (ACT, 2013). This interest, however, does not translate into STEM-related degrees once they are in college. Although women are more likely to hold a college degree than men, they are less likely to have studied in a field that would prepare them for STEM careers. In engineering, only 15 percent of degree holders are women (Buttice and Rogers, 2013). By graduation, men outnumber women in most science and engineering fields; in some fields, women earn only 20 percent of the bachelor's degrees (National Science Board, 2010).

African Americans and Latinos are also underrepresented in STEM occupations, relative to their share of the workforce. In 2011, African Americans made up 11 percent of the workforce, and Hispanics 15 percent. However, their representation in STEM fields were 6 and 7 percent, respectively (Landivar, 2013). National organizations like the Association for the Advancement of Science and the National Science Foundation place high priority on diversifying the nation's STEM workforce, while acknowledging the deep issues that must be confronted (George, Neale, Van Horne, and Malcom, 2001).

1.3. ACCESS TO STEM IN CALIFORNIA LEARNING ENVIRONMENTS

Many of California's students lack consistent access to high-quality STEM education. Although the importance of STEM learning has been widely acknowledged, several factors have limited access to STEM education: the focus on English language arts and skill-based mathematics required by No Child Left Behind; insufficient focus on science as well as on STEM education in the classroom; lack of access to high-quality STEM materials and instruction; insufficient opportunities for students to engage in hands-on, inquiry based learning; and insufficient professional preparation by teachers at all levels. These factors are discussed in the chapters that follow.

California's population is highly diverse, yet it is known that students living in poor urban or rural areas and many students from underrepresented groups lack access to high-quality STEM education. This has resulted in lack of proficiency that disproportionately impacts students of color.

The state has not closed the persistent achievement gap among racial and ethnic groups in math and science. Eighth graders in California have made gains in **mathematics** on the 2013 National Assessment of Educational Progress (NAEP), also known as "the nation's report card."⁴ Most students have far to go to reach a score of 299, NAEP's cutoff for "proficient" performance. The average score for all students was 273, for African American students 258, and for Hispanic students 263 (NAEP, 2013).

On the grade 8 NAEP science assessment, only 22 percent of California students tested proficient or above, and 47 percent tested below basic in **science**. In 2011, 39 percent of white eighth graders reached the proficiency level in **science** while only 8 percent of African American students and 11 percent of Hispanic students reached that level (NAEP, 2013).

One consequence of California's lack of access to STEM education for all students is that the STEM workforce does not reflect the demographics of the state. This is also true at the national level; minorities continue to be underrepresented in STEM occupations relative to their position in the labor market as a whole.

1.4. STEM AND THE CHANGING LANDSCAPE OF LEARNING AND ASSESSMENT IN CALIFORNIA

The current confluence of groundbreaking educational movements in California—the adoption and implementation of the Common Core State Standards, the adoption of the Next Generation Science Standards, the transition to a new statewide assessment system, changes in Career Technical Education Standards, and the innovation made possible through the Local Control Funding Formula—combine to provide a unique and unparalleled opportunity for furthering STEM education and excellence.

Adoption and Implementation of the Common Core State Standards

The Common Core State Standards (CCSS) for English language arts and mathematics, adopted by the California State Board of Education in August 2010, describe what students are expected to learn in each grade or course for both subjects, as well as what students are expected to learn to demonstrate literacy in history, social science, and other technical subjects. Since 2010, forty-four states have adopted the CCSS for English language arts and math. This consistency helps all students prepare for college and career, even if they change schools or move to a different state. Teachers, parents, and education experts designed the standards to prepare students for success in college and the workplace, and the new content standards focus on understanding and abilities rather than knowledge and information recall.

California Career Technical Education and English language development (ELD) standards are also aligned with the CCSS. This facilitates access as well as integration and articulation across subject matter, grade levels, and

secondary school departments and ensures that English language learners are not marginalized and are able to participate in mainstream educational offerings.

Adoption of the Next Generation Science Standards

The Next Generation Science Standards (NGSS), adopted by the State Board of Education in 2013, reflect how science is done in the real world through Scientific and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. The NGSS integrate science, technology, and engineering throughout the K-12 curriculum and correlate with the CCSS in English language arts and mathematics. Implementation of the NGSS in California is scheduled in three phases: 1) Awareness (2013-2015); 2) Transition (2015-2016); and 3) Implementation (2016-2017).

The NGSS will bring science instruction up-to-date by emphasizing a deeper focus on incorporating science and engineering practices, and applying crosscutting concepts within and across the scientific disciplines of Earth and Space, Life, and Physical Science. The NGSS also provides a coherent progression of learning from kindergarten through grade 12, so students learn step-by-step the knowledge and skills they need for college and careers. State Board of Education president, Mike Kirst, emphasized the importance of the NGSS adoption, *“The Next Generation Science Standards represent a huge leap forward for California’s students and our schools. Scientific innovation remains at the core of the California economy, and schools play a huge role in equipping the workforce of tomorrow”* (California Department of Education, 2013).

Transitioning to a Future Statewide Assessment System

AB 484 (Bonilla), signed into law on October 2013, establishes California’s new student assessment system, now known as the California Assessment of Student Performance and Progress (CAASPP), which replaces the Standardized Testing and Reporting (STAR) Program. CAASPP will better integrate teaching, learning, and assessment by providing teachers and schools access to a full suite of assessments, including both summative and interim assessments and formative tools through the new Smarter Balanced assessment system. In addition to providing annual summative assessments, this system will provide teachers with actionable information and resources to help guide instruction on an ongoing basis. The provisions of AB 484 took effect on January 1, 2014, with field-testing conducted in Spring 2014.

Through an assessment system that builds on the CCSS and NGSS as its foundation, California will be able to assess student achievement in a way that is substantially different from approaches used in the past. The CCSS will not only be incorporated into curriculum and instruction; they will be at the core of the CAASPP. Through the Smarter Balanced Assessment Consortium, California is developing and field-testing a cohesive and adaptable assessment program, which highlights building and assessing critical thinking skills, aligning closely with the desired STEM attributes. Assessments for the NGSS will build on the success of the Smarter Balanced assessments and also include performance tasks that would assess students on knowledge and skills used to address complex, real-world scenarios.

Adoption and Implementation of the Local Control Funding Formula

The 2013-14 California budget replaces the previous K-12 finance system with a new Local Control Funding Formula (LCFF). For school districts and charter schools, the LCFF creates base, supplemental, and concentration grants in place of most previously existing K-12 funding streams, including revenue limits and most state categorical programs.

As part of the LCFF, school districts, County Offices of Education, and charter schools are required to develop, adopt, and annually update a three-year Local Control and Accountability Plan (LCAP), beginning on July 1, 2014, using a template adopted by the California State Board of Education. State priorities on the LCAP template include

“Implementation of State Standards,” which now include the NGSS and CCSS as well as “Conditions for Learning: Course Access.” The statute requires the inclusion of parents, including parents or legal guardians of targeted disadvantaged pupils, in the planning and implementation of the LCFF at the District level. LCAP planning therefore provides an opportunity for teachers, administrators, parents, and community members to have a voice in shaping the NGSS and CCSS rollouts in their communities and ensuring that they include STEM competencies.

“Today, I’m signing a bill that is truly revolutionary,” said Governor Brown on signing the historic school funding legislation. *“We are bringing government closer to the people, to the classroom where real decisions are made and directing the money where the need and the challenge is greatest. This is a good day for California, it’s a good day for school kids and it’s a good day for our future”* (State of California, Office of the Governor, 2013).

Career Technical Education as a STEM strategy

In preparing students for college and careers, Career Technical Education (CTE) provides a strong option for development of STEM competencies and skills. STEM knowledge and skills are also essential to many fields such as health care and biotechnology, manufacturing and product development, transportation, and energy and utilities.

Career Technical Education offers students the opportunity to explore and experience careers in the STEM industries. It can also prepare students for beginning technical level STEM employment and help them to construct a realistic postsecondary education plan based on knowledge and experience in their chosen STEM field. The federal Carl D. Perkins Career and Technical Education Act of 2006, one of the primary sources of funding for CTE in California and the country, requires that recipients of this federal funding provide CTE programs of study that align secondary and postsecondary courses and programs, address industry needs, integrate academic with CTE knowledge and skills, and offer dual credit when appropriate— all desired components for students pursuing college and careers in STEM. CTE programs of study frequently prepare students for industry-recognized certification, in addition to preparation for the workforce and for success in postsecondary education. Providing students with knowledge, skills and certifications that are of value to, and recognized by, business and industry allows them the option of employment in STEM jobs while they continue their STEM education. Some students would not be able to continue their education without this fiscal support. CTE offers engaging, relevant curriculum and provides students the ability to explore potential careers, prepare for college, and apply academic and workplace knowledge and skills, creating a highly effective STEM learning environment (National Association of State Directors of Career Technical Education Consortium, 2013).

2. PROFESSIONAL LEARNING

In 2012, SSPI Torlakson and the California Commission on Teacher Credentialing jointly convened the Educator Excellence Task Force, co-chaired by Professor Linda Darling-Hammond of Stanford University and Long Beach Unified School District Superintendent Chris Steinhauser. The task force's report, *Greatness by Design* (2012, p. 9), lays out a comprehensive agenda for successful development of California's educator workforce, and makes a strong case for ongoing professional learning:

"The critical need for investments in teacher and principal learning has been made clear over and over again in efforts aimed at educational change. Those who have worked to improve schools have found that every aspect of school reform – the creation of more challenging curriculum, the use of more thoughtful assessments, the invention of new model schools and programs – depends on highly-skilled educators who are well supported in healthy school organizations."

Building on this important foundation, the STEM Task Force analyzed the current status of California's STEM professional learning systems and developed recommendations for improvements with the awareness that, *"In the final analysis, there are no policies that can improve schools if the people in them are not armed with the knowledge and skills they need"* (California Department of Education, Educator Excellence Task Force, 2012, p. 9).

2.1 PROFESSIONAL LEARNING: CURRENT STATUS OF STEM EDUCATION

Defining Professional Learning

Studies have shown that professional learning most closely linked to improved student learning: a) focuses on teachers understanding the content they will teach; b) is sustained over time; and c) provide opportunities for professional dialogue and critical reflection (Weiss et al., 1999; Zucker, Shields, Adelman, Corcoran, and Goertz, 1998; U.S. Department of Education, 2000). As Smith (2001) writes: *"Professional development of teachers should be situated in practice."* The everyday work of teaching should become the object of ongoing investigation and thoughtful inquiry (Ball and Cohen, 1999). *Greatness by Design* (2012) explains that high-quality professional learning is connected to practice, focused on student learning, and aligned with school improvement efforts. Professional learning opportunities should be ongoing and include externally provided professional development opportunities as well as job-embedded activities such as common planning time and collaborative opportunities to examine student work or tools for self-reflection. Together, these opportunities contribute to increased teacher knowledge and the resulting changes to instructional practices that support and enhance student learning. Lois Brown Easton (Easton, 2008) contends:

"It is clearer today than ever that educators need to learn, and that's why professional learning has replaced professional development. Developing is not enough. Educators must be knowledgeable and wise. They must know enough in order to change. They must change in order to get different results. They must become learners, and they must be self-developing."

Professional Learning Resources

Given the critical value of teacher content and pedagogical content knowledge (Zeidler, 2002), continued professional learning is paramount in promoting student learning in STEM disciplines. Unfortunately, professional learning opportunities for teachers and administrators have severely decreased over the past ten years and are virtually nonexistent in many schools. Funding for professional learning in California has been significantly reduced as a direct result of budget cuts and indirectly as a result of professional learning funds being redirected to fill

other budget gaps. More than half of the districts across California report that they have eliminated or significantly reduced professional learning opportunities that had previously been provided to teachers.

Of the four STEM disciplines, professional learning opportunities for science, technology, and engineering in California are particularly sparse. In a 2011 study of elementary teachers in California, Dorph and her colleagues found that only about one-third felt very prepared to teach science and more than 85 percent had not received any science-related professional development in the past three years. Likewise, more than half of California middle school science teachers surveyed rated the lack of professional learning environments as a major or moderate challenge for quality implementation (Hartry, Dorph, Shields, Tiffany-Morales, and Romero, 2012). More clarity is needed in defining the most effective ways to teach engineering in K–12 classrooms (National Research Council, 2009).

There is a growing consensus that teachers require a base level of knowledge and skills, with subject knowledge deep enough and instructional methods broad enough to deliver a high-quality curriculum to each student (National Board for Professional Teaching Standards, 2007; Wilson, 2011). Teacher quality is one of the most important influences in student achievement and learning (Darling-Hammond, 2000). Thus, a key to the implementation of high-quality STEM programs is that teachers have deep content-area knowledge, particularly in science and mathematics. This content-area knowledge will also be crucial in meeting the demands of the CCSS and NGSS.

The adoption of the CCSS and NGSS will require sweeping changes in curriculum, instruction, and assessment. The new standards focus on deeper understanding and application of content as well as higher-level skills and abilities that were not emphasized in the previous California standards. In order to enable students to meet the new standards, instructional practices across content areas must be deepened. Under the new standards, STEM instruction will require more hands-on and project-based learning. This offers prime opportunities for exploration of integrated teaching and learning programs utilizing the unique potential of three different but related learning environments: informal, expanded learning, and the K-12 regular school day. Each of these provides unique resources that have historically been siloed. Integrating the learning opportunities across all three of these areas will open new doors for collaboration and resource sharing that will benefit educators as well as students.

Current Assets and Practices

Despite the challenging context that has existed for the last decade, California has developed and sustained assets and practices that continue to provide professional learning opportunities to educators statewide. For example, although it has received numerous budget cuts, the California Subject Matter Project (CSMP) has continued to provide content-based professional learning. CSMP was created in 1988 and reauthorized in 2011, demonstrating the California legislature's commitment to supporting educators' ongoing professional learning. The CSMP is a regional network of nine discipline-based projects, including mathematics and science, which provides professional learning opportunities through the creation of communities of practice across ninety sites statewide. Similarly, the K-12 Alliance is a statewide network within WestEd's Mathematics, Science, & Technology Program that has provided professional learning in science and mathematics for more than twenty-eight years. The California Science Teachers Association and the California Mathematics Council support annual conferences in which educators learn about new policies and take home practical experiences to use in the classroom. Other examples of statewide professional learning opportunities are those provided by the County Offices of Education (COE). These opportunities are often provided regionally through COE's curriculum and instruction steering committees (CISC). There are CISCs for STEM components including mathematics, science, and technology that identify professional learning needs and provide professional learning activities.

The CDE has been facilitating a professional learning grant program under NCLB Title II Part B called the CA Mathematics and Science Partnership Grant Program. This program has been successful in helping teachers learn STEM content as well as teaching strategies. This year the grants required recipients to begin the conversation on

STEM by integrating at least two of the content areas. The CDE is hoping to learn more about STEM education through these programs.

Another developing and important source of professional learning opportunities involves informal learning contexts such as science museums. For example, two San Francisco Bay Area institutions, the Lawrence Hall of Science and the Exploratorium, conduct professional development programs.

Recent events in California demonstrate the growing interest in STEM education. In February 2014, The California STEM Summit, convened by the California STEM Learning Network, was held in Santa Clara. The summit is the state's foremost gathering of leaders from PK-12 formal and informal education, higher education, business and industry, government, and science-rich education institutions focused on STEM education. The Summit brought these stakeholders together to advance a common agenda for increasing quality, equity, and innovation in STEM education throughout California. The 2013 STEM Symposium, convened by the CDE, was attended by over 2,000 people including educators, administrators, parents, and other key stakeholders focused on STEM professional learning, curriculum and instruction, and partnerships. The CDE also convened two other events in 2013 that focused on STEM: the 33rd Annual State Migrant Parent Conference, attended by 700 parents, and the Migrant Summer Leadership Institutes for 200 students and 40 parents. These events included a focus on fostering interest in STEM fields among participating students.

A good example of promising professional learning practices that build on existing public and private assets is the Orange County STEM collaboration, known as the OC STEM Initiative. This collaboration of sixteen funders, the Orange County Department of Education, THINK Together, Tiger Woods Learning Center, and Discovery Science Center has successfully developed a regional STEM ecosystem that provides both programmatic experiential learning opportunities for educators and promotes the integration of all disciplines and learning platforms. This collaboration was recently highlighted by the National Research Council in its STEM Is Everywhere convening in February 2014, as well as in the Noyce Foundation report, *How Cross-Sector Collaborations are Advancing STEM Learning* (Traphagen and Taill, 2014). OC STEM also participates actively in the statewide Power of Discovery: STEM² initiative.

2.2. PROFESSIONAL LEARNING: THE STATE'S FUTURE NEEDS AND OPPORTUNITIES

Need to Re-examine Teacher Preparation Programs

A thorough examination of teacher preparation programs was outside of the purview of the working group. However, the group recognizes that in order for in-service STEM professional learning to be most successful, there must be outstanding STEM pre-service teacher preparation. Recent publications have examined the topic of teacher preparation in depth. *Greatness by Design* (2012) provides detailed recommendations for how to recruit, train, and support outstanding teachers in California. *STEM Can Lead the Way* (Read, 2013) examines STEM teacher preparation specifically and identifies changes that need to be implemented in the current credentialing system to develop outstanding STEM educators.

Necessary Resources

The amount of time allotted for professional learning is a local decision. In a financial crisis, resources for professional learning are often one of the first items sacrificed to balance the budget. If STEM education is to be a priority, some of the funding for education must focus specifically on STEM professional learning. *Greatness by Design* (2012) recommends dedicating a consistent share of the state education budget to professional learning. Another approach to securing necessary resources may be to integrate state support with the business and philanthropic communities that have historically supported STEM-expanded learning opportunities.

As educational funding is beginning to be restored across the state, opportunities to utilize this funding for professional learning are emerging. As a result of AB 86, which appropriated funds specifically for the implementation of newly adopted state standards (including the new science standards), \$1.25 billion became available for the 2013-14 and 2014-15 school years. Language in the bill indicates specifically that these funds may be used for professional learning.

Need for STEM Professional Learning Standards

Standards are important indicators of excellence (Darling-Hammond and McLaughlin, 1995; Kaser and Bourexis, 1999). As yet, there are no standards for providers of STEM professional learning; moreover, there are no standards for any provider in the integration of these subjects. Consequently, school districts and educators have no guidelines to identify quality professional STEM learning providers.

Need and Opportunity for STEM Capacity Building

Given the positive change and momentum in California public education described above, we have a current opportunity to create an educational system that builds STEM instructional capacity, yielding strong returns on investment for many generations to come. Creating an environment that allows educators to continue to learn and pursue self-development will build the capacity to provide better STEM learning opportunities for students.

At the state, regional, and local levels the capacity to develop, implement, and support ongoing professional learning must be in some cases strengthened and, in others, rebuilt. The focus of this work should now be placed on the formulation and implementation of the actual strategy to move forward based on building capacity in two interrelated domains:

1. **STEM knowledge and skills for instructional (pedagogical) practice.** Capacity building should focus on instruction, relative to the CCSS and NGSS (capacities for which strong exemplars exist but that are not currently strong in the state) for all within the educational system, from teachers, to para-professionals such as after school educators, to school principals and administrators; and
2. **Leadership knowledge and skills** necessary to mobilize and support instructional practice on a wide scale. This could include creating collaboratives and other mechanisms for individuals and groups to learn from each other as they do this work and developing leadership capacity at all levels to mobilize educators and administrators. It should also include making data on effective practices and on student learning central to this work.

2.3. PROFESSIONAL LEARNING: KEY RECOMMENDATIONS

1. Establish and/or support, with consistent funding, a variety of high-quality STEM professional learning opportunities led by trained professional learning providers that increase state, regional, and district capacity for delivering excellent STEM education.
2. Adopt policies and standards for quality STEM professional learning to provide guidance at the state, regional, and local school levels.
3. Implement a system of periodic review of state STEM-related professional learning practices to monitor effectiveness and provide flexibility.

A full set of recommendations from all sections of the report is available in Appendix 10.2.

3. CURRICULUM AND INSTRUCTION

STEM curriculum and instruction promotes active, collaborative, and meaningful learning, which supports mastery of skills and expands horizons. According to the National Research Council (2011), curriculum and instruction in elementary education should focus on generating interest in the STEM disciplines by exposing all children to engaging applications in STEM areas, building on what they know and on their interests. Every child should enjoy learning and want to be fully engaged in science through hands-on inquiry and in mathematics through solving of authentic problems. Technology should be an integral tool in schools to support learning through multiple means: researching, modeling, communicating, interpreting, and displaying. The ideal secondary school learning environment would engage students in interdisciplinary work and project-based learning using real-world contexts (Larmer and Mergendoller, 2012).

3.1. CURRICULUM AND INSTRUCTION: CURRENT STATUS OF STEM EDUCATION

The Impact and Legacy of No Child Left Behind

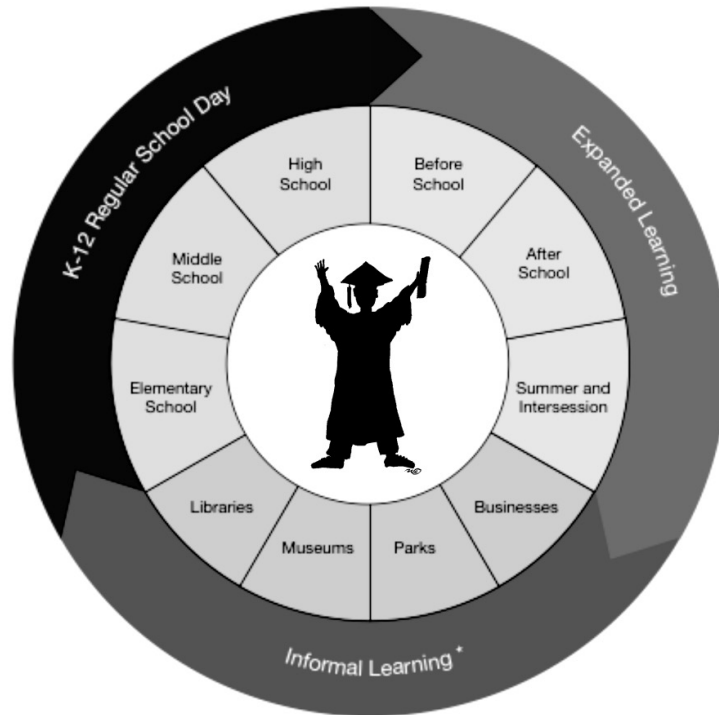
In 2001, the nation's Elementary and Secondary Education Act was reauthorized as the No Child Left Behind Act (NCLB). At its core, NCLB aims to raise student achievement as well as state and school-based accountability for student progress (Education Week, 2011). To measure student achievement, NCLB requires states to conduct student assessments in reading/English language arts (ELA), mathematics, and science. While ELA and mathematics assessments are required in grades 3-8 and once between grades 10-12, science assessments are only required three times: once in elementary school, once in middle school, and once in high school. Currently, in California, science is assessed in fifth, eighth, and tenth grades. As a result, NCLB has been criticized for narrowing the curriculum to largely English language arts and mathematics at the expense of other subjects. Research conducted by the Center on Education Policy found that since NCLB was enacted in 2002, 62 percent of school districts across the nation increased instruction time for ELA and mathematics by as much as three hours per week. Fifty-three percent of these districts reduced science instruction time by at least 1.25 hours per week (McMurrer, 2008) and one study indicated that 40 percent of teachers surveyed reported that they taught science for less than one hour each week. Both teachers and administrators agreed that limited time for science instruction was the most significant challenge to providing science instruction. Beyond instructional time, only 11 percent of elementary school principals surveyed indicated that it was very likely that students would be receiving high-quality science instruction at his/her school and, conversely, 12 percent indicated it was very unlikely that students would receive high-quality science instruction (Dorph et al., 2011). As continued budget shortfalls necessitated decreased overall learning time, classroom time dedicated to subjects outside of ELA and mathematics were disproportionately reduced to enable ELA and mathematics instruction to be maintained at current levels.

Common Core State Standards and Next Generation Science Standards

Both the CCSS and NGSS represent a shift in K-12 content standards from remembering and recalling information to demonstrating students' depth of knowledge within and across content areas, including understanding, applying, and analyzing.⁵ The NGSS reflect the interconnected nature of science by addressing student engagement in three dimensions: 1) Science and Engineering Practices; 2) Crosscutting Concepts; and 3) Disciplinary Core Ideas. The NGSS focus on deeper understanding of content and application of content: "...the focus is on the core ideas – not necessarily the facts that are associated with them. The facts and details are important evidence, but not the sole focus of instruction" (Achieve, 2013, p. 4). In addition to traditional science subjects, engineering and technology are integrated into the NGSS, based on a two-fold rationale: 1) Science, engineering, and technology are often all required to address major world challenges that may motivate students to study these subjects; and 2) A number of abilities are common across these three subject areas, allowing the study of one to increase proficiency in the others (Achieve, 2013).

STEM in Expanded and Informal Learning

Students learn not only in the classroom but also in the real world, and the importance of expanded, informal, and K-12 regular school day learning integration has been emphasized recently by the 2011 convening of the Committee on Integrated STEM Education by the National Academy of Engineering and the National Research Council (NRC), and the NRC convening, *STEM is Everywhere*. The most effective STEM education takes place where expanded, informal learning, and K-12 regular day instruction are integrated and the unique potential of each of these environments is fully leveraged for high-quality STEM education, often referred to as STEM ecosystems. Figure 1 below provides a graphic representation of integrated expanded learning, informal learning, and K-12 regular school day environments.



* Informal learning also provides STEM learning opportunities for parents and educators.

Figure 1

In late 2011, the CDE created the After School Division (ASD), implementing a recommendation from *A Blueprint for Great Schools* (2011) and emphasizing expanded learning as a priority. Shortly after its formation, the ASD launched a strategic planning process that culminated in the finalization and publication of the division's strategic plan, *A Vision for Expanded Learning in California* (California Department of Education, After School Division, 2014). The ASD's plan defines expanded learning as "those programs conducted before and after school, summer, and intersession learning programs, that focus on developing the academic, social, emotional and physical needs and interests of students through hands-on, engaging learning experiences" (2013, p.4). This definition includes those programs that have previously been referred to as after school and out-of-school.

California provides approximately \$500 million for expanded learning programs. That commitment, in conjunction with some federal funding, supports more than 4,400 expanded learning programs at school sites with the capacity to serve more than 420,000 students each school year (California After School Network, 2013). The U.S. Department of Education currently provides California with over \$120 million per year through the 21st Century

Community Learning Centers program (21st CCLC), which the CDE administers through a competitive grant process. The U.S. Department of Education has made STEM a priority for the 21st CCLC program and, as part of that commitment, technical assistance is available online at the Youth For Youth website, which includes a section dedicated to STEM resources. The U.S. Department of Education has also begun planning for the rollout of national technical assistance for STEM in expanded learning programs.

The ASD's strategic plan emphasizes enhanced learning program quality and integration between expanded learning and K-12 regular day instruction. Through its "Expanded Learning/K-12 Integration" initiative, the ASD will seek to strengthen the connection between regular school day instruction and expanded learning. The aim is to enable expanded learning programs to align activities and learning content with classroom instruction, including the CCSS- and NGSS-aligned instruction.

Private foundations have also developed expanded learning STEM initiatives. For example, the S.D. Bechtel, Jr. Foundation, the Noyce Foundation, and the Samueli Foundation have invested in STEM expanded learning through The Power of Discovery: STEM² initiative. This initiative is managed as a partnership between the California Afterschool Network and the California STEM Learning Network and provides expanded learning programs "*with the tools and resources to implement quality STEM learning opportunities*" (Power of Discovery: STEM² n.d.). As of March 2014, The Power of Discovery: STEM² initiative has provided support to over 1,000 publicly funded expanded learning programs.

Current Assets and Practices

Across the state, a few outstanding programs exist at the secondary level that demonstrate how to tie STEM learning to technical and vocational education, including California Partnership Academies, California's Career Technical Academies, Project Lead the Way, and Linked Learning. The California Partnership Academy program integrates disciplines and prepares students for college and careers. The program has been in existence for twenty-six years and has demonstrated research-based success. It is funded through general and federal funds through competitive grants, and there are over 500 of these schools located within high schools.

Career Technical Academies are programs of study that involve a multiyear sequence of courses that integrate core academics with technical and occupational knowledge to provide students with a pathway to postsecondary education and careers in a number of career fields including public service, business, health, engineering, green energy, agricultural science, auto technology, and media.

Project Lead the Way is an in-school STEM curricular program for elementary, middle, and high school students that also offers a comprehensive professional development model for teachers.

One example of an innovative engineering curriculum is Engineering is Elementary (EiE). As of January 2014, more than 61,000 teachers and 4.5 million students in schools and districts across all fifty states have used EiE. The twenty-unit curriculum is designed for grades 1-5 and provides project-based engineering activities that connect to and support the CCSS and NGSS. All units begin with a "storybook" about a child who solves a real world problem. The units include hands-on learning activities. The storybooks integrate both literacy and social studies with the engineering curriculum and help provide students context for how STEM subjects relate to their lives, while the hands-on activities provide students opportunities to deepen and apply their learning.

Research has shown that those students participating in EiE demonstrated more interest in and understanding of engineering and technology than those students in the control group who participated in related science lessons but not in the EiE curriculum. While pre-test measures indicated that males were more likely than females to be interested in engineering careers, post-test measures indicated that females' interest increased after participation (LaChapelle, Phadnis, Jocz, and Cunningham, 2012; Jocz and Lachapelle, 2012).

In addition to regular school day and expanded learning programs, nonprofit organizations have launched statewide, national, and international campaigns encouraging K-12 teachers and students to devote time to STEM topics. For example, the California STEM Learning Network works with regional networks and other partners around the state to advance statewide STEM initiatives that build high-quality STEM teaching and learning. Nationally, the STEMx network is a grassroots organization of nineteen states that share, analyze, and disseminate STEM educational tools.

In addition, there are efforts being made to increase support for providing more computer science and coding opportunities specifically, as many K-12 schools do not currently offer computer science classes. One example is Code.org, an international web campaign to collect digital signatures in support of every student in every school having the opportunity to learn computer science. The Code.org website provides interactive online coding courses and challenges for teachers and educators such as “Hour of Code,” which encourages teachers to reserve one hour of classroom time for an introductory lesson on coding and computer science. Ultimately, Code.org’s motivation stems from projections that, while the number of computer science students will increase by 2020, the number of computing jobs will increase at a much greater rate, resulting in 1 million more jobs than trained employees by 2020.

3.2. CURRICULUM AND INSTRUCTION: THE STATE’S FUTURE NEEDS AND OPPORTUNITIES

Need for High-quality Instructional Materials

California confronts several barriers to providing access to the essential, high-quality educational materials necessary for effective STEM education. One is the need to revise existing materials to ensure that they align with and support the new CCSS and the NGSS. It is the state’s role to develop the curricular framework and review instructional materials. This process has been completed for mathematics and has begun for the NGSS.

The recent proliferation of STEM materials ironically represents another barrier to access. Many existing educator resource exchanges provide access to lesson plans and other classroom materials that contain STEM-related resources. For example, a search for science and technology resources on one popular education resource exchange resulted in almost 22,000 user-generated resources. However, these materials vary widely in terms of quality and efficacy. In the absence of clear guidelines to evaluate what constitutes high-quality STEM materials, educators are faced with the significant challenge of sifting through thousands of resources to assess quality.

High-quality educational materials must, by definition, include a digital component as well. The challenges to deepen and apply knowledge across content areas provided by the CCSS and NGSS demand tools that will help facilitate this learning and some of those tools will be digital. Instructional materials need to evolve beyond simply being digitized. Technology will need to be meaningfully incorporated into instructional approaches to prepare students to be college and career-ready and enable them to develop real world skills and abilities.

Necessary STEM Integration

STEM education is often distilled down to one or two disciplines. A school with a robotics program may identify as a STEM school or another STEM curriculum may focus on science and mathematics education, omitting technology and engineering education entirely. It is most common for the *T* and the *E* of STEM to be overlooked and missing (Miaoulis, 2009). This lack of integration regrettably shortchanges students who need experience applying mathematics and science to problem-solving fields like engineering in order to flourish in today’s workplace.

Opportunities within the Newly Adopted State Standards

The CDE has demonstrated its commitment to STEM in a number of ways including the establishment of a STEM office to help focus system-wide on STEM education. The work of this task force as well as the SSPI’s STEM

symposium focused on classroom strategies for implementation to further support the development of STEM learning opportunities. Given the system-wide support for STEM as well as the recent adoption of the CCSS and NGSS, the field-testing of the Smarter Balanced assessments for ELA and mathematics, and the \$1.25 billion devoted to the CCSS and NGSS implementation, it is clear that the time to fully integrate STEM into teaching and learning practices is now. It is time to increase instructional time for core subjects such as science and mathematics as well as technology and engineering, but clear linkages must be drawn to develop integration among the disciplines.

Opportunities to Involve Parents and Caregivers

Curriculum and instruction strategies must consider the essential role of parents and caregivers in their children’s STEM education. Parents may feel ill equipped to support their children’s STEM learning, and the shift to new content standards will likely magnify this feeling. Fortunately, many expanded learning organizations, some universities, and some community-based organizations, including the Parent Institute for Quality Education and PTAs, provide STEM training for parents. Currently, these resources are limited and could be expanded.

Parents and caregivers as well as teachers and other key STEM stakeholders have the opportunity to be involved in how Local Control and Accountability Plans address STEM within state priority areas #2 (Implementation of State Standards) and #7 (Conditions for Learning: Course Access). This involvement provides parents and caregivers an opportunity to learn more about STEM and have a voice in how it can be integrated into the school’s curriculum.

3.3. CURRICULUM AND INSTRUCTION: KEY RECOMMENDATIONS

1. *Establish a K–12 STEM Framework for teaching and learning that identifies the sequence of STEM knowledge, skills, and attitudes toward developing skills for career and college readiness, and that incorporates the CCSS, NGSS, and associated curriculum frameworks.*
2. *Establish a rubric for determining the quality of STEM instructional materials.*
3. *Establish recommended minimum amounts of instructional time per week for STEM topics. A portion of this instructional time should focus on science, technology, and/or engineering in addition to mathematics.*
4. *Establish a framework for the integration of experiential learning between the K-12 regular school day and expanded learning opportunities.*

A full set of recommendations from all sections of the report is available in Appendix 10.2.

4. STUDENT ASSESSMENT

4.1. STUDENT ASSESSMENT: CURRENT STATUS OF STEM EDUCATION

Transitioning to a Future Assessment System

The passage of AB 484 in October 2013 establishes California’s future statewide assessment system, the California Assessment of Student Performance and Progress (CAASPP), which replaces the previous Standardized Testing and Reporting (STAR) Program. This transition will take several years to complete. For the 2013-14 school year, STAR testing of English-language arts and mathematics will be replaced by field-testing of the Smarter Balanced summative assessments in grades 3-8 as well as grade 11. In 2014, the California Standards Test for science will continue in grades 5, 8, and 10 as required by federal law.

While the prior standards and assessment system concentrated on proficiency, the CCSS and NGSS are more focused on expanding students’ depth of knowledge in relation to college and career readiness. The CCSS and the aligned Smarter Balanced assessments seek to prepare students for college and careers in the 21st century by focusing on building and assessing critical thinking skills (Torlakson, 2013). These standards require that students demonstrate the ability to apply knowledge and related assessments must also model high-quality performance tasks.

Integrating Teaching, Learning, and Assessment

The assessment transition underway represents part of a philosophical shift from a “test-and-punish” to an “assessment-support-and-improve” framework, which is coming into particular focus as California implements the CCSS and, later, the NGSS. Within this new statewide framework, there is an expanded focus beyond just summative assessments to include interim as well as formative assessment tools. In addition to the annual Smarter Balanced summative assessments, districts will also have access to a “suite” of Smarter Balanced interim and formative assessment tools. An effective assessment system incorporates both summative and formative assessment tools and implements them discerningly to address and answer specific questions. For example, summative assessments might include end of the year standardized tests. Data from these assessments are important for identifying evidence of achievement and for broader system accountability purposes. Formative assessments provide teachers, students, and parents with ongoing information regarding how learning is progressing. Evidence gained from formative assessment tools such as quizzes, observations, classroom discussions, and/or student projects will be used by teachers to guide instruction and by students—individually and/or in groups—to reflect on and evaluate their own learning. By integrating both summative and formative tools, assessment becomes more integrated with the overall process of teaching and learning by providing relevant and timely insight into the learning process as well as evidence of achievement (National Research Council, 2013a).

The state will develop assessments for the NGSS to be on par with ELA and mathematics Smarter Balanced assessments, including both summative as well as formative assessment tools. As part of this process, stakeholder input will be collected on when and what to assess. Current plans call for the NGSS assessment recommendations to be presented to the State Board of Education early in the 2015 calendar year.

Current Assets and Practices

As this report is being written, LEAs are beginning the Spring 2014 field-testing of Smarter Balanced summative assessments for ELA and mathematics. By engaging in this field-testing, the state seeks to ensure that results from the final Smarter Balanced assessments are valid, reliable, and fair.

The recent report from the National Research Council *Developing Assessments for the Next Generation Science Standards* (2013) collects and examines best practices for assessing the three-dimensional science learning inherent to the NGSS. For example, sixth-grade students in the Detroit public school system learned about biodiversity by observing and recording all animals and signs of animals in the schoolyard. As the data were combined, the teacher gathered information about the students' abilities to collect and record data. Students were then asked to construct an explanation to the question: Which zone of the schoolyard has the greatest animal biodiversity? Finally, for the end-of-unit assessment, the teacher presented students with excerpts from a different class data collection summary and asked them to construct an explanation, as they did earlier with their own data about animals in the schoolyard. This example illustrates the integration and effective use of both formative and summative assessment tasks.

4.2. STUDENT ASSESSMENT: THE STATE'S FUTURE NEEDS AND OPPORTUNITIES

Necessary Support for the Future Assessment System

Transitioning from the STAR system to the CAASPP requires not only newly developed assessment practices but also a shift in the way that assessment is conceptualized. In order for the transition to be truly successful, there must be widespread support for the concept that assessment is integral to learning and for the move to an "assess-support-and-improve" system that focuses on capacity building. High-quality formative assessment tools are crucial to such a system and demonstrated local support for these will be necessary in order to sustain their development and dissemination and potentially shape the development of the NGSS assessments. Lessons learned from the Smarter Balanced field tests in the spring of 2014 will also inform assessment practices and recommendations for the NGSS.

Opportunities within the Transition to a Future Assessment System

The implementation of AB 484 provides an opportunity to integrate STEM into the state's assessment system in meaningful and efficient ways. AB 484 requires the State Superintendent of Public Instruction (SSPI) to provide recommendations to the State Board of Education on how to expand the assessment system to include other content and/or methodologies. For example, content areas may include science and technology and assessment options may include grade span, matrix-sampling, performance tasks and/or, in the larger system, the creative use of portfolios, digital badges, etc. The SSPI's report on assessment provides the following as an example of potential ways to expand the assessment system:

"For example, the 2016 assessment calendar could include a technology portfolio in grade five, a history-social science assessment in grade seven that includes constructed-response items, and a chemistry locally-scored performance task. The 2017 assessment calendar might include a computer-based science test in grade four and a visual arts performance task in grade eight. This approach would have the benefit of addressing the concern that limiting the assessment system to those ESEA required assessments narrows curriculum to ELA and mathematics while also acknowledging the fiscal constraints to developing and administering assessments in other subject areas" (Torlakson, 2013, p. 44).

Teachers across California are designing creative formative assessments that let them measure their students' ability to apply STEM concepts. Shifting away from multiple-choice tests, many teachers are re-envisioning the assessment process as a project-based learning experience. They are having their students use social media to connect to other students and the larger community of STEM professionals. Students are designing and building authentic real world projects that can solve community-based problems, often alongside local engineers who give them a career-based perspective. Teachers are having their students create presentations that not only incorporate STEM concepts in an integrated approach, but also celebrate their students' ability to express innovation, creativity, and individuality.

4.3. STUDENT ASSESSMENT: KEY RECOMMENDATIONS

1. Consult with STEM teachers and other key STEM stakeholders in the development of the recommendations for assessing grade level and curricular content areas beyond those required by the Elementary and Secondary Education Act.
2. Develop meaningful ways to integrate STEM into the emerging assessment system in a cohesive and innovative fashion, taking full advantage of the entire suite of assessment tools available to the state and LEAs at this time. This should encompass including STEM assessment recommendations as California implements AB 484.

A full set of recommendations from all sections of the report is available in Appendix 10.2.

5. BUSINESS AND COMMUNITY PARTNERSHIPS

5.1. BUSINESS AND COMMUNITY PARTNERSHIPS: CURRENT STATUS OF STEM EDUCATION

Partnerships: Expanding and Enhancing Opportunities for STEM Learning and Application

Traditionally, most STEM instruction has taken place in K-12 science and mathematics classes. Additional STEM education has been available to students outside of the regular school day in two ways: structured expanded learning programs such as afterschool programs, and informal learning opportunities at institutions such as museums, parks, libraries, and other community-based organizations. Multiple STEM learning environments provide more options for student learning as well as opportunities for partnership. Business and community STEM partnerships can play a critical role in creating meaningful connections between curriculum taught in the classroom and practical applications outside of school. Together, K-12, and expanded and informal STEM learning opportunities can create an ecosystem in which students develop higher-level STEM skills and knowledge inside and outside of the classroom, and increase their readiness for college, careers, and life.

In California, a broad array of business, philanthropic, and community partnerships have been formed in the interest of supporting and expanding STEM education. Many of these partnerships are crucial for the financial and in-kind support they provide. The financially driven relationships are commonly seen in the sponsorship or hosting of individual events or activities like science fairs, awards banquets, or fund-raising galas. While these partnerships are valuable, a variety of STEM learning stakeholders have organized more integrated and sustainable partnerships including:

- **Regional cross-sector STEM networks** to engage students, parents, teachers, local education agencies, and community organizations and businesses to address regional needs in STEM education through information and resource sharing, including online platforms. Examples include the California STEM Learning Network, Regional Networks, Power of Discovery: STEM², and others.
- **Career readiness/exploration programs** for K-12 students that integrate academic and career technical education through business partnerships that provide job shadowing, mentoring, internships, and more. The nationally recognized MESA (Mathematics, Engineering, Science Achievement), and California Partnership Academies are two examples that have been replicated across the state and the nation.
- **Professional development initiatives** that provide opportunities for STEM educators to advance their capacity to teach STEM subjects. The Industry Initiatives for Science and Math Education, began as a partnership between a consortium of San Francisco Bay Area companies and the Lawrence Hall of Science at the University of California, Berkeley, and is now statewide. The California Science Project is a collaboration with K-12 and higher education science educators that provides high-quality science instruction focusing specifically on the needs of English learners, students with low literacy, and students in poverty. The California Mathematics Project is similarly structured across the state with a comparable mission in mathematics. Together, they provide an infrastructure for science and mathematics professional development and have eighteen and twenty regional sites across the state respectively.
- **Local partnerships** that vary by community, depth of programming, and support and may be coordinated by the local County Offices of Education, Chambers of Commerce or Workforce Investment/Development Boards. Local businesses, community organizations, and schools may form partnerships with each other to advance initiatives such as small grant/scholarship and internship programs for students. An example is Super STEM Saturday, an annual, free, one-day event in Oceanside, California, that invites and engages young students and families to explore STEM through hands-on activities. It is the result of a partnership

between The Classical Academies, a local public school charter, California State University, San Marcos, and the San Diego Festival of Science of Engineering (Super STEM Sunday).

- **Informal learning opportunities** offered by informal learning institutions such as museums, libraries, parks, and community-based organizations, among others. These informal learning institutions are playing an increasingly important role (Bell, Lewenstein, Shouse, and Feder, 2009) by providing students with experiences that are different from what happens in the classroom and allow them to participate in clubs or competitions (such as FIRST Robotics), and in a variety of STEM activities based on their personal interests (Bell et al., 2009). Informal learning institutions also provide parents, family, and the larger community the opportunity to participate in STEM experiences alongside students. Business and community partnerships can also facilitate and supplement ongoing professional learning for STEM educators. Perhaps more than any other element of STEM education, informal learning institutions are best able to reach populations of underserved students based on their intimate knowledge of and work with the local community, including leveraging resources and partners. A major drawback of informal STEM learning, however, can be that student participation is voluntary and exposure more episodic. The last point here is important to consider. While a single participation or interaction may change a student's attitude toward STEM, it is more likely that attitude, interest, academic and career trajectory, and content knowledge will be affected by partnerships that provide **extended** exposure to STEM opportunities. Programs organized to offer both breadth and depth and those in which the partners understand they are engaged in an ongoing process can produce excellent results.

Current Assets and Practices

California has many assets to draw upon as it moves forward with improving STEM education. With just over 13 percent of the STEM jobs in the U.S., California is home to many STEM industries and businesses, large and small, that depend on a skilled and trained workforce and have a vested interest in increasing the supply of a highly qualified workforce (Wright, 2011). These businesses have expertise and resources that are assets in existing or in developing new STEM learning partnerships.

Additionally, a number of established and emerging regional STEM networks and partnerships, have laid the foundation for strong collaborations and partnerships. Established and emerging state, regional, and programmatically-focused STEM learning networks (California STEM Learning Network, The Power of Discovery: STEM²) provide a model of current best practices in STEM business and community partnerships. Some common characteristics they share include being:

- *Cross-sector, linking partners from government, business, STEM learning institutions (K-12, expanded, and informal programs), and other community organizations and nonprofits;*
- *Highly collaborative in designing and implementing projects/initiatives, engaging at the organizational and individual level, making sure that educators and parents are part of the conversation;*
- *Focused on providing high-quality STEM learning opportunities that align with the CCSS and NGSS as well as future workforce needs;*
- *Involved in research and advocacy to continuously learn about and promote what works and ensure that STEM learning is a statewide policy priority and sustainable;*
- *Hubs for communication, learning, and sharing; and*
- *Responsive to local and regional community needs, and leverage local assets and resources.*

While these regional networks have been successful to date, a more formal assessment of what is working across all types of STEM learning partnerships would be valuable and assist with the institutionalization and dissemination of promising practices in STEM business and community partnerships.

Towards a True “STEM Learning Ecosystem”

A recent report commissioned by the Noyce Foundation (Traphagen and Taill, 2014) examined cross-sector collaboration and partnerships among K-12 and expanded learning programs and informal STEM education programs. The report describes a new approach to STEM learning: STEM learning ecosystems. These ecosystems may include a variety of environments that together create a *“rich array of learning opportunities for young people”* (Traphagen and Taill, 2014, p. 3). The unique contributions of the individual organizations deliver integrated STEM learning for all participants. The ecosystem metaphor is relevant in that *“diverse, individual actors are interconnected in symbiotic relationships that are adaptive and evolve over time”* (Traphagen and Taill, 2014, p. 10).

Researchers found that STEM learning ecosystems have the potential to build children’s scientific practice skills and knowledge through multiple exposure and experience; develop children’s interest in and enthusiasm for STEM over time using a variety of both formal and informal practices; assist children in building complex skills including solving real world problems; and foster diverse and inter-connected STEM learning experiences especially for those children historically under-represented in STEM.

The research identified three building blocks of STEM learning ecosystems:

1. K-12 school or school system with leadership that values cross-sector collaborations;
2. After-school program or other organization with the capacity to collaborate effectively within and across other formal and/or informal learning environments; and
3. Strong STEM-expert institutions that can provide content and resources for STEM experiences for teachers, students, and families (Traphagen and Taill, 2014).

The Noyce Foundation (Traphagen and Taill, 2014) report highlighted two emerging ecosystems in California: the California Academy of Sciences, Science Action Clubs in San Francisco, CA; and the Orange County STEM Initiative. The success of these models could provide important elements for a more comprehensive statewide STEM learning ecosystem.

5.2. BUSINESS AND COMMUNITY PARTNERSHIPS: THE STATE’S FUTURE NEEDS AND OPPORTUNITIES

Need for Guidance in the Partnership Development Process

While it is recognized that partnerships among educational institutions, the community, and businesses are crucial to expanding STEM learning for educators and students, bridging the gap between various partners remains a challenge. A few factors that create initial barriers are effective communication, infrastructure, and opportunities for potential partners to collaborate. For some educators, approaching potential business and industry partners can be intimidating due to perceived differences in the priorities of industry (profit) and education (people). Additionally, finding the time to approach businesses and cultivate partnerships is challenging when many educators struggle to keep up with their own classroom or school administration duties. For industries, knowing who, when, and how to approach potential partners in the education field can be similarly challenging. Creating a dynamic support system to connect and catalyze the development of STEM partnerships would be beneficial for all involved.

Need for Sustained Funding and Resources

The ability to sustain successful partnerships and programs remains challenging in these difficult economic times. Small, locally successful programs are often supported primarily by their communities and are highly sensitive to fluctuations in funding and in-kind resources. Foundations and corporations have shown interest in funding STEM programs, but a statewide strategy for sustained funding is urgently needed. A statewide strategy could include legislated incentives for businesses and industry to partner with the educational system to provide and leverage resources for better STEM learning opportunities for students, educators, and their communities.

Need for Data Collection and Analysis

While many STEM partnerships and expanded learning programs exist, information about their efficacy is inconsistent at best. A comprehensive approach to collecting data about the partnerships and programs, and assessing their outcomes (return on investment for business, enrollment and graduation rates in STEM vocational and academic programs for all students, employment numbers, etc.) is necessary to understanding the current state of STEM learning in California and improving it. Data collection and analysis can indicate where partnerships and programs are having success and need support, and set the stage for effective policy and advocacy for STEM learning opportunities. In their report *Monitoring Progress Toward Successful K-12 STEM Education* (2013b), the NRC developed fourteen indicators to monitor progress and provide data to better understand K-12 STEM implementation.

Change the Equation, a national nonprofit dedicated to mobilizing the business community to improve the quality of STEM learning, has a brief, *The Next Frontier for Data*, which summarizes the data it wished it had in analyzing the state of STEM learning for its own series of state and national reports (Change the Equation, 2012). This brief could act as a starting point or framework for California's own data collection. Collecting and analyzing key data will help California create a healthy statewide STEM ecosystem that evolves and is responsive to the needs of educators, students, and partners.

Opportunities to Deepen STEM Learning

The new CCSS and NGSS require the deepening and application of content knowledge and crosscutting concepts. The teaching and learning of such concepts requires hands-on and inquiry-based practices. Within the NGSS specifically, there is a focus on K-12 science education reflecting real world interconnections in science. Partnerships between businesses, schools, and community organizations that provide expanded and informal STEM education opportunities can offer students and educators more ways to learn and integrate STEM knowledge and skills.

5.3. BUSINESS AND COMMUNITY PARTNERSHIPS: KEY RECOMMENDATIONS

1. Advocate for policies and legislation that provide incentives for the creation and sustainability of partnerships, Career Technical Education opportunities, and hands-on learning opportunities through on-the-job training such as internships, research opportunities, summer employment, and shadow days (for younger students).
2. Establish the ability to access and exchange information statewide regarding STEM partnerships in order to track outcomes and support partnership creation and development.
3. Regularly conduct and disseminate a qualitative analysis (interview/survey) of STEM learning partners across the state for lessons learned and best practices in developing successful partnerships on a range of topics including communication, funding, and implementation.

A full set of recommendations from all sections of the report is available in Appendix 10.2.

6. STEM EDUCATION IN CALIFORNIA: A CALL TO ACTION

Many generations have walked through the doors of California’s public education system from preschools to colleges and universities. They found excellent educators ready to guide them, and they emerged ready to contribute to the state’s economic, social, and political progress. Key to this success has been California’s historically unprecedented investments in state and local educational infrastructure and capacity.

Today, California is in the midst of sweeping education changes. The state is rolling out the Common Core State Standards, the Next Generation Science Standards, and a new assessment system. Voters approved a temporary statewide tax increase, Proposition 30, which provides additional funding to schools after years of spending cuts. The Legislature has adopted a new school funding system (the Local Control Funding Formula, or LCFF) that shifts resources to school districts that enroll large numbers of students living in poverty and English learners, while granting local districts tremendous control over their budgets and spending. These positive changes lead to the inescapable conclusion that public education in California now stands at a crossroads: decisions taken today will influence students, educators, and schools for generations to come.

Given the pivotal importance of STEM education for California’s future, described in detail in this report, the time has come for California to take advantage of the new winds of change to prioritize STEM disciplines and approaches in all dimensions of our state’s educational system. California must ensure that our future education systems successfully provide students with the STEM education they urgently require for success in college, career, and life. This is not a passing fad or a short-term endeavor—as we transform our capacity to deliver quality STEM education, we must recognize that this is a long-term effort. We must think of these challenges and opportunities in terms of decades, not a few months or years. The commitment to STEM education must be ongoing and must transcend single budget and election cycles. It must also be understood in terms of an educational continuum with students and teachers prepared for the transition to the next part of the education structure. Whether this state can meet its STEM workforce needs depends on whether its preschoolers are ready for elementary school, elementary students are ready for middle school, its middle school students are ready for high school and its high school graduates are ready for postsecondary education and the workplace. And our STEM teachers must be ready to help those students achieve as they move along the continuum.

The effort required to achieve quality STEM education for all students will be significant but the rewards will be exponentially greater. California can and should lead the world, becoming again the state that cultivates human ingenuity and intelligence to fuel our economy and create a sustainable, healthy environment. This report provides a roadmap to that future and urges concerned state policy makers, leaders, and community members to take **immediate** action to make it a reality.

6.1. A VISION FOR STEM EDUCATION IN CALIFORNIA

The vision proposed by the task force for STEM education in California is by necessity bold. In the year 2020, current third-graders in California will be entering high school. All students who are now seventh-graders will be enrolled in colleges or universities or entering the workforce. Will they be prepared to major in STEM subjects and fill the critical pipeline of engineers, scientists, and innovators so essential to California’s future? Will they possess the STEM skills and attributes that our workforce demands? Will they have the habits of mind that make them successful in the world? Our ability to answer these questions in the affirmative is linked to the actions we take and the investments we make today to realize this future vision:

California leads the world in STEM education, inspiring and preparing all of its students to seize the opportunities of the global society through innovation, inquiry, collaboration, and creative problem solving.

While the state has pockets of STEM education excellence, the current status of STEM education in California remains far from optimal. This is attributed to several factors: a lack of resources; the need for more robust teacher-preparation programs; outmoded STEM curriculum and instruction; an emphasis on assessing achievement in knowledge retention terms rather than college- and career-readiness; and a lack of STEM-rich learning environments for students and educators as well as the infrastructure or processes that promote more cross-sector collaboration and partnerships.

Integrated, positive change to address all of those factors and the development of a holistic and comprehensive STEM strategy for the state of California requires new resources. Key stakeholders must cultivate the political will necessary to propel STEM education to the top of the priority list by raising awareness of the importance of STEM to the future of our state.

7. RECOMMENDATIONS AND NEXT STEPS

Realizing the STEM Task Force’s bold vision requires bold action. Building from our analysis, the task force recommends action in each of the seven primary strategic areas outlined below bringing the potential for both short-term impact and the longer-term realization of the full vision (see Figure 2 below):

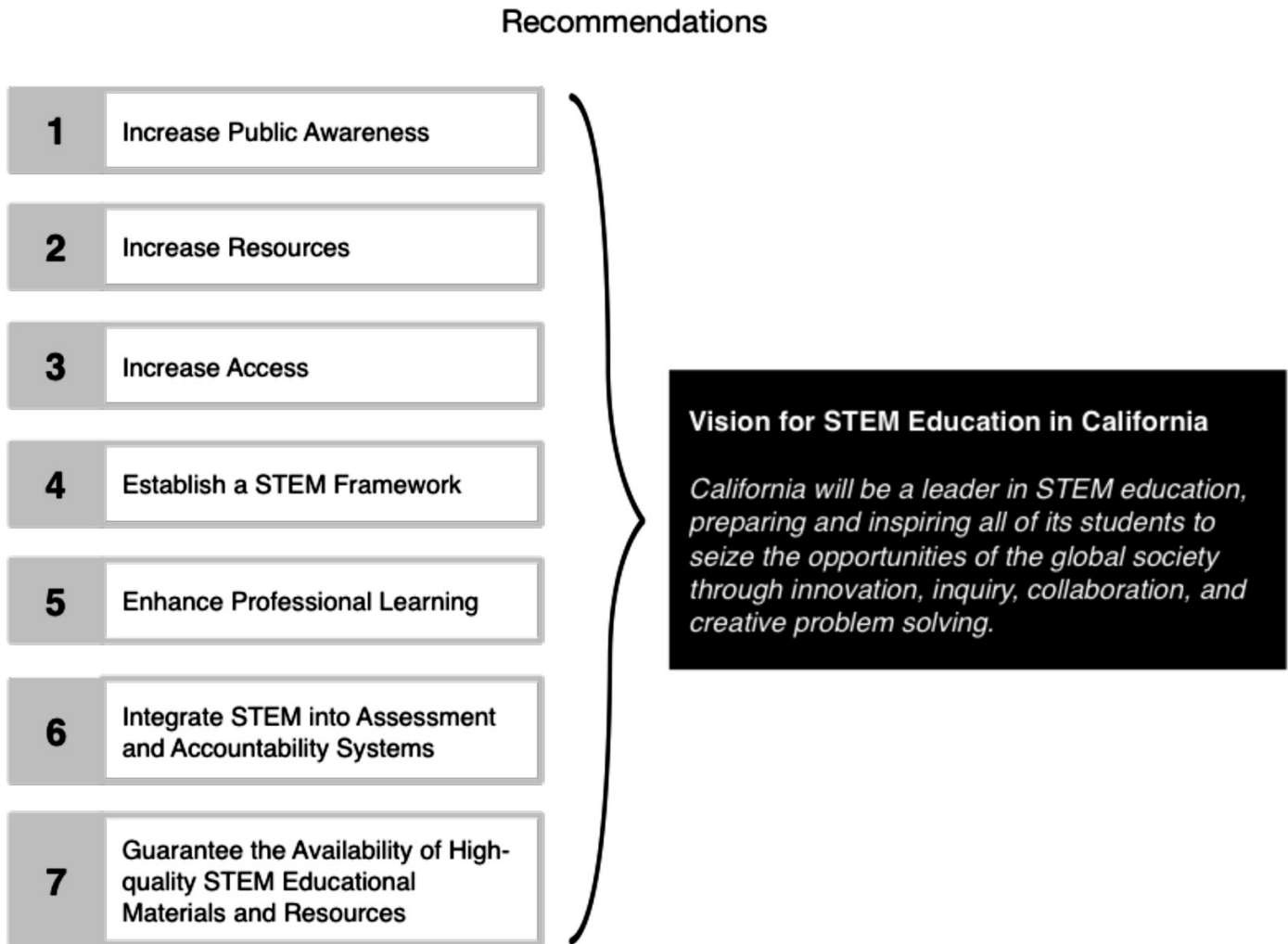


Figure 2

The STEM Task Force recommends aggressive strategic planning and the rapid mobilization of people and resources to ensure effective implementation in these action areas. Table 1 outlines these strategic action areas and the most critical next steps as this planning work translates the task force’s vision to reality.

TABLE 1: STEM TASK FORCE STRATEGIC ACTION AREAS AND PRIORITY NEXT STEPS

Strategic Action Area	Summary Description	Priority Next Steps
1. Increase STEM Public Awareness	Create a broad-based campaign to convey the importance of STEM education and ensure the availability of sufficient resources and public support to realize the vision for STEM education in the state.	<ul style="list-style-type: none"> • Identify campaign partners and leadership • Identify priority audiences • Identify priority messages
2. Increase STEM Resources	Increase resources for STEM learning from all stakeholders (government, business, philanthropy, communities) through additional and reallocated government and philanthropic funding, in-kind support, multi-sector participation, and innovative public/private partnerships.	<ul style="list-style-type: none"> • Advocate for increased state and federal funds earmarked for STEM • Advocate for STEM as a local priority through participation in the LCAP process • Advocate for legislative incentives to businesses to partner in STEM learning environments
3. Increase STEM Access	Make access to high-quality STEM experiences and programs universal to all K-12 students through a variety of opportunities in school, expanded learning, and community partnerships through informal, formal, and digital pathways.	<ul style="list-style-type: none"> • Identify barriers to and opportunities for access • Participate in local LCAP processes to ensure STEM inclusion
4. Establish a STEM Learning Framework	Establish a K-12 STEM Framework for teaching and learning that identifies the sequence of STEM knowledge, skills, and attitudes toward developing college, career, and life readiness skills and that incorporates the CCSS, NGSS, and associated curriculum frameworks.	<ul style="list-style-type: none"> • Identify the sequence of STEM learning from K-12 • Identify high-quality STEM materials that support the developing K-12 STEM Framework
5. Enhance STEM Professional Learning	Adopt policies and standards for quality STEM professional learning, development, and training to guide systems at the state, regional, and local school levels.	<ul style="list-style-type: none"> • Promote collaborative and professional learning at all levels • Increase opportunities for educators and administrators to access STEM learning in the public and private sectors
6. Integrate STEM into Developing Assessment and Accountability Systems	Integrate STEM into assessment and accountability systems in a cohesive, meaningful, and innovative fashion, taking advantage of the entire suite of assessment tools available to, and under development by, the state and LEAs at this time.	<ul style="list-style-type: none"> • Identify high-quality STEM formative and summative assessment tools

TABLE 1: STEM TASK FORCE STRATEGIC ACTION AREAS AND PRIORITY NEXT STEPS

Strategic Action Area	Summary Description	Priority Next Steps
7. Guarantee the Availability of High-Quality STEM Educational Materials and Resources	Ensure that state, regional, and local STEM educators can identify and access excellent learning resources.	<ul style="list-style-type: none">• Identify trusted sources of high-quality materials• Inventory existing high-quality materials• Develop a system to identify and exchange high-quality materials

While the task force would like to applaud the efforts taken to date by the California Department of Education, and highlight its instrumental role in realizing California’s STEM vision, the needs and opportunities in front of us dictate that the work ahead be undertaken and initiated at state, regional, and local levels by **all** concerned public and private stakeholders.

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10. APPENDICES

10.1. THE STEM TASK FORCE

In May 2012, State Superintendent of Public Instruction (SSPI) Tom Torlakson and Assemblywoman Susan Bonilla invited 54 educators, administrators, and leaders of partner organizations to serve as members of the STEM Task Force. The Task Force was charged with making recommendations to the SSPI on the direction science, technology, engineering, and mathematics (STEM) education should take in California, paying particular attention to remedying issues of access to high-quality learning experiences and meeting STEM workforce demands.

*At the beginning of his term of office in 2011, the SSPI brought leaders from across California—teachers, parents, community members, labor and business leaders—to form his Transition Advisory Team and share their thinking about education in the state. The Transition Advisory Team identified key issues impacting students, schools, districts, and the California Department of Education (CDE) and set goals to address them. The resulting report, *A Blueprint for Great Schools (2011)*, provides vision and direction for California’s education system, including a focus on twenty-first century learning, meeting the needs of the whole child, and rebuilding the ranks of California’s teachers with resources and respect. Recommendations in the report prompted the State Superintendent to initiate the formation of the STEM Task Force.*

Task Force History

The STEM Task Force set out to explore the status of STEM education in the areas of professional learning; curriculum and instructional practices; assessment; business and community partnerships; and resources.

The effort was co-chaired by Dr. Herb Brunkhorst, Professor Emeritus of Science Education and Biology, California State University, San Bernardino and Dr. Susan Hackwood, University of California, Riverside Professor of Electrical Engineering and Executive Director of the California Council on Science and Technology. Task force members included teachers and administrators from K-12 and higher education as well as leaders of partner organizations. The CDE staff provided strong support to the work of the task force.

How the Task Force Organized its Work

Five working groups met in person and by conference call to address five key areas—curriculum and instruction, testing and assessment, professional learning, business and community partnerships, and resources— and to develop recommendations for the SSPI.

1. The **curriculum and instructional practices work group** reviewed the status of STEM education and made recommendations on how to improve instructional practices and engage more students in STEM-related fields.
2. The **student testing and assessment work group** recommended state and local STEM-related testing and assessments that measure applied learning in real-world situations and identified what constitutes high-quality STEM programs and disciplines.
3. The **professional learning work group** identified the status of existing professional learning and recommended new support that provides high-quality professional learning opportunities to educators of STEM-related courses and disciplines.

4. The **business and community partnerships work group** identified community and business partnerships and recommended how these partnerships, including those in informal learning settings, can support and engage students in STEM education.
5. The **resources work group** identified existing resources and recommended the development and dissemination of additional resources to assist schools in developing STEM programs that are relevant and engaging to students.

The STEM Task Force members assessed the state’s future needs and created a blueprint for improving teaching, learning, and equal access to STEM-related courses and careers for K-12 students. The public was invited to contribute information—including resources and research—to the Task Force via the Brokers of Expertise Web site at CommentSTEM.myboe.org.

An initial report was prepared in May 2013 at the same time as major new developments in K-12 education in California were evolving. In March 2014, the task force chairs and working group co-chairs met to update the report and align it with these new developments: Common Core State Standards implementation, Next Generation Science Standards adoption, the state’s student assessment system under transformation, and the state’s adoption and rollout of the Local Control Funding Formula.

The Californians Dedicated to Education Foundation engaged the Glen Price Group (GPG), an independent consulting group with prior experience working with the CDE task forces (*A Blueprint for Great Schools, Greatness by Design*) to coordinate and implement the final revisions to the STEM Task Force report.

10.2. STEM TASK FORCE RECOMMENDATIONS

Table 2: Working Group Recommendations
STEM Task Force Vision
<i>California leads the world in STEM education, inspiring and preparing all of its students to seize the opportunities of the global society through innovation, inquiry, collaboration, and creative problem solving.</i>
Professional Learning
Establish and/or support, with consistent funding, a variety of high-quality STEM professional learning opportunities led by trained professional learning providers that increase state, regional, and district capacity for delivering excellent STEM education.
Adopt policies and standards for quality STEM professional learning to provide guidance at the state, regional, and local school levels.
Implement a system of periodic review of state STEM-related policies to monitor effectiveness and provide flexibility.
Curriculum and Instruction
Establish a K–12 STEM Framework for teaching and learning that identifies the sequence of STEM knowledge, skills, and attitudes toward developing skills for career and college readiness, and that incorporates the CCSS, NGSS, and associated curriculum frameworks.
Establish a rubric for determining the quality of STEM instructional materials.
Recommend minimum amounts of instructional time per week for STEM topics. Additionally, recommend that a portion of this instructional time focus on science, technology, or engineering.
Establish a framework for the integration of experiential learning between the K-12 regular school day and expanded learning opportunities.

Table 2: Working Group Recommendations

Student Assessment

Consult with STEM teachers and other key STEM stakeholders in the development of the recommendations for assessing grade level and curricular content areas beyond those required by the Elementary and Secondary Education Act.

Develop meaningful ways to integrate STEM into the emerging assessment system in a cohesive and innovative fashion, taking full advantage of the entire suite of assessment tools available to the state and LEAs at this time. This should encompass including STEM assessment recommendations as California implements AB 484.

Business and Community Partnerships

Advocate for policies and legislation that provide incentives for the creation and sustainability of partnerships, Career Technical Education opportunities, and hands-on learning opportunities through on-the-job training such as internships, research opportunities, summer employment and shadow days (for younger students).

Establish the ability to access and exchange information statewide regarding STEM partnerships in order to track outcomes and support partnership creation and development.

Regularly conduct a qualitative analysis (interview/survey) of STEM learning partners across the state for lessons learned and best practices in developing successful partnerships on a range of topics including communication, funding, and implementation.

11. FOOTNOTES

1. See Appendix 10.1 for the task force charge and key activities.
2. Chapter Seven, *Recommendations and Next Steps*, provides further discussion of each of these recommendations. Each of the task force's working groups also created recommendations that are described in the chapters that follow and are closely aligned with the overarching goals. A full set of recommendations from all sections of the report is available in Appendix 10.2.
3. The Organisation for Economic Co-operation and Development (OECD) (French: Organisation de coopération et de développement économiques, OCDE) is an international economic organization of 34 countries founded in 1961 to stimulate economic progress and world trade.
4. The NAEP is the largest nationally representative assessment of what America's students know and can do in various subject areas. Assessments are conducted periodically in mathematics, reading, science, writing, the arts, civics, economics, geography, U.S. history, and beginning in 2014, in Technology and Engineering Literacy.
5. For example, the 1997 content standards for measurement and geometry mathematics in grade 3 specify that students must be able to identify, describe, and classify polygons (including pentagons, hexagons, and octagons) and identify attributes of quadrilaterals (e.g., parallel sides for the parallelogram, right angles for the rectangle, equal sides and right angles for the square). In contrast, the CCSS for geometry in mathematics in grade 3 requires that students understand that shapes in different categories (e.g., rhombuses, rectangles, and others) may share attributes (e.g., having four sides), and that the shared attributes can define a larger category (e.g., quadrilaterals). They must also recognize rhombuses, rectangles, and squares as examples of quadrilaterals, and draw examples of quadrilaterals that do not belong to any of these subcategories (National Governors Association Center for Best Practices and Council of Chief State School Officers, 2010).

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