

# Cultivating Interest and Competencies in Computing

## Authentic Experiences and Design Factors

### Highlights for Out-of-School Program 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.

Leaders of organizations that provide K–12 students with informal STEM and computing learning experiences outside of school, including libraries and museums, virtual communities, and programs serving underrepresented children and youth will find five key takeaways and five 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 Leaders of informal, out-of-school learning programs can play a vital role in cultivating interest and competencies in computing.** While most students have access to digital devices, many get their first—and sometimes only—exposure to computing in after-school clubs, summer camps, or community programs. Out-of-school programs can be more creative and flexible than formal education—and program leaders can design learning experiences that reflect the interests of the young people and communities they serve. This can spark lasting interest in computing, a sense of belonging, and a growth mindset—persistence, resilience, and the belief that they can succeed.

Widespread calls to action to expand access to computing-related learning experiences extend to a broad array of local and national organizations:





- In-person community programs (e.g., after-school programs, youth development programs, libraries, museums, zoos, botanical gardens, science centers, makerspaces, community centers, higher-education institutions)
- Virtual communities and programs (e.g., classes, exhibitions, and competitions for coding, gaming, robotics, engineering, and technology)
- Organizations that serve underrepresented children and youth (e.g., Girls Who Code, Black Girls Code, Black Boys Code, Digital Divas)

**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. Out-of-school program facilitators 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 out-of-school programs—and particularly personally authentic experiences—may increase participation, interest, and competencies in computing.** Personally and culturally meaningful activities that are designed with attention to learners’ interests, identities, and backgrounds may attract and retain more students than experiences focused solely on mirroring professional practice, which emphasizes skills, such as problem solving, creation, experimentation, and inquiry.

Social interaction and peer learning are critical aspects of authentic learning experiences. Longer-duration programs with multiple interactions over time, and across settings, are the best formats to support authentic learning experiences.

**5** **Facilities and facilitators matter.** Physical space, facilities, and equipment vary widely across out-of-school learning programs. If learning spaces are inadequate, program leaders can consider creating flexible spaces that can be reconfigured quickly, conducting programs at partner organizations’ sites, or bringing programs to students where they are, such as schools, community centers, or juvenile detention centers. Libraries, in particular, are adapting and playing a critical role in providing authentic STEM and computing experiences.

Facilitators are critically important to authentic learning experiences. Their qualifications vary widely. They may not have academic degrees, content-specific knowledge, or education-specific training. Credentialing programs and professional learning experiences targeted for facilitators of out-of-school learning and youth development programs can help bridge this gap.

## Five Steps to Take Now

1. Incorporate personally authentic computing experiences into existing programs.
2. Provide wraparound support to help underrepresented students access and thrive in authentic STEM learning experiences.
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. Engage the business and philanthropic communities for support for out-of-school learning programs that develop computing competencies.
5. Design, implement, and evaluate new programs with intent.



## Meet Raven

### From Personally Authentic Experiences to a B.A. in Computer Science

Raven, a Latinx/Native American woman in her 20s, credits an after-school program as central to her interest in and pursuit of computing as an adult. She joined the program in middle school to meet new people and make friends. Sustained participation in the program also provided a benefit she did not expect—strong, supportive relationships with mentors and facilitators, who helped her develop computing skills and championed the creative process. The program was “a way to build relationships while building things with computational technology,” she told the National Academies’ Committee on the Role of Authentic STEM Learning Experiences in Developing Interest in Competencies for Computing.

Raven stayed with this program and her community of friends and mentors for years. She had time to learn programming languages and software and work on personally meaningful projects. She expressed her family’s value of the arts by creating gifts for them and by designing and developing user interfaces and websites—one of which won a state award. Growing in confidence, she participated in summer programs at a nearby university, furthering her exposure to and competence with computing. She also became a program mentor herself. This breadth of exposure helped Raven appreciate that computing has broad applications in many careers.

As a college student, she continued to mentor and serve as a role model—most prominently as an after-school computer science teacher for a university-affiliated lab school. And she is still in close contact with her mentors and mentees from the middle school program.

Raven did face a disconnect in college, where she struggled with traditional programming assignments. A professor even told her that computer science might not be the right field for her. But she had enough resilience to decide that she would not be dissuaded from completing her degree. She persisted. When she spoke with the committee, she had just earned her degree in computer science with a minor in mathematics.

## 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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