STEM READY AMERICA

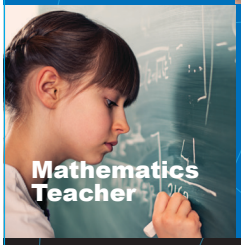
Inspiring and Preparing Students for Success With Afterschool and Summer Learning

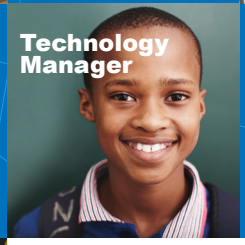
This collection of articles is excerpted from a new resource, *STEM Ready America: Inspiring and Preparing Students for Success with Afterschool and Summer Learning.* In this volume, Executive Editor Ron Ottinger and Contributing Editors Cary Sneider and Ian Hickox have collected expert perspectives on the state of the field of STEM learning—especially in afterschool and summer learning opportunities.

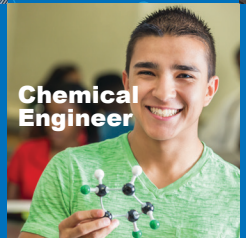
Collectively, these writings from more than 40 thought leaders highlight how young people are developing STEM knowledge and skills that will prepare them to be successful in school today and the workforce tomorrow.

The articles provide persuasive evidence and real-world examples to inform effective partnerships, policies, and actions to bring quality STEM learning to children and youth across the nation. This volume is focused in three key sections:

- **The Evidence for STEM**
- **Partnerships for STEM Learning**
- **Ensuring Access to Quality STEM Learning**







Developed by STEM Next with support from the Charles Stewart Mott Foundation, *STEM Ready America* builds on the award-winning 2013 publication *Expanding Minds and Opportunities: Leveraging the Power of Afterschool and Summer Learning for Student Success* edited by Terry K. Peterson, Ph.D., which made the definitive case for the power and effectiveness of afterschool programs and summer learning.

For more information about STEM Ready America and to download articles visit: www.stemreadyamerica.org.

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Evidence and examples on how young people are developing STEM knowledge and skills that will prepare them to be successful in school today and the workforce tomorrow.
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What Do We Know About STEM in Out-of-School Settings?

A National Research Council Report

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STEM Next | Charles Stewart Mott Foundation

The National Academy of Sciences was chartered in 1863 by President Abraham Lincoln to advise the nation on scientific and technical matters. Today, the National Academies—which now include the National Academy of Engineering and the Institute of Medicine—remain the nation's premier source of objective, nonpartisan information, often weighing in on controversial matters by convening a committee of experts on multiple sides of an issue. The findings of these consensus committees are reported by the National Research Council, which is the operating arm of the National Academies.

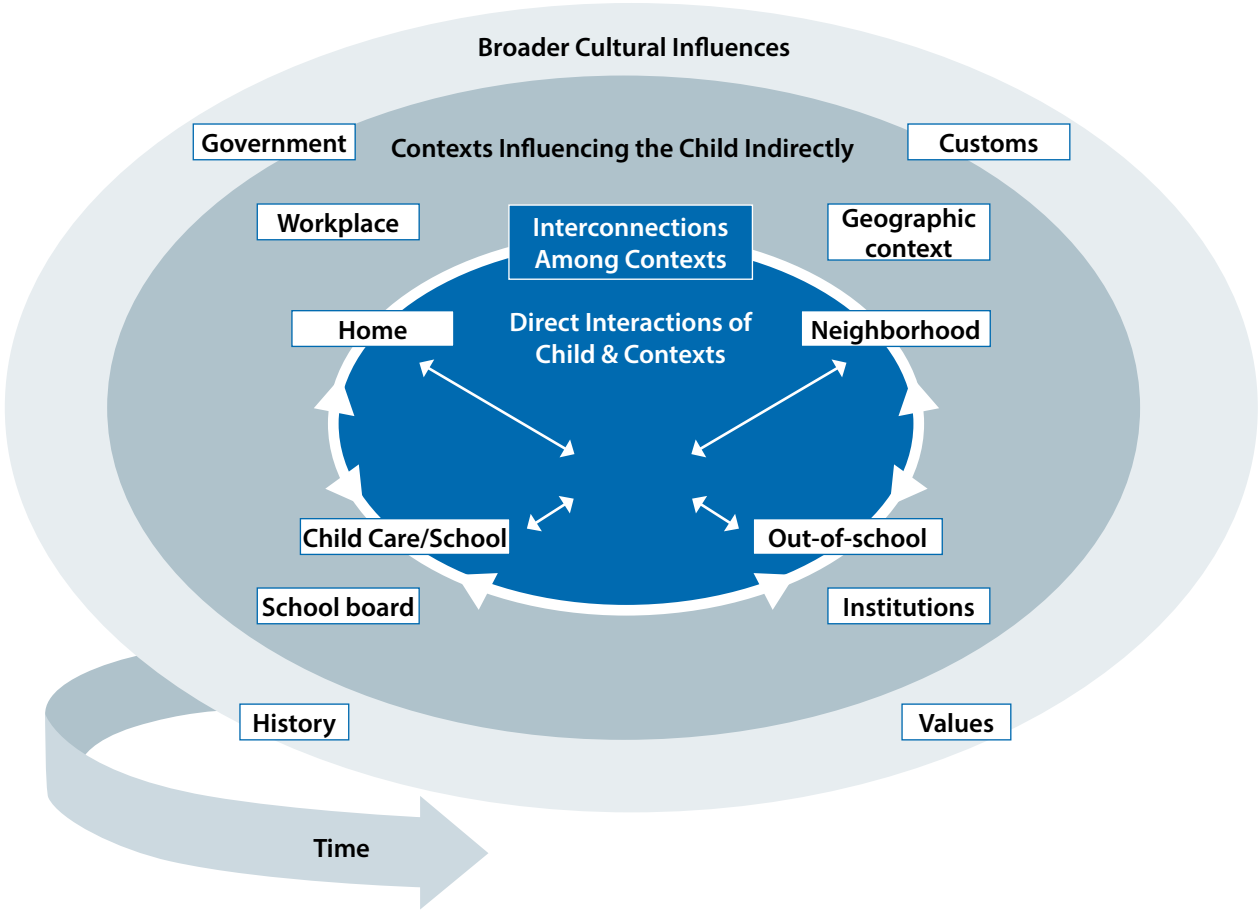
The quality of STEM learning opportunities in out-of-school-time (OST) is an increasingly important component of our educational system, but one that has been difficult to measure since it is so diverse, ranging from afterschool activities and weekend club meetings to citizen science and immersive multiweek summer programs. Because OST STEM is a critical component of our nation's educational infrastructure that continues to pose challenges to researchers, leaders of the National Science Foundation turned to the Academies to examine the research and bring some order to the discussion.

Our Committee on Successful Out-of-School Learning was charged with getting a handle on the criteria for excellent OST STEM programs and examining the evidence to determine if such programs exist. To meet this challenge, the governing body of the Academy of Science assembled a team of experts from a variety of fields. After a two-year study process, during which we commissioned white papers to synthesize the research and held a National Summit on Successful Out-of-School STEM Learning to gather input from a broader audience of stakeholders, our committee issued a report titled *Identifying and Supporting Productive STEM Programs in Out-of-School Settings* (National Research Council, 2016).

The report brings together the findings from disciplines that have developed along separate tracks—and that often do not intersect—including youth development, learning sciences, informal STEM education, and cognitive development. The body

> There is growing evidence that opportunities to learn STEM outside of school directly affect what is possible inside classrooms, just as what happens in classrooms affects out-of-school learning.
>
> —National Research Council, 2015, page vii

Figure 1. STEM learning ecosystem model



NOTE: This representation of the learning ecosystem model is based on Bronfenbrenner's ecological model of human development first published in 1977. The inner most circle represents interactions that directly involve both child and an embedding context (eg., child ◄► school). The next level shows connections among the immediately embedding contexts themselves. These also affect the child's experiences (eg., quality of family ◄► school interactions affect child ◄► school interactions). Influences from the increasingly distant layers influence the child's experiences indirectly. The inclusion of time indicates that both the child and the surrounding contexts are constantly changing, and thus that learning is always a dynamic process.

SOURCE: Adapted from Liben, L.S. (June 2014). An ecological framework for STEM learning. Presentation at the National Summit on Successful Out-of-School STEM Learning. National Academy of Sciences, Washington, D.C.

of knowledge developed across these disciplines reveals basic truths about the role and value of OST STEM programs, and learning more broadly. The key findings from the report are that:

- **Learning happens everywhere;**
- **Learning happens all the time; and**
- **Connections among experiences are essential.**

These findings point to the fact that education should not be viewed as solely the responsibility of schools. It is increasingly clear that experiences outside the classroom directly affect what is possible in the classroom and vice-versa.

The critical functions of so many interrelated yet independently governed components of STEM learning naturally suggested the analogy of an ecosystem. Just as an ecosystem concerns the interactions among the living and nonliving

elements of the natural world, our educational system concerns the interactions among youth and caring adults within formal and informal settings. Other elements of the educational ecosystem include the nature of learning opportunities and the broader culture that has an indirect influence on STEM learning. Just as the behaviors of living organisms within an ecosystem affect the system as a whole, children and youth also shape their learning experiences through their interests, dispositions, and values.

As revealed in the research from many disciplines, there is clear and ample evidence that out-of-school learning environments contribute to STEM learning. In particular, our consensus committee found that out-of-school programs are associated with three outcomes:

- **Development of relationships with caring adults that often serve as mentors;**
- **Increased understanding of and interest in STEM; and**
- **Reduced achievement gaps among genders, races, and people of different economic statuses.**

The evidence is not yet sufficient to say which programs work best for whom and under what circumstances. However, it is clear that the OST STEM programs that contribute to the outcomes discussed above share three key characteristics. Namely, such programs are **engaging, responsive, and they create connections**. The NRC study committee unpacked each of these qualities and examples of programs that reflect these qualities.

Engaging

Participants in OST programs benefit from first-hand, sustained learning experiences. Given the additional time and flexibility of OST programs, these experiences need not be just any hands-on activities. They can be authentic place-based scientific investigations, computer-based studies, or observations of natural phenomena. In addition, they can allow for learner-driven investigations so that young people have ownership over the questions they investigate as well as the method of collecting and interpreting data—all in a supportive environment. These practices lead to a better understanding of STEM concepts, increased interest in STEM, and an improved awareness of how STEM knowledge develops.

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Engaging STEM learning environments outside of school time are safe places where young people can make mistakes and where not getting the "right" answer is seen as part of the process rather than a failure. In essence, these environments should support learners as they explore concepts they are unfamiliar with and extend their understanding. OST STEM programs are well-suited to provide young people with authentic STEM learning experiences because they can be designed to provide the time, community, and support needed to engage in STEM practices.

Responsive

There is a strong relationship among a learner's prior experiences, beliefs, and culture and their participation in STEM learning experiences. Consequently, it is important for out-of-school educators to be responsive to the learner's culture, promote collaboration, and position adults as co-investigators. These characteristics of OST STEM programs help young people experience STEM as more than an abstract concept that has little connection to their daily lives.

OST STEM programs are culturally responsive when they connect STEM to problems that are central to the learner's community and when they leverage the cultural orientation, resources, and practices of the participants. Such programs often lead young people to see STEM as relevant to their lives, their family, and their culture, and to identify as someone who can learn STEM.

Developing an identity as a STEM learner is also advanced by engaging and collaborative learning experiences, which allow young people to be both leaders and learners and assume agency in their learning. Collaborative learning strategies allow young people to leverage their own strengths, interests, and skills, while working with peers and adults.

Skilled and caring adults are essential for developing responsive programs. Supportive relationships, where adults are both mentors and co-investigators, empower learners to recast "failure" as part of the process of solving STEM problems, promote increased interest in STEM, and support identifying as STEM learners.

A strength of the ecosystem analogy of STEM learning is that it focuses on the potential for increased achievement by connecting multiple learning experiences.

Creating Connections

The line from inexperienced STEM learner to expert is not straight. STEM learning develops, fluctuates, and deepens across settings and over time. Young people bring their understanding of STEM concepts and practices from one setting to the next— from what is learned in school to programs at museums, from conversation in their homes to summer programs, and so forth. To encourage learning across settings, productive OST STEM programs create connections, leverage community resources, and broker additional learning opportunities.

A strength of the ecosystem analogy of STEM learning is that it focuses on the potential for increased achievement by connecting multiple learning experiences. For example, an afternoon visit to a science center can inspire the imagination and ignite curiosity about science learning that can be foundational to a learner's later persistence with science curriculum in a formal setting. OST settings

can allow iterative and recursive experiences outside of time-bounded classroom learning and allow for self-paced advancement toward mastery.

Connections across learning experiences are not likely if left to chance. Rather learning experiences need to be coordinated so that youth understand the connections between the STEM concepts and practices that they are exploring in different settings. This requires communication among museums, schools, afterschool and summer programs, science-rich institutions, and other STEM education providers. In the ecosystem context, "coherence"—the logical and consistent alignment of independent sectors towards a shared goal—is essential to advancing learner outcomes in the aggregate.

Connections across learning experiences allow each educational setting to focus on its own strengths while leveraging the strengths of other settings. For example, partnerships between schools and museums allow teachers and museum professionals to collaboratively design coursework that incorporates the instructional expertise of school teachers and the STEM expertise of museum professionals. In addition, such partnerships promote opportunities for young people to extend and deepen their knowledge of STEM as they engage in aligned learning opportunities in the classroom and museum-based programs.

It is also important that youth are supported in finding ways to expand their understanding and interest in STEM, which requires active brokering of learning experiences. This can include directing young people to more advanced programs, identifying apprenticeship opportunities, and creating connections to possible mentors.

Recommendations

The study committee suggested six steps that policy makers, program developers, and other stakeholders can take to promote OST STEM programs that reflect the characteristics of successful programs and build our understanding of what works.

1. **Build a map and bridge the gaps:** To strengthen the STEM learning ecosystem, it is important to take inventory of existing STEM resources and identify gaps. The results of such an inventory can help policymakers, funders, and program developers understand the strengths and needs of community, what resources can be leveraged for greater impact, and where the greatest potential for return on investment exists.
2. **Connect young people to opportunities to learn:** Equitable access and participation in out-of-school STEM programs will only be accomplished through intentional and thoughtful action. It is essential to engage the community in creating programs that align with learners' interests, identities, and values, and to provide brokers who can connect youth with the appropriate learning programs.
3. **Provide professional development:** STEM learning is facilitated in out-of-school settings by adults who come from a wide array of professional backgrounds. Professional development in STEM, pedagogy, youth development, and program management is needed to equip adult leaders to consistently run effective programs.

4. **Build an infrastructure that will last:** Only a fraction of the need for out-of-school STEM programing is being met, and not all reflect the characteristics of productive programs. To expand and sustain quality programing, policymakers and funders need to provide opportunities for collaboration across learning environments, for programs to develop and be sustained, for professionals to share best practices, and for community networks to develop.

5. **Support innovative evaluation approaches:** Encouraging the use of creative and responsive approaches to evaluate the success of programs at the individual, program, and community levels will help answer questions about what programs work best for whom and under what conditions. In addition, evaluations that go beyond testing individual outcomes are key to understanding how out-of-school programs are contributing to the health of the full STEM learning ecosystem.

6. **Explore how STEM learning ecosystems work:** Research on OST STEM learning and STEM learning ecosystems, along with program evaluation, is needed to expand our knowledge of how learning emerges across the complex network of a STEM learning ecosystem.

Further elaboration of these six components will help us better understand the critical factors that are necessary and essential to learner success. Tracking the existence, availability, and cultural relevance of programs, and coordinating critical factors for success, will also clarify any issues of equity that must be accounted for in order to create a vibrant ecosystem—that goes beyond formalized learning—for all STEM learners. As our reliance on OST STEM learning expands, so must our thoughtful coordination and management of these opportunities.

To expand and sustain quality programing, policymakers and funders need to provide opportunities for collaboration across learning environments, for programs to develop and be sustained, for professionals to share best practices, and for community networks to develop.

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Eric Jolly, Ph.D. joined Minnesota Philanthropy Partners in 2015, after 11 years as the president and CEO of the highly esteemed Science Museum of Minnesota. He is a former Kellogg Leadership Fellow, where he studied international philanthropy and first wrote professionally about the realities and differences between donor interests and community need. His work leading MN Partners gives him the opportunity to apply his unique perspective, which has been honed over the years through service on many prestigious boards and councils. Eric has a Ph.D. in psychology from the University of Oklahoma, and is chair of the National Academies of Science Expert STEM Panel, where he advances national policy in education especially for engineering and the STEM disciplines. He has a background in higher education and has lectured around the world on the importance of STEM education in contemporary societies.