POSITION STATEMENT

STEM Education Teaching and Learning

Introduction

The National Science Teaching Association (NSTA) strongly supports STEM (science, technology, engineering, and mathematics) education that provides students with an interdisciplinary approach to learning. STEM education makes learning "real" and gives students opportunities to see the connection between the content they are studying and the application of that content in authentic and relevant ways. STEM education is an experiential learning pedagogy in which the application of knowledge and skills are integrated through in-context projects or problems focused on learning outcomes tied to the development of important college and career readiness proficiencies. The research (Renninger 2000; Tai et al 2006) identifies that personal interest, experience, and enthusiasm are critical to supporting children's science learning and can be a catalyst for long-term, sustained interest into adulthood. As

described in *A Framework for K–12 Science Education,* many important decisions in the 21st century will require the abilities of the citizenry to frame scientific questions pertinent to their interests; evaluate complex social, civic, economic, political, and personal issues; seek out relevant data and scientific argument; and communicate their understandings and arguments to others.

The importance of STEM education to our nation's future cannot be overstated. As explained in the National Science Foundation (NSF) report *A National Action Plan for Addressing the Critical Needs for U.S. Science, Technology, Engineering, and Mathematics Education System,* "In the 21st century, scientific and technological innovations have become increasingly important as we face the benefits and challenges of both globalization and a knowledge-based economy. To succeed in this new information-based and highly technological society, students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past." (NSF 2007)

Over the past 25 years, STEM education has been evolving from a convenient clusterin Help lapping disciplines (science, technology, engineering, mathematics) toward a more coh ge base and skill set critical for the 21st century. It now encompasses areas of computer science, the "designed world," and robotics, as each of these areas reflect the integration of the original four domains of study in which the goals are to resolve problems and create innovative solutions to proposed challenges. These broader categories reveal the opportunities in the current and future workforce. According to the U.S. Department of Commerce, employment in STEM occupations grew much faster than employment in non-STEM occupations over the last decade (24.4% versus 4.0%, respectively), and STEM occupations are projected to grow by 8.9% from 2014 to 2024, compared to 6.4% growth for non-STEM occupations (Department of Commerce 2017).

Recent Pew Research Center (Graf et al 2018) data shows that STEM workers earn approximately 25% more than similarly educated non-STEM workers, regardless of the education level attained. Overall, blacks and Hispanics are underrepresented in the STEM workforce relative to their shares in the U.S. workforce as a whole. The number of women in STEM-related jobs has increased in the areas of life and physical sciences, but has actually decreased in one of the highest-paying and fastest-growing STEM clusters: computer occupations. In 1990, 32% of workers in computer occupations were women; today, women's share has dropped to 25%.

A STEM-literate populace and workforce is necessary to sustain the U.S. competitive advantage in the age of globalization: not only as researchers, doctors, and engineers, but also as a hugely technical workforce that can help secure our health and safety, revitalize our utility infrastructures, monitor our food production, and improve our manufacturing efficiencies and capabilities. We must employ all members of the labor pool, especially those who have been overlooked and underrepresented, such as women and minorities. The National Science Board in *A Policy Companion Statement to Science and Engineering Indicators 2018* states, "All our people must be armed with the skills and knowledge to meet the future head-on. Among the groups that are underutilized, yet essential to our future competi-

tiveness, are workers who use technical skills in their jobs but who do not have a four-year degree ("skilled technical workers"), and people at all education levels who have been historically underrepresented in STEM. Growing the skilled technical workforce and reducing barriers to participation in STEM will increase individual economic opportunity and support our Nation's leadership in science and technology."

STEM Education Today

Modern STEM education promotes not only skills such as critical thinking, problem solving, higher-order thinking, design, and inference, but also behavioral competencies such as perseverance, adaptability, cooperation, organization, and responsibility (NSTC 2018).

STEM is not a single subject, and it should not replace other subjects. Students need to learn the same concepts and skills in science and mathematics as they did before, and how to solve problems through engineering design challenges. STEM experiences must be connected and support the goals of state science standards, as well as those established in *A Framework for K–12 Science Education* and articulated in the *Next Generation Science Standards* (*NGSS*),by providing students the opportunity to grasp and experience the relevancy of what they are learning.

STEM is also not a curriculum, but rather a way of organizing and delivering instruction. It is not another "ingredient" in the lesson "soup," but the recipe for helping learners apply their knowledge and skills, collaborate with their peers, and understand the relevance of what they are learning. This does not de-emphasize the teaching of core ideas, but rather gives students the ability to know how they can apply the content they are learning.

Today STEM is identified in many different ways, including in computer science and engineering/robotics. Computer science courses focus on problem solving through coding, as in the coding opportunities presented in the Hour of Code, the global movement spurred by education leaders in computer science, or in Girls Who Code, the national nonprofit organization that aims to close the gender gap in technology by building girls' confidence and expanding their computer experience. Robotic challenges highlight engineering challenges like the FIRST Robotics Competition, which teams students, coaches, and companies. Many corporations, such as Shell, Toyota, Boeing, and Lockheed Martin, also promote these engineering design/problem challenges, which are mainly for middle and high school students.

STEM education leaders must continue to broaden and deepen the scope of STEM education and further transcend the fields of study beyond just a combination of the four disciplines to include the arts and humanities (i.e., STEAM). The ability to think creatively, to communicate ideas in writing and speech with precision and clarity, to formulate and defend arguments based on evidence, and to create visual or digital models that convey evidence clearly and succinctly require students to have a strong founda-

tion in language and creative arts. The ability to fully comprehend global issues requires that students can acknowledge and appreciate important cultural norms, social biases, and historical accomplishments of other countries and peoples. It is the combination of all of these factors that drive our innovations and technological advancements.

To achieve this, educators and other leaders representing the entire educational system should consider redefining what learning success looks like for STEM education. This includes reevaluating how the physical classroom structure could better support inclusion, peer discourse, and ongoing engineering design innovations; making a commitment to advocate for a comprehensive STEM education that begins in preschool and continues post–high school; and actively promoting diversity in STEM education for all students.

Lastly, STEM experiences should provide opportunities to unify communities by engaging multiple stakeholder groups, including teachers, business leaders, parents, policy makers, and most of all, students, in working toward common goals. The engagement of the entire community should play a critical role in shaping the STEM vision, promoting its importance economically, supporting its implementation through active participation like mentoring, and creating an environment of shared values. Such community advocacy can improve opportunities for many community members and raise the standard of living for all citizens.

Declarations

As the leading organization for science teaching and learning, NSTA asserts that educators, administrators, parents, and all stakeholders should consider the following recommendations as they develop and refine STEM education programs.

1. STEM education programs should be grounded in the tenets of constructivism supported by the findings of three decades of cognitive science. Integrated STEM education occurs when
   - learning is viewed as an active, constructive process, and not a receptive one;
   - student motivation and beliefs are integral to cognition;
   - social interaction is fundamental to cognitive development; and
   - knowledge, strategies, and expertise are contextualized in the learning experience.

2. High-quality K–12 STEM education is an essential, relevant, and continual endeavor for all students. STEM education
   - enables analytical and critical thinkers;
   - increases science, mathematics, and technology literacy;
   - fosters the next generation of innovators and entrepreneurs;
   - provides opportunities for students to engage in 21st-century skills of teamwork, collaboration, problem solving, communication, and creative thinking; and

- offers learning experiences in which students apply what they are learning in relevant, meaningful ways.

3. The promotion and advocacy of STEM education should focus on the following:
   - Teachers, school administrators, school boards, and school and district leaders should identify common goals and pathways to create a shared vision and definition of STEM teaching and learning for their communities.
   - Teachers of STEM should be provided with resources necessary to implement quality STEM education in their classrooms, including opportunities for professional growth and learning through continual and sustained training, mentoring, and support services, as they plan, develop, and execute their STEM lessons and units.
   - Schools and districts should continually provide access to technologies, materials, tools, and resources to facilitate the application of integrated STEM teaching and learning.
   - Schools and districts should recognize that STEM education begins as early as preschool and provide accessible educational experiences that span the preK–16 spectrum. This includes embracing new approaches to STEM teaching, creating new definitions of learning success, and considering new ideas about the physical structure of the educational environment so that it is more inclusive and conducive to exploration, discovery, and design iteration.
   - Schools and districts should implement models of professional learning and ongoing support to sustain changes in pedagogy, including instructional methods that promote learning for adults that mirror the methods to be used with students.
   - Schools, districts, employers, the community at large, and all interested stakeholders should seek opportunities to build a capacity for joint learning, job shadowing, and mentoring of students to support students' transition into the workforce.
   - Schools, districts, employers, the community at large, and all interested stakeholders should help promote, facilitate, and financially support STEM educator training so that all teachers can enhance their cross-disciplinary skills and knowledge, and provide for or increase the necessary collaboration time for educators to plan, learn, share, and improve their integrated STEM instructional units.

—Adopted by the NSTA Board of Directors, February 2020

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