



Strengthening Pre-College STEM Education in the United States as a Technology Literacy and Workforce Imperative

INTRODUCTION

Since the 1990's, there has been increasing bipartisan support by federal, state, and local policymakers for strengthening science, technology, engineering, and mathematics (STEM) concepts and skills in pre-college (K-12) education curriculum. However, the United States is not the only country that has recognized a need for increased focus on STEM education. As the world marketplace becomes more reliant on STEM skills, global competition for a technologically literate and ready workforce grows, deeming it essential that the U.S. aligns its K-12 core curriculum to the expectations of its 21st century workforce.

Strong K-12 STEM education is not only important for students wishing to pursue technical degrees in higher education. All citizens need to be more technologically literate to be competitive in an economy where many emerging industries are based on technology and its applications, and where technological tools permeate a broadening spectrum of workplace tasks. Additionally, access to pre-college STEM education will help aid in the transition to a more diverse U.S. workforce. With predicted changes in demographics by the middle of the 21st century, bolstering access to, and the participation of, women and underrepresented groups in the U.S. STEM workforce is essential to fueling innovative and diverse ideas for the future.

Since 1992, ASME'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. ASME considers K-12 STEM education a top priority for action by policymakers and itself plays an active role in developing a technologically literate and skilled workforce through [ASME K-12 STEM Education Programs](#).

RECOMMENDATIONS

Parents, educators, and 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 students receive the STEM education and training essential for future success.

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

1. *Encourage all K-12 schoolchildren to build STEM skills and understand what is needed of them now to be able to major in STEM in college.*
2. *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.*
3. *Recruit, train, and retain qualified K-12 STEM teachers to meet demand.*
4. *Encourage women and underrepresented groups to pursue STEM coursework and careers.*
5. *Increase federally funded research focused on improving STEM teaching and learning, especially grants to schools that are focused on implementation, adoption, and widespread expansion of evidence-based teaching methods.*
6. *Foster partnerships among educational institutions, industry, and non-profit organizations to leverage resources and improve STEM education.*

1. *Encourage all K-12 schoolchildren to build STEM skills and understand what is needed of them now to be able to major in STEM in college.*

Despite the rapidly growing STEM job market, not enough American students are picking STEM majors and those who do need to be more adequately prepared and better able to compete with talent globally. Engineering majors and careers specifically should be encouraged among K-12 students as accreditation requirements have made engineering curricula less flexible, requiring students to be more selective in choosing their courses. For example, completing a bachelor's degree in engineering in a reasonable timeframe is difficult if a student lacks preparation in calculus and physics before entering college. Students who are interested in becoming engineers would be well-served to plan for this during high school. Further, it is imperative that colleges and universities be involved in aiding these K-12 STEM efforts. This can take the form of research in education and pedagogy, conducting outreach to help students know what is needed in high school to be prepared to pursue a STEM major, or developing curricula intended to help STEM majors enter teaching careers.

In addition to encouraging students themselves to pursue STEM majors and careers, it is important that teachers are educated in the curriculum and STEM pathways. It is important for K-12 educators and curriculum developers to recognize that educational materials are increasingly delivered online. As more and more schools and students can access online

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materials, we have the opportunity to bring high-quality instructional materials to schools and students who may not have access to well-trained STEM teachers. The materials alone are not a substitute for good teaching, but their availability can begin to alleviate the disadvantages faced by students who do not have the benefit of STEM teachers at their own schools.

Policymakers can encourage all schoolchildren to pursue STEM careers by:

- Encouraging students to consider engineering majors and careers specifically, not just STEM generally.
- Emphasizing the need to encourage all schoolchildren to pursue STEM.
- Enlisting colleges and universities to aid with K-12 STEM efforts.
- Using online platforms to create greater access STEM education materials.
- Encouraging students with potential interest in STEM careers to take more math and science courses while in high school.

2. 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.¹

ASME has been supportive of the next generation science standards (NGSS) since their inception. The NGSS values engineering education equally with mathematics and science, which have traditionally been taught to all students beginning at a young age.² The NGSS represents the first-time engineering content has been included in K-12 science standards in a meaningful way.

Policymakers can help strengthen K-12 STEM education by supporting efforts that aim to:

- Increase 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.

¹ Engineering in K-12 Education: Understanding the Status and Improving the Prospects. National Academies, 2009.

² <https://successfulstemeducation.org/resources/engineering-emphasizing-%E2%80%9Ce%E2%80%9D-stem-education>

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

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

High-quality teaching can have lasting effects on students.³ According to the most recent Science and Engineering Indicators report, “highly qualified teachers are less prevalent at schools with high-minority and high-poverty populations.”⁴ For instance, in 2015 (most recent year for which data are available), 75% of all eighth graders had a mathematics teacher with more than 5 years of teaching experience. That number dips to 69% of students when only considering schools with high minority enrollment, and the number rises to 78% of students when only considering schools with low minority enrollment.⁵

For college 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. Those who have STEM degrees and may have an interest in teaching, but are not certified, might face time and/or cost requirements for educational certification that can further discourage them from pursuing teaching careers.

There is also a significant need for increased teacher involvement in planning, expanding, and improving pre-college engineering education. A recent National Academies of Engineering report titled [Increasing the Roles and Significance of Teachers in Policymaking for K-12 Engineering Education](#) found that “many of the policies and practices that shape K-12 engineering education have not been fully or, in some cases, even marginally informed by the knowledge of teacher leaders ... the problem is exacerbated for education in engineering, because this is a subject about which most K-12 educators, administrators, and policymakers lack content or conceptual knowledge.” Therefore, it is not only essential to recruit, train, and retain qualified STEM teachers, but it is equally important to involve them in the development of curriculum and educational policies surrounding pre-college engineering education.

³ Chetty, Friedman, Rockoff, “The Long-Term Effects of Teachers: Teacher-Value Added and Student Outcomes in Adulthood. National Bureau of Economic Research: December 2011.

⁴ <https://nces.nsf.gov/pubs/nsb20196/teachers-of-mathematics>.

⁵ <https://nces.nsf.gov/pubs/nsb20196/teachers-of-mathematics>.

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

- Attracting new university graduates with degrees in STEM fields to teaching careers through student loan forgiveness, bonuses, tax incentives, and financial support for teacher certification.
- Developing and implementing alternative certification and transition-to-teaching programs for engineers and other technical professionals.
- Allowing for differential pay scales to help attract and retain qualified STEM educators.
- Improving in-service professional development focusing on STEM curricula.
- Instituting mentoring programs for STEM personnel in schools.
- Educating pre-service and in-service teachers on proven student-learning methodology in teacher professional development programs.
- Promoting STEM coursework in pre-service/university teacher training.
- Producing, evaluating, and disseminating the best practices in STEM programs and online curricula, so that they are easily accessible to educators.
- Increasing the roles and significance of teachers in policymaking for K-12 engineering education.

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

The U.S. economy relies on the productivity, creativity, and entrepreneurship of all U.S. citizens, yet women and minorities are significantly underrepresented in STEM fields. To address the issue of gender and racial underrepresentation in the engineering workforce and the STEM workforce more broadly, it is important to examine gender and racial disparities in overall postsecondary education. For instance, when it comes to racial diversity specifically, the underrepresentation of minority groups in engineering and STEM can in large part be attributed to the lack of diversity in higher education in general.ⁱ However, the underrepresentation of women in engineering is specifically related to the field of study and not tied to the overall number of female postsecondary degree seekers. While racial underrepresentation is a systemic issue in postsecondary education, gender disparity is specifically a problem in engineering.

Understanding why and in which ways women and minorities are underrepresented in engineering is essential in making actionable, result-driven recommendations on how best to increase diversity and inclusion in STEM. 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.

ⁱ Su, L. (2010). Quantification of diversity in engineering higher education in the United States *Journal of Women and Minorities in Science and Engineering* 16(2), 161–175.

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We urge policymakers to aim to broaden participation by underrepresented groups in STEM fields, by:

- Enabling 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.
- Increasing public awareness of STEM careers, including supporting efforts to foster outreach to all students, teachers, parents, and K-12 guidance counselors.
- Consciously working against biases (conscious or unconscious) and striving for a STEM workforce that reflects the U.S. citizenry.
- Offering incentives and mentoring for women and underrepresented groups to pursue STEM coursework and careers, including teaching careers, and continuing to provide professional achievement opportunities post-graduation and throughout their careers.

5. *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, often 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 for:

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

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

The ASME INSPIRE program—a scalable STEM education program that delivers a mind-expanding learning experience primarily to middle and high school students who might otherwise never be exposed to the opportunities available in engineering—is currently being offered to more than 100,000 students in over 1,300 schools in all 50 states.⁶ Many other non-profit organizations, educational entities, and corporations also sponsor educational projects at their local community schools to further K-12 STEM learning.

⁶ <https://www.asmefoundation.org/programs/stemeducation/asme-inspire/>.

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

- Facilitating the ability for STEM professionals to work with teachers and students, while also improving the image of STEM careers.
- Fostering adopt-a-school programs.
- Promoting relevant summer externships for teachers in STEM positions at local corporations, government laboratories, and universities.
- Developing recognition awards for private-sector STEM involvement.
- Creating and funding 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.
