

Out-of-School Time STEM: Building Experience, Building Bridges

**Trends, Questions, and Findings from the Field
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EXECUTIVE SUMMARY



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STEM in Out-of-School-Time Settings

This report reviews patterns, challenges, and questions developing in the field of out-of-school-time (OST) science, technology, engineering and mathematics (STEM) programs by drawing on the efforts of some two dozen federally funded programs that participated and presented their work at a conference held in Washington, DC in October of 2009. Reflecting the questions and concerns of both practitioners and researchers in the OST STEM field, the report is intended to inform the work of OST educators, researchers, and funders.

The recent *Learning Sciences in Informal Environments* (2009) report from the National Research Council suggests that learning science is a complex and multi-faceted process. It entails not only the development and mastery of conceptual knowledge and skills, but also insight into the epistemologies of science, as well as understanding the ways in which science is enacted in everyday and professional settings. Interest in and affiliation with fields of scientific practice develop through, and also drive, learning in science. The American Association for the Advancement of Science (1991) similarly concludes that learning science entails “being familiar with the natural world and respecting its unity; being aware of some of the important ways in which mathematics, technology, and the sciences depend upon one another; understanding some of the key concepts and principles of science; having a capacity for scientific ways of thinking; knowing that science, mathematics, and technology are human enterprises, and knowing what that implies about their strengths and limitations; and being able to use scientific knowledge and ways of thinking for personal and social purposes” [1]. In short, there is a broad consensus that science literacy is more than knowing, and even more than knowing and doing, but involves acts of knowing, doing, and being that occur over multiple timeframes and settings [2, 3].

The National Context

There is growing interest and investment in OST STEM programs. Federal agencies such as the National Science Foundation, NASA, and NOAA have dramatically increased funding and access to these programs. More than 90% of leaders of afterschool programs would like to increase science programs for children [4]. It is widely held [2, 5, 6] that out-of-school-time programs such as summer camps,

afterschool programs and Saturday classes provide students with important opportunities to

- Spark, sustain, and deepen their interest in science, technology, engineering, and mathematics (STEM).
- Develop and expand their understanding of STEM.
- Advance an awareness of and commitment to pursuing academic, career, and lifelong pathways in STEM-related fields.

The development of growing interest in OST STEM has been accompanied by a growing concern about the need to align, document, and assess OST science programs goals and outcomes for students [2, 7-10]. But there are tensions in the field about the best ways to do this. How can the subject matter learning in OST settings be developed in ways that enable and encourage further learning in other settings and timeframes, including in schools, without adversely affecting the developmental qualities of the OST setting that make it accessible, inviting, engaging, and intellectually, socially, and emotionally empowering for a broad and diverse array of students? This report has been developed to inform decision-makers who are involved in funding, designing, and evaluating such programs and their future trajectories.

OST STEM Program Types

Supporting a rich and multi-faceted conception of science learning is a rich and multi-faceted field of OST science programs. OST science programs vary from science-specific summer or weekend programs, often set in science-rich institutions like museums or zoos, to brief activity units offered as part of a broader and more generic afterschool program. Sometimes OST STEM activities are organized around extended inquiries in the field, such as local wetlands or urban ecologies. At other times, they might involve using kits or worksheets in classroom-like settings. In some cases, children commit to consistent participation over sustained periods of time; in other cases, programs are offered as drop-in opportunities and are subject to widely varying attendance patterns. Some programs aim to develop children's conceptual understanding in particular science domains, others emphasize epistemologies of science (e.g., inquiry) through supporting student research projects; yet others emphasize STEM careers and endeavors.

Despite these variations, there are typically some general differences between OST STEM and school STEM. For example, OST STEM activities tend to be less verbal and abstract, and more tactile and situated in or connected to everyday settings. They are more often experienced through group inquiries or collaborative investigations, rather

than through individualized activities. Because they are not subject to covering mandated curricular topics, they can be characterized by a flexible use of time that permits children to pursue new ideas as they come up or linger on particularly motivating ones when there is interest. They often build on firsthand experiences with science-related places, people, phenomena, data, and tools -- resources that may be more difficult to integrate into the school classroom.

Above all, because most OST environments are low-stakes (non-evaluative) environments, they provide opportunities for students to play or experiment with science, taking on new roles and stances that may be less accessible or possible in school settings -- where there is often more pressure to follow particular procedures or arrive at specific answers. This may be especially important for students who have been discouraged by school science and might have self-identified as not competent or interested in science; such students, it has been shown, are disproportionately female or from non-dominant cultural communities [11]. As developmental spaces, OST STEM programs can reinforce and expand children's experiences with school STEM, both supplementing and complementing it through supporting children's interest, understanding, capacity, and identity with respect to STEM learning.

This variation of OST STEM program goals, design, and participation patterns might suggest that adopting a singular way to design, document, and evaluate such programs could operate adversely to homogenize the conceptual -- and diminish the developmental -- potential of the OST setting. Indeed, from a policy perspective, providing and ensuring a rich and diverse science learning ecology within our communities may be one of the most important contributions OST science programs can make toward ensuring more accessible and equitable science education for all [12].

NSF AYS: Designing, Documenting, and Assessing OST STEM

In response to the growing interest in the OST field, the rich diversity of programs, and a relative lack of evidence about how such programs impact student interest and learning in science fields, in 2006 the National Science Foundation (NSF) created a new program, the Academies for Young Scientists (AYS). This program was designed specifically to support and test the potential of OST projects to build student interest in STEM fields and practices with the goal of contributing to the body of literature regarding the design and assessment of OST STEM programming.

The NSF AYS program funded 16 projects, each of which had a distinct program design and addressed different science-based disciplines. In common, all 16 projects provided students opportunities to deepen their interest in, understanding of, and career

awareness of science, technology, engineering, and mathematics fields. All formed partnerships among school districts, universities, businesses, and community-based-organizations. All offered approximately 100 hours of programming, over one to two years, to children attending afterschool, weekend, and/or summer programs. All experimented with ways to incorporate pre-service, in-service, or community-based organization educators as lead teachers in the afterschool programs.

The AYS program contributed to NSF's existing efforts to expand the knowledge base regarding OST STEM projects, which already included projects funded by the Informal Science Education (ISE) and the Information Technology Experiences for Students and Teachers (ITEST) programs. NSF AYS placed a particular emphasis on children in K-8 and was designed to support research into the ways in which these programs supported student interest in science and science fields. The program also awarded a grant to the Learning and Youth Research and Evaluation Center (LYREC) headed by the Exploratorium's Center for Informal Learning and Schools (CILS) with SRI, International. LYREC used both quantitative and qualitative measures to document (a) whom the NSF AYS projects served, (b) what each project provided, and (c) whether and how they built student interest in, understanding of, engagement with, and opportunities to persist in STEM learning.¹ LYREC was charged with analyzing and synthesizing local project evaluations and research studies that addressed program impacts on students. LYREC also examined the role of classroom teachers in leading these out-of-school-time programs. Analysis of the data collected over the past three years is currently underway.

Out-of-School Time STEM: Building Experience, Building Bridges Conference

The NSFAYS projects were implemented during the 2007-2010 academic years. Towards the end of 2009, as projects were beginning their data analysis phase, LYREC worked with project leaders from NSFAYS, as well as from ITEST and ISE, to design a conference that would bring together leaders from the field to share what they were learning with respect to design, documentation, and assessment of OST STEM programs. The *Out-of-School Time STEM: Building Experience, Building Bridges* conference met on October 19-20, 2009. Over 115 educators and researchers attended. The goal of this conference was to surface issues, challenges, and solutions related to OST science; to provide opportunities for cross-pollination, particularly as projects were reaching their

¹ LYREC defines understanding of STEM to encompass the strands of STEM learning described in the NRC (2009) volume *Learning Science in Informal Environments*.

data analysis phase; and to identify emerging findings or questions that could inform a larger research agenda in the OST science field.

The two-day conference was organized around five strands:

1. OST STEM Program Design, Partnerships, and Implementation
2. Research and Evaluation of OST STEM Programs
3. Student Learning in OST STEM Programs
4. Teacher Learning in OST STEM Programs
5. OST STEM Program Sustainability

Additionally there were two hands-on data workshops offered. Keynote talks were provided by Kevin Crowley, University of Pittsburgh, and Philip Bell, University of Washington. Crowley spoke about the need to maintain the rich, localized variety of science in OST settings. Bell discussed the recently published National Academies of Sciences report *Learning Science in Informal Settings*, stressing the six different strands of what constitutes capacity to engage with science, and how OST settings may be especially strong in supporting children's interest in science and identity as science learners.

There were a total of 13 workshops offered in the five strands. The full report contains workshop descriptions and expanded summaries of the synthesis conclusions drawn about each of these strands.

Strand One: Design and Implementation of OST STEM Learning Environments

The workshops in this strand focused on features of design and implementation that impact projects' challenges and successes. Strand Discussants were Joyce Malyn-Smith, from Education Development Center, and Diane Miller, from the Saint Louis Science Center. There were three workshops in this strand; themes that emerged included:

- (1) OST STEM programs are especially well positioned to help children make connections between science and real world contexts, needs, applications, and communities.
- (2) OST STEM programs pose unique opportunities for teachers and other program staff to experiment with new ways of interacting with the scientific phenomena and with new pedagogies.

- (3) OST STEM programs need to cultivate partnerships carefully, with attention to the capacities and expectations of each collaborator within the practical context of implementation.

Strand Two: OST STEM Research and Evaluation Frameworks

In this strand, AYS, ITEST, and ISE projects presented their research and evaluation methodologies and designs. Strand Discussants were Drew Gitomer, from ETS, and Kevin Crowley, from the University of Pittsburgh. There were three workshops included in this strand. Emergent themes include:

- (1) There is a need to design data collection methods that do not interfere with the students' experience of the OST program.
- (2) There is interest in capturing changes that may be more strongly related to the development of long-term dispositions, understanding, and trajectories than they are to short-term effects.
- (3) There is a need to clarify intended outcomes (at both a policy-funding level and at the level of program design) and aligning data collection strategies in ways that take into account the highly idiosyncratic and contingent nature of the programs as they vary across settings.

Strand Three: Scaling and Sustainability

This strand focused on issues related to (a) sustaining programs beyond their NSF funding cycles and (b) scaling programs beyond their initial scope. Synthesizers of this session were Julie Johnson of the Science Museum of Minnesota and Gil Noam of the Program in Education, Afterschool & Resiliency (PEAR) at Harvard Medical School. There were three workshops in this strand. Presentations and discussions focused on the following three themes:

- (1) There is a need to bring greater complexity to notions of sustainability and scale-up; rather than expanded replication, there is a need to consider isolating features or elements that are (trans)portable and scalable.
- (2) There is a need for more adequate and reasonable timelines to allow for project innovation, project maturation, and, then, project scale-up and sustainability. There are many problems associated with the pressure to act quickly because of funding requirements and expectations.
- (3) There is a need to design project evaluations with sustainability and scale-up in mind and then to use these evaluations to inform decisions about sustaining and scaling the projects in future phases of the work.

Strand Four: Student Learning and Development in OST

In this strand, project leaders shared their goals and evaluation methods related to their programs' impacts on students. Synthesizers of this session were Rob Semper from the Exploratorium, Stephanie Robinson from the Education Trust, and Philip Bell from the University of Washington. There were two workshops in this strand. Presentations revealed that programs had a wide variety of goals for student learning as well as different approaches to documenting program impacts. Themes that emerged included:

- (1) A diversity of approaches seems to be the strength of OST programs, appealing to different children with different interests, frequently by tapping into local resources, settings, and authentic questions and needs.
- (2) There is a need to better understand and build coherence across OST and school settings in order to spark, sustain, and develop students' interests and understanding in STEM fields.
- (3) There is a need to build understanding in both OST and school communities about the needs, interests, resources, and potential power of each.

Strand Five: Teacher Learning and Development in OST

This strand focused on how the OST setting could be used to support teacher learning and development in STEM content and pedagogy. Strand Discussants were Mark St. John from Inverness Associates and Patrick Shields from SRI International. There were two workshops in this strand. The core assumption underlying these efforts is that in order to provide children opportunities for authentic science learning in school, teachers need similar opportunities, which they can receive in OST settings. Emergent themes included:

- (4) OST programs can provide classroom teachers opportunities for professional development and growth that they would not have otherwise.
- (5) There is a need to explore whether the use of OST settings as a practicum site for new or continuing teachers is a sustainable model that can be brought to scale.
- (6) There are challenges associated with developing a robust theory of teacher change in and through the OST setting, and modeling aspects of it sufficiently to support ongoing research. Additionally, the assumption that the impact should be unidirectional—from OST to school—is largely under-theorized and untested.

Conclusions and Recommendations

Looking across the strands, and referencing the expanded syntheses of each strand, found in the full report, the following big picture trends or needs emerge that have implications for program design, funding, and research. Further detail on these trends can be found in the description of the strands and the syntheses of their findings.

- (1) **There is no one model of OST STEM. Most programs are designed to reflect local resources, needs, and communities and therefore program goals, design, and outcomes vary widely. This diversity enriches the science learning landscape, providing multiple points of entry for many different learners.** This diversity has implications for funding, research, assessment, and scaling up.
- (2) **OST STEM programs offer important developmentally supportive environments for children to develop their interest in, affinity with, understanding and pursuit of STEM.** The low-stakes nature of these programs can provide all students with learning opportunities and activities that legitimate them as productive science learners. What developmental science settings look like, and what outcomes they promote, vary across particular programs and participating groups.
- (3) **There is a need to develop new research and evaluation questions, methods and instruments** that can take into account the nature of the OST STEM setting, program treatment and dosage, and analyze and document how the experiences contribute to children's lifelong, as well as immediate, engagement with STEM.
- (4) **Most OST STEM programs are not extensions of school STEM. They draw on different resources, have different timeframes, and therefore have different potentials and outcomes.** They must be researched and evaluated differently. On the two ends of a spectrum, they can both attract and interest children who are not engaged in school STEM and they can provide advanced experiences for children who are deeply engaged in school STEM. They can also be accessed at different times as children's engagement in STEM ebb and flow.
- (5) **There is a need to better understand the complex connections between school and OST experiences in STEM and how they contribute to lifelong engagement with science, including career pursuits.** This work will require longitudinal and ethnographic studies that take into account the developmental power of the OST setting as well as the nature of the STEM that is experienced in school, OST, and home or community settings. Reflecting the complex interacting parts and systems in which the work is taking place, no one pathway will prove right for all communities or participating groups or at all times.
- (6) **There is a need to better understand the ways in which OST STEM programs can provide important professional development sites for classroom teachers, both**

pre-service and in-service: (a) for learning STEM subject matter; (b) for experimenting with new STEM teaching materials and approaches; (c) for seeing their own students: as capable engaged STEM learners; and (d) for engaging with children and STEM in the context of joy and excitement, thus (i) “inoculating” new teachers against narrow conceptions of what science education can look like and (ii) rejuvenating seasoned teachers’ enthusiasm for teaching STEM.

- (7) **Funding for OST programs should provide sufficient time and resources** for these complex spaces to develop partnerships, programs, and evaluation strategies that can test innovations, investigate sustainability, and support strategic scale-up efforts.

Towards a Focused OST STEM Research Agenda

There is a need to develop and maintain a focused research agenda that takes into account these trends, needs, and challenges. Overarching questions that emerged from this conference that might help to frame such an agenda include the following:

- (1) What are the important ways that OST programs build children's capacities to engage in science?
- (2) What features of high quality OST STEM programs can or must be maintained in efforts to introduce STEM into a broad array of OST settings at scale?
- (3) What research methods can be employed in the OST setting that can document program impacts on students and teachers without altering the typically low-stakes and child-centered nature of the setting?
- (4) In what ways can the OST space support new and veteran teachers' views of science and science teaching and learning?
- (5) In what ways do high-quality OST STEM programs differ from and relate to high-quality school STEM programs, and how do these differences and relationships operate to strengthen student engagement with STEM?
- (6) How can schools become aware of and build on the capacities and interests that students develop in OST STEM programs?

The participants in this conference are making progress in addressing many of the issues these questions represent. The field as a whole is beginning to gather momentum to specify the terms, tools, and concepts that will generate more appropriate methods, more salient questions, and more meaningful results for use in the OST setting. Much work, using approaches as diverse as the OST programs and the children they serve, is needed to understand the many ways that OST experiences fit within the lifelong trajectories of children who participate in them and the larger educational landscape that they enrich.

References

1. Rutherford, F.J. and A. Ahlgren, *Science for all Americans*. 1991, New York: Oxford University Press. 272.
2. National Research Council, *Learning science in informal environments: People, places, and pursuits*. Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education, ed. C.o.S.L.i.I. Environments. 2009, Washington, DC: The National Academy Press.
3. Herrenkohl, L.R. and V. Mertl, *How students come to be, know, and do: A case for a broad view of learning*. Learning in Doing, ed. R.D. Pea. in press, New York: Cambridge University Press.
4. Chi, B., J. Freeman, and S. Lee, *Science in Afterschool Market Research Study*. 2008, Lawrence Hall of Science, University of California, Berkeley: Berkeley, CA.
5. Douglas, J.A. and C. Katz, *It's all happening at the zoo: Children's environmental learning after school*. *Afterschool matters*, 2009. 8: p. 36-46.
6. Fusco, D., *Creating relevant science through urban planning and gardening*. *Journal of research in science teaching*, 2001. 38(8): p. 860-877.
7. Afterschool Alliance, *Afterschool programs: At the STEM of learning*. Issue Brief No. 26. 2006, Afterschool Alliance: Washington, DC.
8. Halpern, R., *Confronting the big lie: The need to reframe expectations of afterschool programs*. 2006, Partnership for After School Education: New York.
9. Honig, M. and M. McDonald, *From promise to participation: Afterschool programs through the lens of socio-cultural learning theory*, in *Afterschool Matters Occasional Paper Series*, J. Gallagher, Editor. 2005, The Robert Bowne Foundation: New York.
10. Hussar, K., et al., *Toward a systematic evidence-base for science in out-of-school time: The role of assessment*. 2008.
11. Bouillion, L.M. and L.M. Gomez, *Connecting school and community with science learning: Real world problems and school-community partnerships as contextual scaffolds*. *Journal of research in science teaching*, 2001. 38: p. 878-889.
12. Bartels, D., R.J. Semper, and B. Bevan, *Critical questions at a critical time: Reflections of the contributions of LSIE to museum practices*. *Curator*, 2010. 53(2): p. 163-179.



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