ASME
SETTING THE STANDARD

GENERAL POSITION PAPER

STRENGTHENING PRE-COLLEGE

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS (STEM)

EDUCATION IN THE U.S.

A Technological Literacy & Workforce Imperative

PS14-23 | SEPTEMBER 2014

GOVERNMENT RELATIONS
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INTRODUCTION

Over the past quarter century, there has been an increased understanding and support by many federal, state, and local policymakers about the importance of strengthening U.S. science, technology, engineering, and mathematics (STEM) concepts and skills in the pre-college (K-12) education curriculum. Yet, a more focused effort is needed as U.S. students continue to be average or below average on international tests, and the number of workers engaged in scientific and engineering research continues to rapidly increase worldwide[1,2]. With this ever increasing global and technology-driven workforce, it is essential that the United States align its K-12 core curriculum to the expectations of its 21st century workforce, ensuring its future leaders remain competitive in the global economy.

Strong K-12 STEM education is not just for those students wishing to pursue technical degrees in higher education. In a world in which so many emerging industries are based on technology and its applications, all citizens should be technologically literate, and able to participate in an increasingly technological society. Additionally, with the predicted changes in future U.S. workforce demographics by the middle of the 21st century, bolstering the access to and participation of women and underrepresented groups in the U.S. STEM workforce is essential to fueling innovative and diverse ideas for the future.

Every two years, ASME, a professional technical society of more than 130,000 members worldwide, surveys its members regarding their public policy priorities. K-12 STEM education has remained one of the Society's top priorities for action by public policymakers for several years. Since 1992, the Society's Committee on Pre-college Education has been actively developing and supporting programs and materials that strengthen STEM education in the K-12 classroom through its own initiatives and in partnerships with many other organizations.

For more information, please visit:
https://community.asme.org/board_education_pre_college_engineering/default.aspx

RECOMMENDATIONS

Parents, educators, governments at all levels, and the private sector each have important roles in ensuring that future generations will possess the skills and critical competencies necessary to be successful in a highly competitive, global, and technologically sophisticated 21st century economy. These stakeholders must work together to ensure that all children receive the STEM education and training essential for future success.

1 *PISA 2012 Results in Focus*. Organisation for Economic Co-operation and Development, 2012.
2 *Science and Engineering Indicators 2014*. National Science Board, 2014.

ASME offers the following recommendations for improving K-12 STEM educational performance:

- Support efforts to strengthen the inclusion of engineering and technology concepts in K-12 STEM education through the promotion of high-quality common standards and assessments.
- Recruit, train, and retain qualified K-12 STEM teachers to meet demand.
- Encourage women and underrepresented groups to pursue STEM coursework and careers.
- Increase federally funded research focused on STEM teaching and learning, especially grants to schools that are focused on implementation, adoption, and widespread expansion of evidence-based teaching methods.
- Foster partnerships among educational institutions, industry, and non-profit organizations to leverage resources and improve STEM education.

Support efforts to strengthen the inclusion of engineering and technology concepts in K-12 STEM education through the promotion of high-quality common standards and assessments.

Development of effective STEM curriculum and assessment tools must be based on high standards of achievement. These standards should extend well beyond requiring knowledge of fundamental STEM facts, processes, and techniques. They should support curricula that cultivate creative, critical thinking skills and encourage interdisciplinary approaches to issues and problems.

According to the National Academy of Engineering report, *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*, the introduction of engineering education to the K-12 classroom has the potential to promote critical thinking, provide new levels of relevancy to motivate students to learn science content, make engineering and engineering careers more accessible to all students, and prepare the next generation to solve global problems facing humanity.[3]

ASME has been supportive of the next generation science standards (NGSS) since their inception, especially since it is the first time engineering content has been included in K-12 science standards in such a meaningful way. While exposure to formal engineering education has increased dramatically over the past 20 years, most students in the United States have never experienced an engineering course or lesson, or still have a misperception and misunderstanding about engineering.

Policymakers can help strengthen K-12 STEM education through efforts that:

- Support the development of hands-on, open-ended problem-solving curricula and modules of engineering problems, grouped by discipline and level of difficulty and based on research, for the K-12 classroom;
- Promote engineering habits of mind, including systems thinking, creativity, collaboration, communication, and attention to ethical considerations;
- Fully incorporate the engineering design process into NGSS and other K-12 state and local standards;
- Pursue the development of better assessment mechanisms aligned with state and local

[3] *Engineering in K-12 Education: Understanding the Status and Improving the Prospects.* National Academies, 2009.

standards;

- Resist the tendency to "push back" standards when assessment results are less than satisfactory; and,
- Improve coordination of existing STEM education programs across the federal science and engineering agencies.

Recruit, train, and retain qualified STEM teachers to meet demand.

High-quality teaching can have lasting effects on students.[4] According to the 2014 Science and Engineering Indicators, however, "novice science teachers—those with 2 or fewer years of experience—are more prevalent at schools with the highest proportions of low-income and non-Asian minority students."[5] Other school factors like the pursuit of reduced class sizes or pay differentials between individual school districts also increase the demand for more qualified STEM teachers.

A related concern is the number of teachers who are currently teaching out of their respective fields of expertise, especially in the middle and high school grades. In 2012, 73% of high school mathematics teachers had an undergraduate or graduate degree in mathematics or mathematics education, and 82% of high school science teachers had an undergraduate or graduate degree in science (any subject), engineering, or science education. However, the percentages vary widely between individual districts.[6]

In addition, for graduates with STEM degrees, the lure of higher salaries in the private sector depletes the potential supply of qualified K-12 science, mathematics, and technology/engineering teachers. And for those degreed in STEM that may have an interest in teaching but are not certified, they might face additional time and/or cost investment for educational certification, depending on state requirements, which might further discourage STEM graduates from pursuing teaching careers.

Policymakers can enhance the recruitment, training, and retention of qualified STEM teachers by creating programs which:

- Attract new university graduates with degrees in STEM fields to teaching careers through student loan forgiveness, bonuses, tax incentives, and financial support for teacher certification;
- Develop and implement alternative certification and transition-to-teaching programs for engineers and other technical professionals;
- Allow for differential pay scales to help attract and retain qualified STEM educators;
- Improve in-service professional development focusing on STEM curricula;
- Institute mentoring programs for STEM personnel in schools;
- Educate pre-service and in-service teachers on proven student-learning methodology in teacher professional development programs;

[4] Chetty, Friedman, Rockoff, "The Long-Term Effects of Teachers: Teacher-Value Added and Student Outcomes in Adulthood. National Bureau of Economic Research: December 2011.
[5] *Science and Engineering Indicators 2014*. National Science Board, 2014.
[6] *Science and Engineering Indicators 2014*. National Science Board, 2014.

- Include/increase STEM coursework in pre-service/university teacher training; and,
- Produce, evaluate, and disseminate the best practices in STEM programs and online curricula, so that they are easily accessible to educators.

Encourage women and underrepresented groups to pursue STEM coursework and careers.

Currently, the U.S. has an untapped pool of potential STEM professionals, particularly women and underrepresented minorities. By leveraging the diversity of these individuals' perspectives and bolstering their participation in the STEM workforce, more innovative and diverse ideas would be generated, which would fuel the innovation necessary for our future global competitiveness.

We urge federal, state, and local policymakers to strengthen and re-examine oversight of existing legislation and programs aimed specifically at broadening participation by underrepresented groups in STEM fields, including those which:

- Enable all students to have access to a rigorous STEM curriculum, hands-on laboratory experiences, and informal learning that increases academic performance and interest in STEM careers, which can also provide opportunities for families and future economic stability;
- Increase public awareness of STEM careers, including supporting efforts to foster outreach to all students, teachers, parents, and K-12 guidance counselors;
- Consciously work against biases (conscious or unconscious) and work toward making sure the STEM workforce reflects U.S. citizenry;
- Offer incentives and mentoring for women and underrepresented groups to pursue STEM coursework and careers, including teaching careers, and continue to provide professional achievement opportunities post-graduation and throughout their careers.

Increase federally funded research focused on STEM teaching and learning, especially grants to schools that are focused on implementation, adoption, and widespread expansion of proven teaching methods.

The educational research community has developed many excellent pilot studies and programs based on what teaching methods work best in K-12 STEM education classrooms. However, many times, there are insufficient funds to be able to widely disseminate these evidence-based teaching methods into local schools. Policymakers should increase federally funded research focused on STEM teaching and learning, especially those programs which:

- Provide resources to help schools implement and adopt proven STEM teaching methods, i.e. allows schools time to undergo the curriculum changes and teacher training needed to adopt these programs into their schools; and,
- Increase the evaluation components of research focused on STEM teaching and learning.

Foster partnerships among educational institutions, industry, and non-profit organizations.

ASME and other organizations currently partner with non-profit organizations and educational entities (e.g., the FIRST Robotics Competition, the Girl Scouts and the Boy Scouts) to further K-12 STEM

learning. Many corporations also sponsor educational projects at their local community schools.

Leveraging these resources, policymakers should support the development of partnerships among educational institutions, industry, and non-profit organizations which:

- Facilitate the ability for STEM professionals to work with teachers and students, while also improving the image of STEM careers;
- Foster adopt-a-school programs;
- Promote relevant summer externships for teachers in STEM positions at local corporations, government laboratories, and universities;
- Develop recognition awards for private sector STEM involvement; and,
- Create and fund the publication and dissemination of materials for public outreach, including parental and guidance counselor education, on the potential impact of a quality K-12 STEM education on the future workforce.