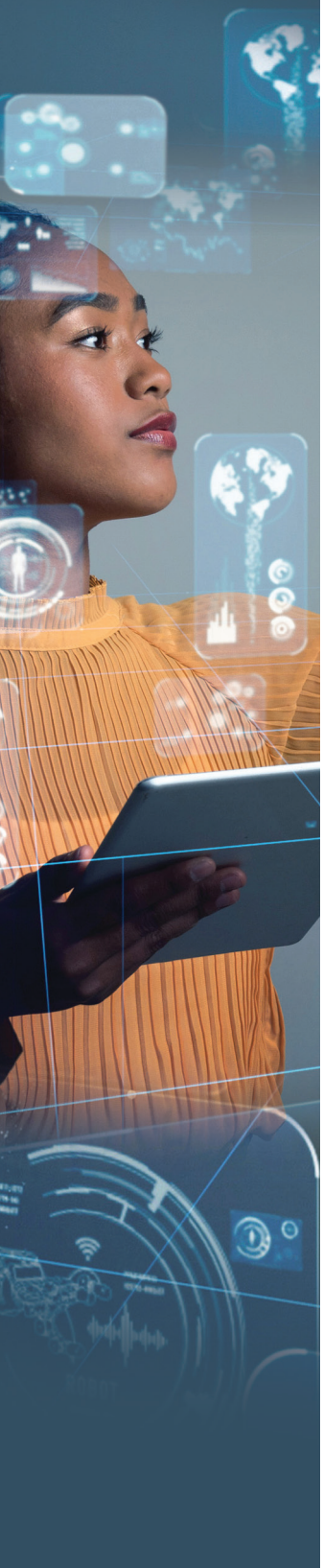

Cultivating Interest and Competencies in Computing

Authentic Experiences and Design Factors

Highlights for Business and Philanthropic Leaders

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.

Business and philanthropic leaders will find five key takeaways and four steps for action outlined in this brief.

Five 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 and out of school time settings—but it's time to raise expectations and outcomes.** In 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 and many learners get their first—and sometimes only—exposure to computing in afterschool clubs, summer camps, or community programs.

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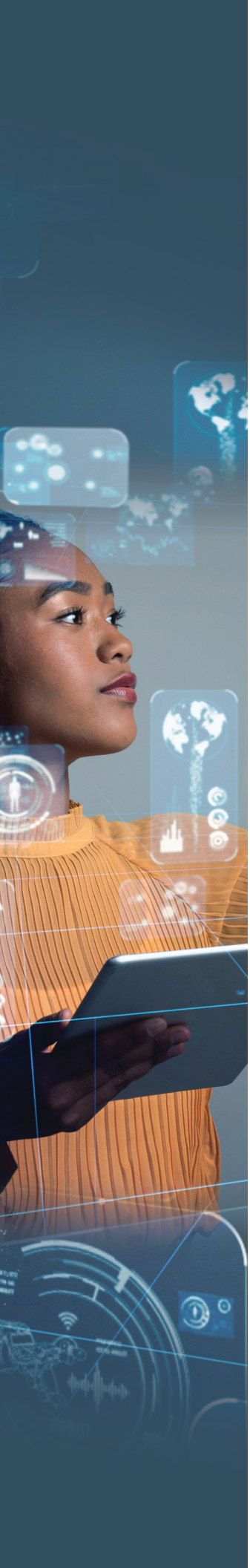


The bottom line: many students still have limited opportunities to develop critical computing skills. Providing learning experiences that reflect the interests of the young people and communities they service can spark lasting interest in computing, a sense of belonging, and a growth mindset—persistence, resilience, and the belief that they can succeed.

3 **Prioritizing opportunities for underserved and underrepresented students is critical.** Girls, students of color, economically disadvantaged students, and students with disabilities are underrepresented in computing-related learning experiences. Gender, race, economic, and geographic barriers discourage many students from participating. Stereotypes, implicit biases, and overt or implicit racism, sexism, and ableism make them feel that they do not belong. Educators, leaders and role models who look like them can help students develop a "computing identity," which is critical to fostering their interest, sense of belonging, and persistence in developing skills.

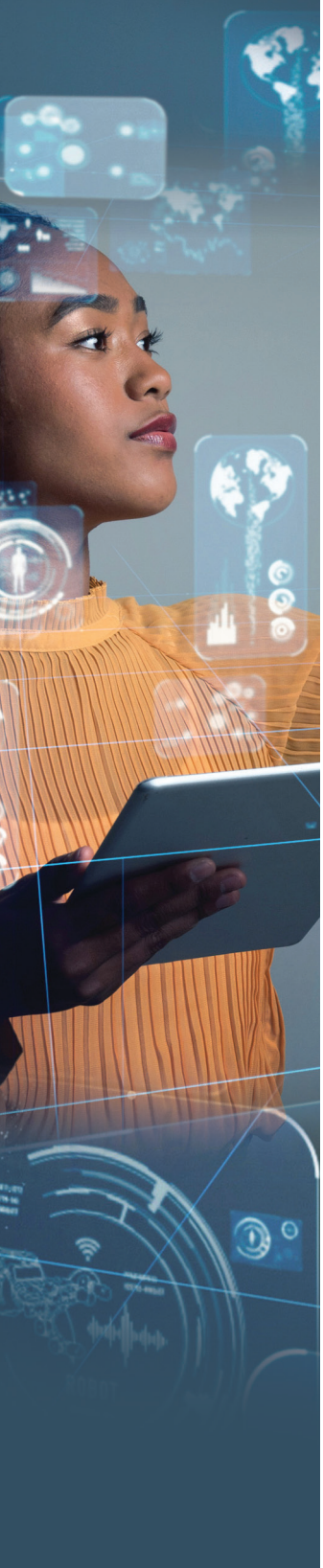
4 **Authentic STEM learning experiences in school and in out-of-school programs may increase participation, interest, and competencies in computing.** Authentic learning experiences reflect professional practice—using skills such as problem solving, creation, experimentation and inquiry—and personally and culturally meaningful activities that are designed with attention to learners' interests, identities, and backgrounds.

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. Longer-duration programs with multiple interactions over time, and across settings, are the best format to support authentic learning experiences.

5 **Purposeful, concerted, multi-sector action is the best way to nurture all students' participation, interest, and competencies in computing.** An ecosystems approach recognizes that both schools and many other local and national organizations can play vital roles in developing computing competencies. Business and philanthropic leaders can network, collaborate, and forge partnerships with schools and leaders of organizations and online platforms that provide out-of-school learning opportunities to mutually reinforce their offerings for students. Engaging a wide group of stakeholders, including education policymakers and out-of-school time providers, will help expand access.

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. Prioritize access to authentic STEM learning experiences for underrepresented students—and provide wraparound support to help them thrive.
3. Network, collaborate, and partner with schools and other public and private organizations that provide in-school and out-of-school learning experiences to students.
4. Require evaluation of program design and implementation in funding and grant programs to strengthen the evidence base for authentic STEM learning experiences.



Meet Nathan

Tinkering, Gaming, Coding, and High School Experiences

When Nathan, a white man in his twenties, was growing up in Texas, he shared a family laptop with his two younger siblings. As a middle schooler, he often played Minecraft with friends in the neighborhood when it was his turn to use the laptop.

Nathan and his friends realized they could set up their own server version of his favorite online game and decided to do just that. They customized the server, configuring it for the play styles they preferred. "Completing that installation was the first real experience with debugging and exposure to programming," he told the National Academies Committee on the Role of Authentic STEM Learning Experiences in Developing Interest in Competencies for Computing. "Even though it took time and problem solving, I felt competent and empowered." This formative experience gave him his first sense of his identity as a computing professional.

His interest in the backend of computing piqued, Nathan later spent time on the shared family laptop watching online video tutorials that introduced coding basics in the Java programming language. Working on online programming problems exposed him to discrete mathematics and number theory problems that arise in computing. This led him to search for solutions to the problems online, where he stumbled upon online coding communities that posted mathematics coding challenges. He started completing the challenges and participating in the communities.

By this time, Nathan was in high school, where he enrolled in computer science courses, including AP computer science. "My first classroom computer science teacher was an inspiration ... who demonstrated a strong understanding of coding and was a highly effective teacher." This teacher ended up being an influential figure in Nathan's journey developing computing competencies.

Throughout high school, biology also captivated Nathan's interest. He started a high school club focused on synthetic biology. In his summers, he worked at a biology laboratory at the local university, which he learned about from his parents' contacts. There, too, he had opportunities to use his coding skills.

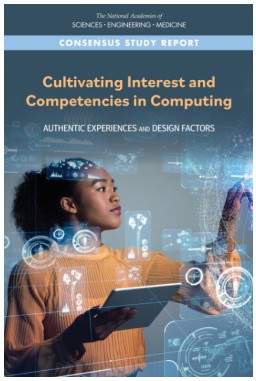
After high school, Nathan decided to pursue both of his interests with a double major in bioengineering and computer science at a major research university. His studies will prepare him for career opportunities in multiple industry sectors.

Years later, Nathan is still in touch with his first high school computer science teacher through social media—and he still participates in online coding communities and the open-source movement.

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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