Implementing Out-of-School Time STEM Programs in STEM Ecosystems

August 2024

AnLar

Acknowledgments

The contents of this document were developed under a contract from the U.S. Department of Education through the Office of Innovation and Early Learning Programs (IELP) within the Office of Elementary and Secondary Education (OESE), by AnLar under Award #GS00F229DA. This contains resources that are provided for the reader's convenience. These materials may contain the views and recommendations of various subject matter experts as well as hypertext links, contact addresses, and websites to information created and maintained by other public and private organizations. The U.S. Department of Education does not control or guarantee the accuracy, relevance, timeliness, or completeness of any outside information included in these materials. The views expressed herein do not necessarily represent the positions or policies of the U.S. Department of Education. No official endorsement by the U.S. Department of Education of any product, commodity, service, enterprise, curriculum, or program of instruction mentioned in this document is intended or should be inferred.

Suggested Citation

Holian, Laura and Gold, Benjamin P. (2024). Implementing Out-of-School Time STEM Programs in STEM Ecosystems. Cross-project summary produced by AnLar and the Office of Elementary and Secondary Education; Education Innovation and Research Program (EIR).

Table of Contents

Why Is OST STEM Education Important? 1
How Do OST STEM Programs Benefit Students? 2
STEM Ecosystems 3
Examples of EIR Projects with an OST STEM Component 4
EIR Projects' Relationship to STEM Ecosystems 7
How Can STEM Ecosystems Affect Uptake and Sustainability of OST Programs? 8
Call to Action 10
References 12
Appendix A: EIR Projects Highlighted in This Summary 14

Why Is OST STEM Education Important?

STEM (science, technology, engineering, and mathematics) is an increasingly integral part of modern life and work. In 2021, 24 percent of the U.S. workforce was employed in STEM occupations (**National Center for Science and Engineering Statistics [NCSES], 2023**). Demand for workers in STEM occupations is expected to grow by 10.5 percent between 2020 and 2030 (**U.S. Bureau of Labor Statistics, 2024**). These workers will be employed in fields including architecture and construction, health care, business, security, teaching, manufacturing, and more.

While preparing students for these fields, STEM education also nurtures curiosity, tenacity, leadership, innovation, and widely applicable skills like critical thinking, problem solving, communication, creativity, and collaboration. STEM education is thus essential for all learners, whether they enter the STEM workforce or not.

STEM learning occurs in both formal and informal environments. Children spend less than 20 percent of their waking time in school, but they are spending more and more time learning online from home and/or in educational programs before and after school, on weekends, and during summers and holidays (**National Research Council [NRC], 2015**). These out-of-school time (OST) programs can enrich STEM education by bridging learning across different environments with different resources and opportunities (**Levay et al., 2018**). As a result, OST STEM programs are associated with increased STEM engagement, identity, career interest, relationships, perseverance, and critical thinking (**Allen et al., 2019**).

OST STEM education is especially important for learners with limited access to quality STEM teachers, courses, equipment, and programs in their schools. Structural inequalities related to these and other resources disproportionately affect students of color, students living in poverty, and students in rural areas (**NRC, 2015**; **National Science Board [NSB], 2021**; **Beckett et al., 2009**). For example, schools with high-poverty enrollment or high-minority enrollment regularly have less experienced STEM teachers (**NSB, 2021**). Language barriers and cultural factors also limit opportunities for students who are female, immigrants, or non-native English speakers (**Levay et al., 2018**). Yet OST programs generally enroll higher percentages of students from underserved communities than schools and deliver greater benefits for these students (**Afterschool Alliance, 2011**; **NRC, 2015**; **Beckett et al., 2009**). OST STEM programs are therefore well suited to narrowing achievement gaps.

> **"Research shows how a sense of belonging in rich and rigorous classrooms is directly correlated to students' long-term academic success. Moreover, the Department's Civil Rights Data Collection continues to demonstrate that students of color and students with disabilities are disproportionately excluded from learning opportunities in STEM. Today, we are saying unequivocally to all students and educators that they belong in STEM and that they deserve to have rigorous and relevant educational experiences that inspire and empower them to reach their full potential as productive, contributing members of our nation's workforce."**
>
> *–U.S. Deputy Secretary of Education Cindy Marten at the 2022 "You Belong in STEM" event*

To address disparities in STEM education access and outcomes, the U.S. Department of Education is committing to the **Raise the Bar: STEM Excellence for All Students** initiative. The Education Innovation and Research (EIR) program is one of many supporting this priority.

How Do OST STEM Programs Benefit Students?

In the past several years, organizations like nonprofits, state and federal education agencies and networks, and foundations have made significant investments in OST STEM programs (**NRC, 2015**). These programs are based on the hope that engaging with STEM content outside of school will improve classroom competencies, broaden participation in STEM, and help prepare students for the workforce (**Saw, 2020**; **NRC, 2015**). Even though OST STEM programs have existed for many years, and there is a growing body of research on them, we are just beginning to understand what makes OST practices effective and what works best for students, especially underserved students.

In 2015 the National Academies of Sciences commissioned a review of research on OST STEM programs, noting fundamental changes in the STEM learning landscape over the preceding decade. The report concluded that while "research and evaluation findings are not yet robust enough to determine which programs work best for whom and under what circumstances" (**NRC, 2015, page 2**), there are discernible characteristics of programs that most benefit students. Specifically, high-quality OST STEM programs:

- **Engage students intellectually, academically, socially, and emotionally** by providing firsthand experiences with phenomena through sustained STEM opportunities.
- **Establish a supportive learning community** with positive student-staff and student-student relationships.
- **Respond to students' interests, experiences, and cultural practices** by positioning STEM as socially meaningful and relevant and allowing students to collaborate and lead alongside program staff.
- **Link STEM learning across out-of-school, school, home, and other settings** by leveraging community partnerships and brokering additional STEM learning opportunities (**NRC, 2015**).

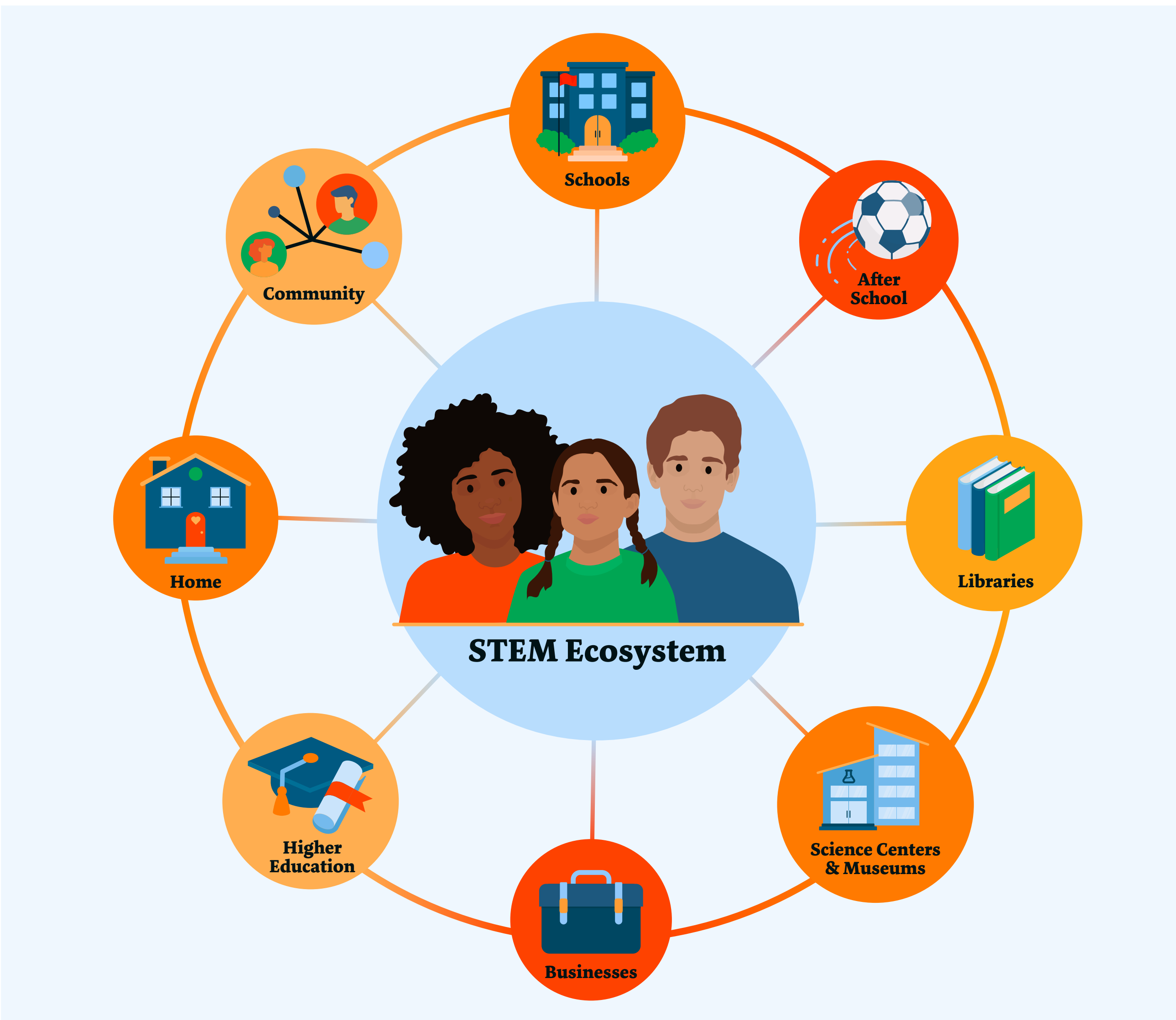
Research conducted since the 2015 report was published has also shown that OST STEM programs yield larger improvements in STEM attitudes and social-emotional learning/21st-century skills when they:

- Last **at least four weeks**
- Focus on helping students **understand STEM concepts**, participate in the **inquiry practices of STEM professionals**, and **reflect** on their experiences
- Include **opportunities for students to voice their opinions and ideas**
- Provide an **organized and flexible learning environment** with **appropriate and appealing materials (Allen et al., 2019)**

OST STEM programs can meet these criteria and benefit students in a variety of ways. For example, a defining feature of many OST programs is their ability to actively involve students in their learning with engaging, hands-on activities. This practice promotes student interest, autonomy, and identity as a STEM learner (**NRC, 2015**; **Allen et al., 2019**), consistent with decades of research on effective science education that characterizes science learning as an active process that takes place through observation and interaction (**Linn and Eylon, 2011**; **NRC, 2007**; **Smith and Neale, 1989**). Similarly, connecting students to STEM professionals may provide them with role models and a personal relationship to STEM, which can in turn inspire students to pursue STEM careers (**Saw, 2020**). Fostering a positive community of students and facilitators may offer the students support when they navigate higher education and career trajectories in STEM (Saw, 2020). In turn, STEM interest, engagement, sense of belonging, and support may lead to greater participation in STEM coursework and higher achievement in STEM subjects (NRC, 2015; Allen et al., 2019; Saw, 2020).

STEM Ecosystems

A **STEM ecosystem** is a collection of organizations and individuals committed to developing STEM-related opportunities in their community. Key partners in a STEM ecosystem may include a lead organization, schools, school districts, OST programs, museums, science centers, institutions of higher education, STEM-related companies, businesses that need employees with STEM competencies, libraries, youth organizations, family/parent/caregiver organizations, philanthropic organizations, and other community-based organizations. Through the coordination of a lead organization, STEM ecosystems cultivate cross-sector partnerships, create and connect STEM-rich learning environments, build the capacity of educators through professional learning and externship experiences, and help build pathways for students from childhood to adulthood (Allen et al., 2020).



A key part of successful STEM ecosystems is time spent developing relationships among partners (**Allen et al., 2020**). Foundational work in establishing partnerships is important, and continuous efforts are needed to sustain and strengthen relationships. All members of the ecosystem collaborate to help support student learning and develop STEM skills and knowledge, often by learning about the quality of the partnerships and using data to improve programs and offerings within the ecosystem. Other recommendations for STEM ecosystems are listed in Box 1.

Box 1. Recommendations for STEM Ecosystems

- Develop strong partnerships with many organizations, including K-12 schools and businesses.
- Improve communication to raise awareness of ecosystem efforts.
- Diversify funding streams and balance the goals of funders with the goals of other members of the community.
- Change leadership if necessary and invite new voices to join or lead the initiative.
- Encourage stakeholders to align their actions to the ecosystems' mission and aspirations.
- Involve all members in goal setting and decision-making.
- Develop and implement new strategies to increase reach and capacity while minimizing burden on staff.
- Expand STEM learning opportunities to underrepresented and underserved youth.
- Expand use of data for continuous improvement.

Adapted from **Allen et al., 2020**

OST STEM programs have a natural fit in STEM ecosystems, through which they can connect students' learning across settings, engage students' diverse interests, offer meaningful and relevant experiences, and more (**NRC, 2015**; **Allen et al., 2020**). OST STEM programs may even serve as the lead organization in a STEM ecosystem — or they may operate outside of formal STEM ecosystems. In the following sections, we consider how different OST STEM programs interact with STEM ecosystems, if applicable, and what effects these interactions have on OST STEM programs.

Examples of EIR Projects with an OST STEM Component

Three projects recently funded by EIR (between 2017 and 2021) focus on middle school STEM and use OST components to achieve their goals. Two (BoSTEM and FirstHand) are in areas with STEM ecosystems, and the other (STEM.LD) is in a rural area without a formal STEM ecosystem.

BoSTEM

The United Way of Massachusetts Bay and Merrimack Bay (UMWB) leads **BoSTEM**, a STEM ecosystem of nonprofit organizations, corporations, and schools committed to closing achievement and opportunity gaps for students who are traditionally underrepresented in STEM. The program serves Boston Public Schools, Somerville Public Schools, and Cambridge Public Schools by providing students opportunities to apply hands-on math and science skills in real-world OST settings.

The goals of BoSTEM are to strengthen students' academic skills, test scores, social-emotional skills, and interest in STEM postsecondary education and careers. The program begins with a needs assessment and employs a collaborative, continuous performance feedback cycle for partner organizations. Throughout the implementation of programs and services, BoSTEM collects and analyzes data and provides each partner organization with access to a data dashboard. Next, BoSTEM offers professional development on topics such as cultural responsiveness, STEM, and use of the Achieve, Connect, Thrive Skills Framework, along with coaching for OST program staff. Finally, BoSTEM helps OST programs provide STEM programming, hands-on learning, and STEM career exposure for middle-school students.

BoSTEM works with 12 OST partner organizations to provide training and coaching in social-emotional learning and STEM project-based learning, and with numerous local businesses that provide externships for educators and learning opportunities for students. BoSTEM coordinates and manages these partnerships and relationships to create a supportive environment for Boston students (**Rennie Center for Education & Research, 2022**).

FirstHand

The University City Science Center (UCSC) is part of the **Philadelphia STEM Ecosystem**. UCSC's FirstHand program is designed to provide access to and equity in high-quality STEM experiences through free, industry-relevant programming. **FirstHand** supports traditional classroom learning by introducing some of Philadelphia's most underserved students to STEM learning and career pathways through OST STEM experiences. The program's key components are:

- Hands-on, discovery-based STEM experiences (curricular tracks) for urban middle school students
- An immersive, place-based learning environment (the UCSC research campus)
- Industry-relevant mentoring by and social networking with STEM professionals

FIrstHand has seven curricular tracks for middle school students, ranging from synthetic biology to electrochemistry. The curriculum was developed in partnership with local industry professionals. FirstHand's staff has deep, longstanding partnerships with public, private, and charter schools throughout Philadelphia, primarily concentrated within UCSC's West Philadelphia neighborhood. The staff coordinates closely with partner schools to select the track that best supplements students' classroom learning, interests, and knowledge base. Once a school has chosen a curricular track, a small group of middle school students (12-14) from each partner school visit the UCSC campus for two hours per week (students walk to UCSC or take public transit, with the fare provided by FirstHand). There, the students gain scientific knowledge and skills by engaging in a free, 10-week (20-hour) program of scientific practices such as designing and conducting experiments, synthesizing knowledge from different sources, brainstorming, communicating, and collaborating with mentors and peers. Mentors from local companies visit FirstHand's space and take students on field trips to their company workspaces. Schools can elect to send the same students to multiple 10-week programs to expose them to different content and industries.

This program is widely supported by partner school principals as a way to enhance STEM learning. By eliminating common barriers such as cost, academic achievement requirements, and transportation, FirstHand fills a gap in the Philadelphia STEM education landscape with its equitable, accessible, and high-quality programming. The FirstHand program aims to improve students' sense of belonging in science and build STEM social capital by connecting students to the broader STEM ecosystem.

STEM.LD

The Niswonger Foundation, in partnership with local education agencies (LEAs) in northeast Tennessee, operating partners (**STREAMWORKS Robot Drone League**, **BioBuilderClub**, and **HammerBuild**), and postsecondary institutions, launched the STEM.LD (Learning Design) program to deepen and grow STEM culture in middle and high schools across the region. This two-year, school-wide program has three primary goals:

1. Build educator STEM knowledge, skill, and pedagogy by providing teachers with professional development to effectively implement curriculum supplements.
2. Deepen exploration and enhance readiness for STEM coursework among rural middle and high school students through increased access to and awareness of high-quality OST activities.
3. Provide more challenging opportunities for students and increase student academic readiness to take advantage of these opportunities.

To achieve its goals, the STEM.LD program provides teachers with the resources to design student-centered learning environments and pathways that encourage interest and engagement in STEM content. The intervention uses the Opportunity Myth framework from **TNTP**, which is based on helping students prepare for the future, to guide the professional learning opportunities and engage students in STEM content. STEM.LD has four major components:

1. **Professional learning for teachers and school leaders on student engagement in instruction.** To establish a common understanding of STEM.LD, school teams of administrators, science teachers, math teachers, and STEM teachers participate in an orientation that includes a one-hour meeting with TNTP. Then, teachers and administrators participate in six hours of asynchronous training, and administrators participate in an additional six hours of synchronous training. Training materials introduce the Opportunity Myth framework and how to provide engaging, grade-appropriate assignments and instruction; how to give students materials that have them think and engage deeply with challenging material; how to identify practices or decisions that give some students greater access to key resources than other students; how to maintain high expectations; and how to work with students and families to receive feedback. At the beginning of the first school year of implementation, teams have a follow-up meeting with TNTP to establish a plan for the next two years. A common day of collaboration for teachers and administrators across participating schools occurs midway through implementation.
2. **Deep-dive professional development for teachers.** Following the orientation, science and math teachers have opportunities to engage in deeper learning around topics such as standards-based math and science training, cybersecurity, synthetic biology, applied measurement, epidemiology, computational statistics, geographic information systems (GIS), technology and

design thinking, and/or aerospace engineering. TNTP, higher education partners, and other community partners provide focused training. Community partners may also provide externship opportunities for teachers.

3. **Learning environments with rich STEM curriculum resources.** The Niswonger Foundation's Comprehensive Educational Resources (CER) website, a resource teachers already used for other curricula, is now populated with STEM curricula for participants. Partners from higher education and industry participate in the design and development of additional STEM curriculum content, and teachers in STEM.LD schools are encouraged to use CER resources and develop resources to share through CER.

4. **Student coursework and extracurricular OST opportunities.** STEM.LD focuses on providing students with opportunities to engage in STEM courses, particularly algebra 1 in middle school. One piece of the coursework component includes supporting middle school teachers in obtaining the necessary content knowledge and credentials to teach algebra 1 in middle school. In addition, students have opportunities to participate in OST programs online and in person. Among high schools, students in STEM.LD schools have opportunities to participate in dual enrollment and advanced placement courses available at no charge through the Niswonger Online system, a learning portal and online course provider operated by the Niswonger Foundation.

These four components are theorized to lead to a school climate that is more academically challenging and supportive for students. This in turn will lead to greater student engagement and improved student achievement in math and science.

EIR Projects' Relationship to STEM Ecosystems

Both the BoSTEM and FirstHand programs were started before their organizations received EIR funding, and are connected with existing STEM ecosystems (in Boston and Philadelphia, respectively). The STEM.LD program, in contrast, was started through the EIR funding and is in a rural area without an existing STEM ecosystem. However, the Northeast Tennessee STEM Innovation Hub has served the area since 2012 (Tennessee STEM Innovation Network [TSIN], 2024). In addition, the Niswonger Foundation engages in the strategies of STEM learning ecosystems (partnering with many organizations, diversifying funding streams, including new voices, expanding STEM learning opportunities, and using data for continuous improvement). Many of the partnerships that the Niswonger Foundation has facilitated are opportunity-based, sharing knowledge and resources to pursue overlapping interests between autonomous parties. STEM ecosystems often start this way, but may eventually develop more collaborative, interconnected, and/or transformational partnerships with a greater focus on common goals, close communication, joint decision-making, and mutual benefits (**Allen et al., 2020**).

Both the BoSTEM program and the STEM.LD program are similar in offering professional development for educators, coordinating with local industry partners, linking K-12 schools with institutions of higher education, and improving access to OST programs for traditionally underserved students. These programs operate as conveners. They provide support and resources to programs, help raise awareness of the programs across local schools, and help connect schools and programs with one each another. By comparison, FirstHand is a single program that works with multiple schools and local industry partners.

How Can STEM Ecosystems Affect Uptake and Sustainability of OST Programs?

Ensuring that OST programs are adopted and sustained is critical to their long-term effectiveness. STEM ecosystems can strengthen the uptake and sustainability of OST programs through four key components: relationship building, exposure to real-world problems and project-based learning, cultural relevance and responsiveness, and retaining educators and partners.

Relationship building

Relationship building is a key part of all OST STEM programs. The BoSTEM and STEM.LD programs in particular – as lead organizations that manage multiple partnerships, coordinate multiple programs, and offer flexibility in content based on needs – must have clear and constant communication, transparency, and the ability to foster collaboration.

Being part of an existing STEM ecosystem can reduce the amount of time needed to build lasting relationships across partner organizations. For example, FirstHand has leveraged its partnerships in the Philadelphia STEM ecosystem to develop industry-informed curricula, fund its programming and student transportation, help schools select the curriculum best suited to their students, and connect students with mentors at partnering companies (**UCSC, 2024**). Similarly, BoSTEM partners provide students and educators with workshops, site visits, internships, and externships that connect student experiences with real-world STEM. In the process, industry partners help to build pathways into STEM fields for a diverse pool of potential future employees and learn how they can make their workplaces more inclusive (**Rennie Center for Education & Research, 2022**). These opportunities are available because BoSTEM emphasizes reciprocal, long-term connections that benefit all parties by meeting their needs and building a more supportive environment for students interested in STEM.

Though STEM.LD is not part of a STEM ecosystem, the project director, Vicki Kirk, makes building relationships a focus. To do so, she prioritizes listening to the needs of many diverse members of the community, foreseeing potential problems, and offering solutions. This is an ongoing process that takes an extraordinary amount of time. However, partners eventually can act as champions for the program in the larger community which can justify the investment of time. Some of the most important relationships to build and maintain are with political leaders. Initiatives often need political support to be successful and must also align with existing priorities. Other key relationships are with potential funders. Being able to see the larger picture and make connections to seize opportunities as they arise is a way of using relationships to help sustain and scale parts of a program.

Exposure to real-world problems and project-based learning

OST STEM programs are well suited to connect academic concepts with real-world projects, careers, and industries that require STEM skills and knowledge. This is especially true when local businesses and organizations are committed to improving the skills and knowledge of potential future employees and have established relationships with the program provider, as is often the case in STEM ecosystems. Partnerships like these are also helpful for sustaining and scaling a program, as partners have the opportunity to have a hand in developing their future workforce and help OST STEM programs adapt to changing workplace demands.

In the BoSTEM program Courageous Sailing, students use their creativity to build instruments that can measure strong winds and propel handmade boats. With Autodesk, a BoSTEM partner, teachers learn about the content knowledge and skills involved in developing software while expanding their networks. FirstHand's partners take an active role in planning and developing curricular tracks that directly relate to their work, including projects like testing for foodborne pathogens, designing mobile apps, and developing original business plans and pitches. During the height of the COVID-19 pandemic, FirstHand and its industry partner Crazy Aaron designed an activity where students made their own hand sanitizer and delivered materials to students for a virtual lesson on the science of hand sanitizer and the importance of adaptability. FirstHand partners also provide industry mentorships that bring STEM skills and careers to life.

Through its own relationships, STEM.LD offers curricular resources informed by local partners in higher education and industry, as well as dual enrollment and advanced placement classes for high school students. The program also connects teachers with industry partners to learn about real-world careers and applications, and with STEM education partners that promote real-world, project-based experiences like building and coding robots for the STREAMWORKS Robot Drone League or building a house with HammerBuild.

Cultural relevance and responsiveness

Due to their flexibility and informal learning environments, OST STEM programs are uniquely positioned to make STEM education relevant and responsive to students' cultural identities, experiences, and practices. Programs that leverage students' cultures and connect STEM to issues and interests in a community can deeply impact STEM engagement, interest, and learning. For example, valuing the knowledge, concepts, and references that students and their families bring to scientific activities can help students see themselves as science learners or future professionals.

STEM ecosystems offer a variety of environments, opportunities, and resources for students to pursue their interests and experience different norms and expectations. This variety is a priority for FirstHand, which exposes students to different STEM contexts with programming at the University City Science Center, industry mentorships, and field trips to local businesses. BoSTEM includes an OST program, Sociedad Latina, that conducts bilingual programming to help students feel welcome and facilitate relationships between them. Another BoSTEM OST program, CitySprouts, engages students in learning about the specifics of gardening in their communities. BoSTEM also offers training to program staff on cultural responsiveness, race and equity, family engagement, and related topics, and it conducts observations and assessments that examine how youth voices are prioritized and how relevance is centered in its programming.

Through its own network, STEM.LD leaders work to connect students and teachers with local industry and higher education partners, with a focus on preparing students for the future. The program provides educators with training on engaging, grade-appropriate, and rigorous STEM instruction and on ensuring that students have access to adults with high expectations for their success. The STEM.LD team also maintains a calendar and social media presence so that students, teachers, and parents can track and access local OST opportunities and other events that might be relevant and responsive to students' interests and experiences. For example, to better meet the needs of girls, STEM.LD covered the cost for students to attend a Girls Coding Summer Camp.

Retaining educators and partners

Despite its many benefits, being part of a STEM ecosystem does not protect programs from all challenges. Through partnerships, programs can offer educators new opportunities and professional development like teacher internships and externships, but retaining quality teachers and staff remains a common challenge across all educational programs. The BoSTEM project director noted that "the most important factors influencing sustainability moving forward are retention of educators and out-of-school-time organizations that have the capacity to implement BoSTEM programming."

Programs can both retain and recruit partners by basing their relationships on mutual benefit and collaboration. Partners may help one another solve problems and address needs, as BoSTEM, FirstHand, and STEM.LD all do. When all participants feel that their goals are being met and their efforts are reciprocated, they seek out ways to sustain the relationship. Partnerships also benefit from transparent communication and opportunities for feedback, like BoSTEM's continuous performance feedback cycle. Finally, maintaining a robust network of long-term partners can help with recruiting new partners as a program scales.

Call to Action

Although there is still much to learn about the best practices for OST STEM programs, the programs discussed above offer several lessons for operating either within or without formal STEM ecosystems. Clearly, there are many ways that OST STEM programs can leverage partnerships and other resources to enrich students' relationships to and learning of STEM content and skills. Based on the insights gleaned from EIR projects like BoSTEM, FirstHand, and STEM.LD – and from a growing body of research – we identify four actions that policymakers, program developers and staff members, partners, and others can take to make OST STEM programs effective, sustainable, and scalable.

1. Understand the local environment and find ways to make connections

Some programs may benefit from existing STEM ecosystems, while others might not have robust networks to draw on as they begin. In both cases, programs should identify the resources in their community, the needs of their students, and the gaps in what is currently available. When reaching out to potential partners, programs should focus on building reciprocal relationships that recognize and meet the needs and goals of each party. Current partners can also help expand and enrich a program's network.

2. Leverage connections for student and staff opportunities

OST STEM programs and their partners should ensure that students have access to engaging, project-based, relevant, and responsive STEM opportunities. These opportunities are invaluable for students to connect learning across settings, encounter real-world issues and professionals, experience the different norms and expectations of diverse STEM environments, and prepare for their futures. Program staff members should also have opportunities to pursue their curiosity about STEM topics, deepen their knowledge and skills, and work toward their professional goals. Well-connected OST

STEM programs can draw on partners for support on issues from program design and administration to evaluation and assessment. Partners may also be instrumental in funding programs, either directly or by helping to identify and secure sources of funding.

3. Build our understanding of OST STEM programs and STEM ecosystems

Research clearly shows that OST STEM programs have great potential for cultivating STEM interest and identity, enriching STEM learning, and closing opportunity and achievement gaps (**Levay et al., 2018**; **Allen et al., 2019**; **Afterschool Alliance, 2011**; **NRC, 2015**; **Beckett et al., 2009**; **Saw, 2020**). Yet research on best practices in OST STEM programs and how they may best leverage STEM ecosystems is still in its infancy (**NRC, 2015**). Policymakers and funders should invest in expanding and combining research on these topics. For example, grant programs can require that funded projects collect and share data, and/or fund longitudinal data infrastructure to track program effects over time and meta-analyses to compare effects across programs and STEM learning environments. These activities might be shared among partners, such as those in a STEM ecosystem. Funders and programs can also specifically invest in research-practice partnerships that combine the knowledge of previous studies and benefits of conducting rigorous research with practical understanding of the context and implementation issues involved in delivering the program.

4. Advocate for OST STEM education, especially for students impacted by structural inequities like racism, sexism, or poverty

STEM education is a national priority because it offers many benefits for students whether or not they pursue STEM careers (**NRC, 2007**; **NRC, 2015**; **NCSES, 2023**). Even so, there is still much room for improvement, especially regarding inequities in access to and support for high-quality STEM resources and education (**NRC, 2015**; **NSB, 2021**; **Beckett et al., 2009**). Policymakers, funders, program staff, parents, partners, and other interested parties must advocate for improvements in STEM education, especially for underserved students. To the extent possible, these parties should coordinate their efforts to maximize their impacts. For instance, OST programs and their funders can collaborate to share their impacts with their communities and policymakers. Industry partners can reinforce messaging from OST programs on their return on investment and importance for the workforce. OST programs and advocacy groups can mobilize parents with talking points and tips for discussing STEM education issues with their children's schools and with their local, regional, and national policymakers. This sort of dovetailed advocacy is especially important for sustaining existing programs and expanding access to programs for students underrepresented in STEM fields.

References

Afterschool Alliance. (2011). STEM learning in afterschool: an analysis of impact and outcomes. Washington, DC. Retrieved from **https://www.afterschoolalliance.org/STEM-Afterschool-Outcomes.pdf**.

Allen, Patricia J., Chang, Rong, Gorrall, Britt K., Waggenspack, Luke, Fukuda, Eriko, Little, Todd D., & Noam, Gil G. (2019). From quality to outcomes: a national study of afterschool STEM programming. International Journal of STEM Education, 6(37): 1-21. **https://doi.org/10.1186/s40594-019-0191-2**

Allen, Patricia J., Lewis-Warner, Kristin, & Noam, Gil G. (2020). Partnerships to Transform STEM Learning: A Case Study of a STEM Learning Ecosystem. Afterschool Matters, n31 p30-41 Spr 2020. Retrieved from **https://eric.ed.gov/?id=EJ1249559**.

Beckett, M., Borman, G., Capizzano, J., Parsley, D., Ross, S., Schirm, A., & Taylor, J. (2009). Structuring out-of-school time to improve academic achievement: A practice guide (NCEE #2009-012). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from **https://www.isbe.net/Documents/ies-prac-guide.pdf**.

Levay, K., Volmert, A., & Kendall-Taylor, N. (2018). Crossing the boundaries: Mapping the gaps between expert and public understandings of bridging STEM learning environments. Washington, DC: FrameWorks Institute. Retrieved from **https://joanganzcooneycenter.org/wp-content/uploads/2018/05/jgcc_frameworksinstitute_crossingtheboundaries.pdf**.

Linn, M. C. & Eylon, B.-S. (2011). Science learning and instruction: Taking advantage of technology to promote knowledge integration. Routledge/Taylor & Francis Group.

National Center for Science and Engineering Statistics [NCSES]. (2023). Diversity and STEM: Women, Minorities, and Persons with Disabilities 2023. Directorate for Social, Behavioral and Economic Sciences, National Science Foundation. Retrieved from **https://ncses.nsf.gov/pubs/nsf23315/report**.

National Research Council [NRC]. (2007). Taking Science to School: Learning and Teaching Science in Grades K-8. National Academies Press. **https://doi.org/10.17226/11625**.

National Research Council [NRC]. (2015). Identifying and Supporting Productive STEM Programs in Out-of-School Settings. Washington, DC: The National Academies Press. **https://doi.org/10.17226/21740**.

National Science Board [NSB]. (2021). Elementary and Secondary STEM Education. Retrieved from **https://ncses.nsf.gov/pubs/nsb20211**.

Rennie Center for Education Research and Policy. (2022). The BoSTEM Initiative: Creating Pathways to the STEM Workforce. Retrieved from **https://files.eric.ed.gov/fulltext/ED627155.pdf**.

Saw, Guan. (2020). Leveraging Social Capital to Broaden Participation in STEM. Policy Insights from the Behavioral and Brain Sciences. 7. 35-43. 10.1177/2372732219895997.

Smith, D. C. & Neale, D. C. (1989). The construction of subject matter knowledge in primary science teaching. Teaching and Teacher Education, 5(20), 1-20. **https://doi.org/10.1016/0742-051X(89)90015-2**.

Tennessee STEM Innovation Network [TSIN]. (2024). Regional STEM innovation hubs. Retrieved from **https://irp.cdn-website.com/d980f98f/files/uploaded/digital.tennessee-stem-innovation-design-final(3).pdf**.

University City Science Center [UCSC]. (2024). An enduring impact: 2023 University City Science Center impact report. Retrieved from **https://sciencecenter.org/news/science-center-2023-impact-report-2**.

U.S. Bureau of Labor Statistics. (2024). Employment Projections. Retrieved from **https://www.bls.gov/emp/tables/stem-employment.htm**.

Appendix A: EIR Projects Highlighted in This Summary

Grantee	Project
United Way of Massachusetts Bay and Merrimack Valley	**BoSTEM**
University City Science Center	**Experiencing STEM FirstHand: The Impact of a Novel Approach to Bolstering Scientific Identity, Interest, and Knowledge in Low-Income Middle School Students of Color**
Niswonger Foundation	**STEM.LD (Learning Design)**