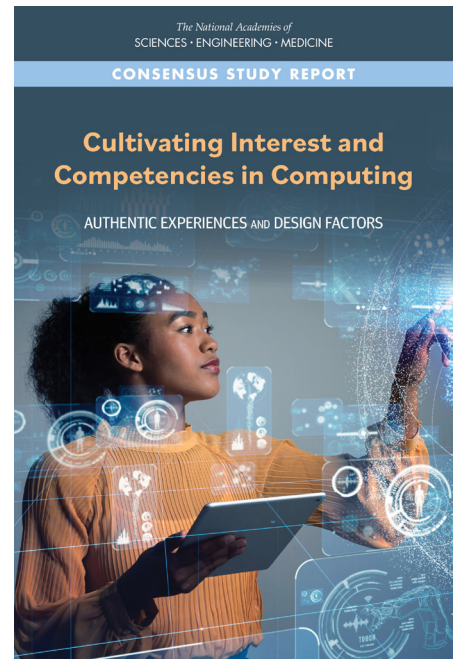


Cultivating Interest and Competencies in Computing: Authentic Experiences and Design Factors

The field of computing has changed the way society functions, interacts, and works in a fundamental way. Given its widespread presence in both personal and professional life, engaging learners in opportunities that enable them to develop computational literacy and skills is imperative. This has led to findings ways to expand access to computing learning experiences, both in terms of increasing diversity in the field, but also through expansion of more formal experiences offered in schools, youth development programs, or self-initiated hands-on experiences at home. The well-documented lack of diversity in the computing workforce and in programs that engage learners in these fields highlights the critical need to expand access, engagement, and learning around computing.

To address this gap in knowledge, the National Academies of Sciences, Engineering, and Medicine convened a committee with expertise in the design and construction of learning spaces in formal and informal STEM and computing educational settings, to examine the evidence on the ways in which authentic STEM experiences develop interest and competencies for computing.

The committee's report, *Cultivating Interest and Competencies in Computing: Authentic Experiences and Design Factors* (2021), identifies that authentic experiences for computing, or experiences that reflect professional practice and connect learners to real-world problems that they care about, are one possible approach for reaching a broader range of learners. The report addresses issues of design and institutional/organizational infrastructure to highlight the particular contexts that may best support the development of learners' interest and competencies for computing. It further provides guidance for educators and facilitators, program designers, and other key stakeholders on how to support learners as they engage in authentic learning experiences in computing.



WHAT DOES AUTHENTIC LEARNING FOR COMPUTING LOOK LIKE?

In examining these issues, the committee took a closer look at what authentic learning for computing might consist of in practice. These learning experiences may include recreational pursuits such as playing and modifying video games or engaging with on-line creative communities as well as more structured

activities in out-of-school learning institutions and in classroom settings. Long-term interest, skills, and participation in computing are influenced by a wide range of experiences at home, school, online, and in the local community as well as by individual factors. The social interactions that take place and the relationships that develop in the context of these activities can be an important driver for engagement and continued participation for learners.

Authentic learning experiences in computing that are designed to closely mirror professional practice—professional authenticity—may engage some learners. However, historical inequities in computing, biases and stereotypes may also make these kinds of experiences unattractive to learners from communities that have typically been excluded from computing. Learning experiences in computing designed with attention to learners’ interests, identities, and background—personal authenticity—may attract and retain more learners from underrepresented groups in computing because of their gender, race, ethnicity, or perceived ability than learning experiences that focus solely on professional practice.

In the design of authentic experiences for computing, it is important to carefully consider whether the experience is appropriate for the context in which it is implemented, has a defined set of outcomes, and accounts for learners’ prior interests and experiences in their homes and communities. The committee acknowledges that designing, implementing, and documenting effective authentic learning experiences for computing is both time consuming and expensive. Despite these challenges, the possibility of ensuring learners have access to authentic experiences that will allow for the development of interest and competencies for computing is enticing—particularly in its potential for developing both a knowledgeable and creative citizenry and a robust and diverse computing workforce.

THE COMMITTEE’S RECOMMENDATIONS

The committee’s report, including its conclusions, recommendations, and research agenda strongly suggest the potential for authentic learning experiences to cultivate the interest and competencies for computing. To realize this potential, the energy, creativity, and resources of researchers, practitioners, and funders must now be directed at generating more thoughtful, high quality, and evidence-based work.

The recommendations below were developed with the goal of ensuring that a broader, more representative set of learners have access to authentic experiences in an effort to spark and cultivate interest and competencies for computing.

RECOMMENDATION 1: Program designers should be intentional in the design and implementation of inclusive programs offering authentic learning experiences that build interest and competencies for computing. This includes:

- having clear and explicit programmatic goals and continuous refinement of the program to ensure alignment to those goals;
- designing for personal authenticity that builds on learners’ interests, identities, and backgrounds while also designing for professional authenticity;
- ensuring that the participants include people are from underrepresented groups in computing because of their gender race, ethnicity, or perceived ability;
- considering inclusion of families and community members as well as learners in opportunities to co-create;
- ensuring educators and facilitators have adequate preparation and access to 89 necessary materials and resources; and
- reflecting on whether the communication, outreach, and operation of the program is inviting for learners who are from underrepresented groups in computing because of their gender, race, ethnicity, or perceived ability.

RECOMMENDATION 2: Practicing teachers in schools and facilitators in out-of-school time settings should seek out opportunities and materials on how to incorporate effective practices for creating authentic learning experiences in computing within an existing program that includes utilizing problem-/project-based learning strategies, allowing learner choice among activities, and considering learners’ contexts outside of school time.

RECOMMENDATION 3: Preservice and in-service teacher educators and trainers of out of-school time facilitators should ensure that educators and facilitators are equipped to engage learners in personally authentic learning experiences in computing. This includes providing ongoing opportunities for educators to learn and practice using inclusive pedagogical approaches, as well as having access to materials and resources that build on learners’ interests, identities, and backgrounds.

RECOMMENDATION 4: School leaders should consider a variety of ways to provide inclusive access to authentic learning experiences for computing. These include (1) addressing challenges (e.g., lack of instructional time and teacher expertise) associated with integrating authentic computing experiences into instruction in a variety of subjects, (2) increasing access to stand-alone computing courses, and (3) ensuring schools have adequate resources such as equipment, reliable broadband Internet, and time.

RECOMMENDATION 5: Program providers in out-of-school settings should increase efforts to expand access to inclusive authentic learning experiences for computing through growth of opportunities and active program promotion within underserved communities and in rural areas. This includes considering ways to reduce barriers to participation such as time, cost, and transportation. It also includes offering programs multiple times or during the evening and weekends, reducing program costs or offering financial assistance, and subsidizing transportation.

RECOMMENDATION 6: Program evaluators should develop and apply robust models of evaluation that take into account the distinctive features of authentic learning experiences in computing. More specifically, this includes attending to personal and professional authenticity, considering connections across settings, and to the extent possible, disaggregating findings and examining differences between and within groups (e.g., gender, race, ethnicity, socio-economic status, etc.) for computing outcomes as a central part of model building and evaluation.

RECOMMENDATION 7: There should be a broad-based effort to cultivate a network of opportunities, as well as supports for learners to navigate between them, both in and out of-school to increase access and opportunities for sustained engagement with computing. To achieve this:

- funders should support initiatives that make connections across settings—both formal and out-of-school settings including home and online—and between industry and educational efforts for authentic learning experiences in computing;
- designers and educators across formal and out-of-school settings should consider tailoring to the community context, learners’ backgrounds and experiences, and attending to cultural relevance;
- local STEM institutions, schools, and out-of-school providers should develop partnerships that allow them to develop complementary programs that fill in gaps and connect learners to other opportunities within the network; and
- stakeholders in the network should be sure that they are providing opportunities in communities of underrepresented learners.

COMMITTEE ON THE ROLE OF AUTHENTIC STEM LEARNING EXPERIENCES IN DEVELOPING INTEREST AND COMPETENCIES FOR COMPUTING

BARBARA M. MEANS (*Chair*), Digital Promise, San Mateo, CA; **KAREN BRENNAN**, Harvard University, Cambridge, MA; **STEPHANIE CHANG**, Maker Ed, Berkeley, CA; **SHAUNDRA B. DAILY**, Duke University, Durham, NC; **CHERI FANCSALI**, Research Alliance for New York Schools, New York, NY; **JUAN E. GILBERT**, University of Florida, Gainesville, FL; **JOANNA GOODE**, University of Oregon, Eugene, OR; **MARK GUZDIAL**, University of Michigan, Ann Arbor, MI; **MIZUKO ITO**, University of California, Irvine, CA; **LEAH H. JAMIESON** (NAE), Purdue University, West Lafayette, IN; **ERIC KLOPFER**, Massachusetts Institute of Technology, Cambridge, MA; **IRENE LEE**, Massachusetts Institute of Technology, Cambridge, MA; **VICTOR LEE**, Stanford University, Stanford, CA; **REBECCA MAYNARD**, University of Pennsylvania, Philadelphia, PA; **DANIEL A. RABUZZI**, Indigo Pheasant, LLC., New York, NY; **MEGA SUBRAMANIAM**, University of Maryland, College Park, MD; **AMY STEPHENS**, *Study Director*; **KERRY BRENNER**, *Senior Program Officer*; **LETICIA GARCILAZO GREEN**, *Research Associate*; **JON EISENBERG**, *Senior Board Director, Computer Science and Telecommunications Board*; **HEIDI SCHWEINGRUBER**, *Board Director, Board on Science Education*.

For More Information . . . This Consensus Study Report Highlights was prepared by the Board on Science Education based on the Consensus Study Report, *Cultivating Interest and Competencies in Computing: Authentic Experiences and Design Factors* (2021). The study was sponsored by Google and the Grable Foundation. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242 or <https://nas.edu/AuthenticComputing>.

Division of Behavioral and Social Sciences and Education

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

The nation turns to the National Academies of Sciences, Engineering, and Medicine for independent, objective advice on issues that affect people's lives worldwide.

www.national-academies.org

Copyright 2021 by the National Academy of Sciences. All rights reserved.