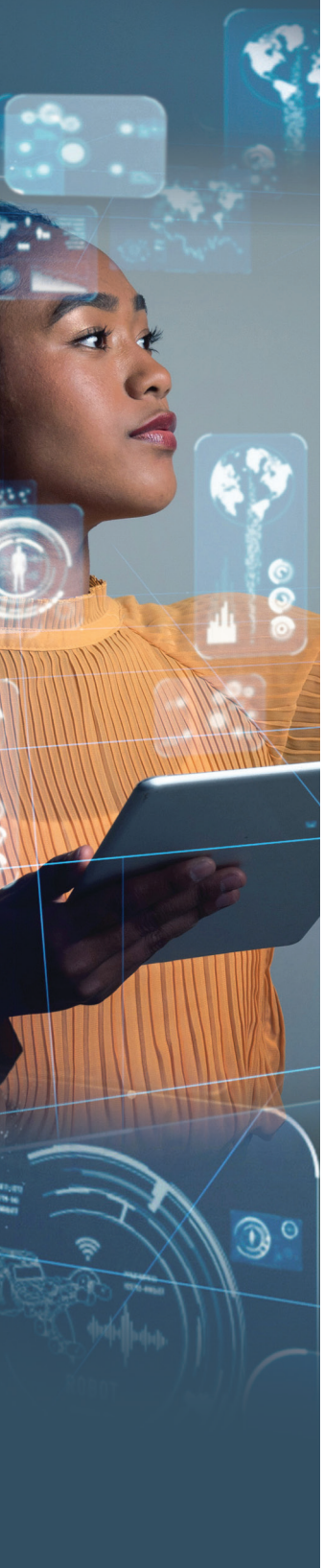

Cultivating Interest and Competencies in Computing

Authentic Experiences and Design Factors

Highlights for Policymakers

This consensus study by the National Academies of Sciences, Engineering, and Medicine documents the evidence on the role of authentic science, technology, engineering, and mathematics (STEM) learning experiences in developing interest and competencies for computing. The authoring committee consisted of experts in the design and construction of learning spaces in formal and informal STEM and computing education settings. The full report includes the committee's findings, conclusions, and recommendations.

This brief presents six key takeaways and five steps for action for national, state, and local leaders who shape policies, priorities, and funding for primary, secondary, and postsecondary education and informal learning.

Six Takeaways

1. **To thrive in our digital world, all K–12 students must develop computing competencies.** Computing touches nearly every facet of our daily lives, both personal and professional. Computing competencies are now critical not only in the technology industry, but in nearly every occupation—and computing will drive the careers of tomorrow that have yet to emerge. Developing computing competencies will prepare young people for informed civic engagement as well as for rewarding careers, strengthening the pipeline of talent for employers.

> Computing is more than coding or computer science. Computing refers to a broad range of foundational knowledge and competencies that cut across disciplines—including computer science and other STEM subjects. Engaging in computational thinking and using computational methods are important for solving problems in all fields, including the arts. Computing competencies are valuable because they are broadly relevant to personal life, professional pursuits, and civic participation.

2. **Computer science education is broadly supported in public policy and in K–12 institutions—but it's time to raise expectations and outcomes. I**n response to widespread calls to expand access to computing-related learning experiences, 39 states have developed (or are developing) computer science standards over the past decade, and 19 states require all high schools to offer computer science. This national movement has both public- and private-sector support. However, while most K–12 students have access to digital devices, many schools still do not offer computing-related learning experiences beginning in the formative elementary and middle school grades. Without early opportunities to engage in computing activities and develop foundational computing skills, few students will be positioned to thrive in high school computer science classes. The bottom line: many students still have limited opportunities to develop critical computing skills.

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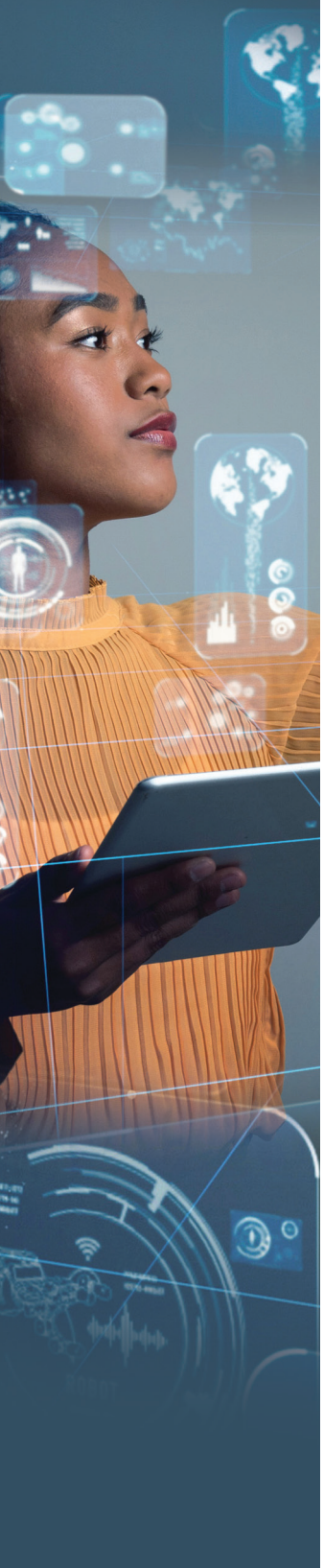


3 **National, state, and local policymakers must respond with policies, priorities, and funding to support expanded access to learning experiences that engage all students—and particularly underrepresented learners—in computing.** Girls, students of color, economically disadvantaged students, and students with disabilities are underrepresented in computing-related learning experiences. Overcoming gender, race, economic, and geographic barriers is paramount for promoting diversity, equity, and inclusion in education and in the workforce. Internet access and network bandwidth, transportation, and costs also present barriers to participation that policymakers should address.

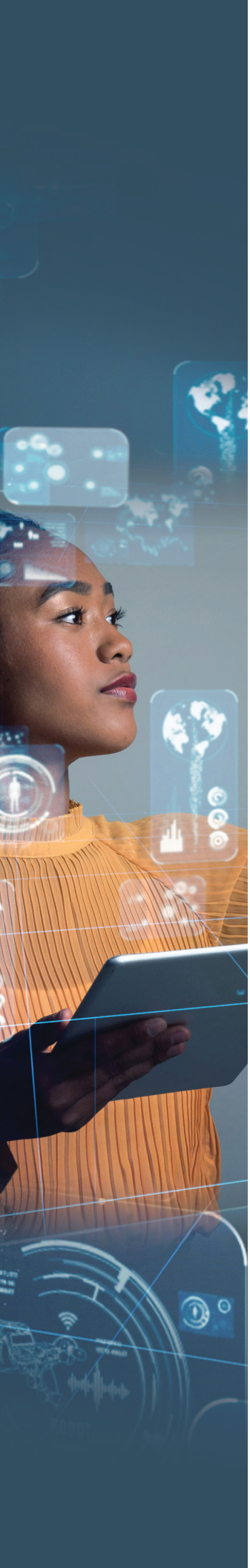
4 **Authentic STEM learning experiences in school and in out-of-school programs may increase participation, interest, and competencies in computing.** Authentic learning experiences reflect professional practice—using skills such as problem solving, creation, experimentation and inquiry—and personally and culturally meaningful activities. Sustained engagement in multiple authentic learning experiences over time fosters students' personal "computing identity," which is critical to spark their interest, sense of belonging, and persistence in developing skills. Moving from a hodgepodge of offerings to coherent pathways into computing could have significant impact—particularly for underrepresented learners.

5 **Professional learning is urgently needed. Few K–12 educators have computer science degrees or pedagogical training to teach computing.** Facilitators of in-school and out-of-school programs have widely varying education and skill levels; they need professional learning as well to deliver authentic learning experiences.

6 **Providers of out-of-school learning programs—such as libraries, youth development organizations**, makerspaces, robotics competitions, online gaming communities, and **postsecondary institutions—play a valuable role in sparking students' interest in computing**. Policymakers should take an ecosystem approach to supporting formal education and informal learning experiences that develop computing competencies. An expansive and inclusive view of the landscape should extend to postsecondary institutions, which can prepare more educators to teach computing, and to the business and philanthropic communities, which have a strong interest in developing computing competencies.

Four Steps to Take Now

1. Increase support for computing education in K–12 schools, and for national and community-based organizations that provide computing-related out-of-school learning experiences, including funding for professional learning, facilities, and learning spaces.
2. Require evaluation of program design and implementation in funding and grant programs to strengthen to evidence base for authentic STEM learning experiences.
3. Develop policies and practices that remove barriers to participation and promote diversity, equity, and inclusion in computing education.
4. Support higher education institutions and other providers of preservice education and in-service professional learning to build educators' knowledge, competencies, and confidence to teach computing across the curriculum.



Meet Antonio

Diverse Computing Experiences Create a Path to Engineering

Antonio, a Latino high school senior, fits the demographic of students who are disproportionately underrepresented in computing education and careers. But multiple opportunities to develop computing competencies over time led to his acceptance in the college of engineering at a major research university.

Antonio grew up in Mexico, where his primary early exposure to computing was in his school's computer literacy courses, which emphasized learning keyboarding skills and productivity software. More interesting to him at the time were video games on his smartphone. "My friends and I would search for online videos on how to hack some of those games," he told the National Academies Committee on the Role of Authentic STEM Learning Experiences in Developing Interest in Competencies for Computing. He also explored and customized the settings on his smartphone because "I wanted to figure out how things worked."

Computing opportunities opened up for Antonio when he moved to the United States as a high school freshman. He discovered that the local public library had a makerspace—and offered free workshops and classes. Twice a week, he showed up, learning to program an Arduino, operate a 3D printer, build robots, and laser-cut objects. "The staff and instructors really encouraged and motivated me as I programmed games, made miniature light sabers, and built webpages," he said. Over the years, he spent more time engaged in this hands-on learning, participating in workshops sponsored by the local university in the library makerspace—and becoming a mentor as well.

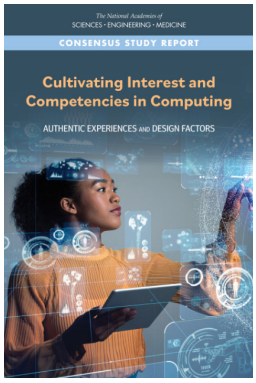
In school, when his schedule opened up for electives in his junior and senior years, he took courses in programming, robotics, and media editing software, honing his skills in creating custom videos. "The classes were more enjoyable than some of my other classes because the teachers were more fun and entertaining," he said. Before he graduated, he worked as a programming intern at local organizations.

Antonio attributes his interest and competencies in computing to the range of learning experiences and encouragement he's had in the library makerspace, school learning spaces, and university workshops. Although he hasn't decided on a specific major at the college of engineering, he knows it will be computing- and technology-intensive.

Learn More

Read the report highlights and the full report online, download a free PDF, or order the paperback publication today.

Cultivating Interest and Competencies in Computing: Authentic Experiences and Design Factors (2021)



This highlight is one in a series prepared by the Board on Science Education based on the report *Cultivating Interest and Competencies in Computing: Authentic Experiences and Design Factors* (2021). The study was sponsored by Google and the Grable Foundation. Any findings, conclusions, or recommendations expressed in this publication are those of the study committee and do not necessarily reflect those of the sponsors.

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