PARTNER PERSPECTIVE

what afterschool STEM does best

How Stakeholders Describe Youth Learning Outcomes

by Anita Krishnamurthi, Bronwyn Bevan, Jen Rinehart, and Vicky Ragan Coulon

Afterschool programs are increasingly recognized as venues for effectively engaging children and youth in science, technology, engineering, and mathematics (STEM). Since the last set of national science standards was published in 1996, the number of afterschool programs and participants—and of dollars invested in STEM learning in these settings—has expanded substantially. The afterschool field has enthusiastically embraced STEM education. According to a 2011 Afterschool Alliance survey, a majority of providers now believe that it is important for them to offer STEM programming.

As more stakeholders get involved in the effort to engage youth in STEM outside of school, afterschool providers are being asked to document a wide range of outcomes, from generating interest in STEM to improving standardized test scores in math and science and to increasing the number of students who pursue STEM majors in college. Although stakeholders agree that afterschool STEM education can be powerful, there is less agreement on the critical question of which aspects of STEM education the afterschool field is best positioned to support (e.g., Sefton-Green, 2012). This issue has significant policy implications as lawmakers work on legislation that affects STEM education and decide on funding for efforts to improve it.

ANITA KRISHNAMURTHI is director of STEM policy at the Afterschool Alliance, a national nonprofit working to ensure that all youth have access to affordable, quality afterschool programs. She leads efforts to advance policies, research, and partnerships so children and youth can have rich STEM experiences in their afterschool programs.
BRONWYN BEVAN is associate director of program at the Exploratorium, a museum in San Francisco. Her research focuses on how institutional settings shape opportunities for learning.
JEN RINEHART is vice president for policy and research at the Afterschool Alliance. She takes a primary role in the Afterschool Alliance's coalition-building, policy, and research efforts, including leading the study *America After 3PM*.
VICKY RAGAN COULON is director of Evaluation & Research Associates, which specializes in evaluating programs supporting STEM equity, informal and formal education, and teacher professional development, as well as conducting research in those content areas.

The Next Generation Science Standards (Achieve, 2013) call for STEM education to move beyond facts and procedures by introducing broad *concepts*, such as scale or systems, and by engaging students in STEM *practices* such as developing evidence-based explanations. Because this expanded perspective will require active and contextualized modes of learning, the afterschool field has a clear and compelling opportunity to position itself as a key partner in a STEM learning "ecosystem" comprising schools, afterschool programs, and other community settings and partners.

In this context, greater clarity about appropriate afterschool STEM learning goals and outcomes is essential to demonstrating how afterschool programs can best facilitate STEM education. Hence, in spring 2012, the Afterschool Alliance undertook a study to ask afterschool stakeholders what aspects of STEM learning the field is best positioned to support. The aim of the Afterschool STEM Outcomes Study was to identify consensus views on appropriate and feasible outcomes and indicators for afterschool STEM programs. The study provides a realistic vision of the field's potential for supporting student learning, a vision that can inform policy decisions and evaluation design.

Listening to the Field

The growth in afterschool STEM has been accompanied by expansion of the field of informal science education (ISE), where a significant body of work has accumulated to define youth outcomes and guide assessment. Most notably, *Learning Science in Informal Environments*, a report of the National Research Council (NRC, 2009), articulates the multi-faceted dimensions of science education, which involves not only scientific concepts and skills but also scientific practices, ways of knowing, fields of activity, and the development of interest and identities.

Other work has articulated ways to discern evidence of science learning (Friedman, 2008), for example, through changes in interest, skills, and patterns of behavior. In addition, work in the learning sciences has revealed how science literacy develops across settings and over time (Bransford et al., 2006; Ito et al., 2012). Policy studies have posited the importance of integrating the full array of institutional settings—schools, afterschool programs, and other cultural and community settings—to support STEM learning (Carnegie Corporation of New York & Institute for Advanced Study, 2009; President's Council of Advisors on Science and Technology, 2011).

However, as many of these reports note, assessing the full impact of ISE projects is complex. Afterschool programs face a particular challenge. They differ from other commonly discussed ISE settings, such as museums, mass media, and gaming environments, because they:

- Sit at the junction of formal and informal learning settings
- Are driven by strong youth development goals
- Are commonly led, and their activities facilitated, by non-STEM experts
- Are more likely than other non-school educational settings to work with young people from populations historically underrepresented in STEM fields (Afterschool Alliance, 2009)

Not only are afterschool programs different from other ISE settings, they are also diverse among themselves, varying in such particulars as:

- Student ages, prior STEM experience, and interests
- Staff members' formal training and STEM background
- Time dedicated to STEM, ranging from daily to a few times a year
- Local resources and partnerships with, for example, universities, museums, or parks
- Level of resources allocated to science programming
- Type of STEM programming, from isolated hands-on activities to multi-year mentorships

> As afterschool becomes more widely accepted as a partner in STEM education—and therefore subject to increased scrutiny—the field must clearly articulate how afterschool programs contribute to children's STEM learning.

This diversity is an important asset. Key to a robust learning ecology is a wide array of opportunities for learners to develop and pursue new interests. However, the diversity complicates efforts to describe concisely the contributions of the field as a whole. As afterschool becomes more widely accepted as a partner in STEM education—and therefore subject to increased scrutiny—the field must clearly articulate how afterschool programs contribute to children's STEM learning.

The Afterschool STEM Outcomes Study, *Defining Youth Outcomes for STEM Learning in Afterschool* (Afterschool Alliance, 2013), used a process called the Delphi method. In this process, a carefully selected group of experts answer questionnaires in multiple rounds. After each round, a facilitator summarizes responses; the experts are then encouraged to revise their answers in light of the replies of other panelists. During this process, the range of the responses is expected to decrease as the group converges toward consensus. The process ends at a pre-defined stop point: completing a certain number of rounds, achieving consensus, or getting stable results. Participants remain anonymous throughout the process.

The Delphi method was chosen for the Afterschool STEM Outcomes Study to achieve convergence of opinions among two groups of experts:

- A panel of 55 afterschool providers: experienced afterschool leaders responsible for selecting, designing, or leading programming; providing professional development; and delivering program outcomes
- A panel of 25 afterschool STEM supporters: funders; national education policy leaders; and state education department representatives responsible for providing funding, making policy decisions, and establishing outcomes for afterschool programs

Three rounds of online surveys were conducted with each of these two groups in order to work toward consensus on:

- The main outcomes for which the field as a whole could be responsible
- The indicators of progress toward these outcomes
- Specific sub-indicators that afterschool programs could document to demonstrate their contributions toward achieving these outcomes

Afterschool STEM Outcomes Study Results

The Afterschool STEM Outcomes Study yielded consensus about three major outcomes for children and youth in diverse afterschool STEM programs: developing young people's interest in STEM, building their capacity to engage productively in STEM learning activities, and helping them come to value STEM. These broad developmental outcomes and indicators of learning resonate with prior literature on afterschool STEM programs (Afterschool Alliance, 2011), child and human development (e.g., Hidi & Renninger, 2006; Holland, Lachicotte, Skinner, & Cain, 1998; Lave & Wenger, 1991), youth development (e.g., Barber, Stone, Hunt, & Eccles, 2005; Eccles, 2005), and science learning (e.g., NRC, 2007, 2009). For each of the three outcomes, participants identified a set of indicators and sub-indicators, as shown in Table 1. Participants also indicated which outcomes they felt the field was best positioned to address.

The results of the Afterschool STEM Outcomes Study provide a framework for thinking about how individual programs can demonstrate their support for STEM learning. For example, many afterschool leaders believe that their programs support children's ability to work in teams, but not all are aware that teamwork is intrinsic to STEM practices and professions. The Afterschool STEM Outcomes framework helps afterschool leaders connect STEM learning outcomes to the program goals they value.

Although the expert panelists achieved consensus on the outcomes and indicators shown in Table 1, several interesting distinctions in their responses have implications for policy and practice.

STEM Activities vs. STEM Values

In defining the outcomes that afterschool STEM programming is best positioned to affect, the expert consensus ranked the following three indicators highest: active participation in STEM learning opportunities; curiosity about STEM topics, concepts, or practices; and ability to productively engage in STEM processes of investigation. Panelists also agreed that afterschool programs are less likely to be able to affect the other three indicators: awareness of STEM professions, ability to exercise STEM-relevant life and career skills, and understanding of the value of STEM in society. This finding suggests that the afterschool field is more confident about affecting indicators related to the active *doing* of STEM and less confident about affecting indicators that relate to the practices and value of STEM in society.

Shorter-Term vs. Longer-Term Sub-Indicators

In ranking sub-indicators, panelists indicated the most confidence that the field's work supports young people's interests, inquiries, and engagement with STEM activities. These sub-indicators of progress toward STEM learning can be seen and documented in immediate ways. The experts felt comparatively less confident about achieving impacts described by some of the longer-term sub-indicators of learning such as demonstration of STEM knowledge, understanding of STEM methods of investigation, and pursuit of further in-school or out-of-school STEM learning. The comparative lack of confidence about longer-term sub-indicators may reflect the uncertainty of participant attendance and other inherent structural features of the afterschool setting. These structural features must be considered in policy decisions and evaluation design.

Table 1. Framework for Developmental Outcomes and Learning Indicators for Afterschool STEM

OUTCOME Through STEM afterschool programs, children and youth...	INDICATOR You know or can see that children and youth demonstrate...	SUB-INDICATORS If you had appropriate tools, you could document the following types of evidence...
A. **Develop an interest in STEM and STEM learning activities** "I like to do this."	**Active participation in STEM learning opportunities**	**Active engagement and focus in STEM learning activities** *Examples of evidence: persisting in a task or program; sharing knowledge and ideas; expressing enthusiasm, joy, etc.* **Pursuit of other out-of-school time STEM learning opportunities** *Examples of evidence: enrolling in programs; attending programs regularly; reporting performing STEM-related activities at home* **Pursuit of school STEM learning opportunities** *Examples of evidence: participating more actively in school STEM activities; enrolling in courses; selecting special programs or schools; improving academic achievement*
	Curiosity about STEM topics, concepts, or practices	**Active inquiries into STEM topics, concepts, or practices** *Examples of evidence: exploring ideas verbally or physically; questioning, hypothesizing, testing* **Active information-seeking about mechanical or natural phenomena or objects** *Examples of evidence: conducting Internet searches for more information; getting books or journals about STEM; watching TV programs on science*
B. **Develop a capacity to productively engage in STEM learning activities** "I can do this."	**Ability to productively engage in STEM processes of investigation**	**Demonstration of STEM knowledge** *Examples of evidence: demonstrating increase in knowledge in specific content areas; making connections with everyday world; using scientific terminology* **Demonstration of STEM skills** *Examples of evidence: formulating questions; testing, exploring, predicting, observing, collecting and analyzing data* **Demonstration of an understanding of STEM methods of investigation** *Examples of evidence: demonstrating understanding of the nature of science; using evidence-based reasoning and argumentation; demonstrating engineering design practices*
	Ability to exercise STEM-relevant life and career skills	**Demonstration of mastery of technologies and tools that can assist in STEM investigations** *Examples of evidence: developing capacity to use measurement and other scientific instruments; running computer programs for data analysis; developing effective methods to communicate findings* **Demonstration of ability to work in teams to conduct STEM investigations** *Examples of evidence: communicating effectively with team members; collaborating effectively with team members; demonstrating leadership on the team* **Demonstration of applied problem-solving abilities to conduct STEM investigations** *Examples of evidence: engaging in critical thinking; questioning, sequencing, reasoning*

OUTCOME Through STEM afterschool programs, children and youth...	INDICATOR You know or can see that children and youth demonstrate...	SUB-INDICATORS If you had appropriate tools, you could document the following types of evidence...
C. **Come to value the goals of STEM and STEM learning activities** "This is important to me."	**Understanding of the value of STEM in society**	**Demonstration of an understanding of the relevance of STEM to everyday life, including personal life** *Examples of evidence: referencing examples of STEM in everyday life, everyday problems* **Demonstration of knowledge of important civic, global, and local problems that can be addressed by STEM** *Examples of evidence: contributing to projects that address a community need; developing awareness of how STEM is implicated in larger societal issues* **Demonstration of awareness of opportunities to contribute to society through STEM** *Examples of evidence: engaging in a service-learning project*
	Awareness of STEM professions	**Development of an understanding of the variety of STEM careers related to different fields of study** *Examples of evidence: gaining knowledge about relevant professions; gaining knowledge of where such jobs and careers exist* **Demonstration of knowledge of how to pursue STEM careers** *Examples of evidence: acquiring knowledge of what courses are needed to prepare for or pursue STEM degrees; declaring STEM interests or majors* **Demonstration of awareness that STEM is accessible to all** *Examples of evidence: expressing a desire to meet role models; declaring STEM interests and majors; desiring to become a role model to pave the way for others*

Availability of Assessment Tools

When asked about the availability of assessment tools to document the learning outcomes and indicators, the afterschool STEM supporters—state and national education leaders and funders—were much more optimistic about the availability of such tools than were the afterschool providers. This difference, though it did not meet the criterion for statistical significance, suggests that the two expert groups may have different standards for assessment. Another possibility is that providers are unaware of existing tools or feel that these tools are not usable or not accessible.

In-School vs. Out-of-School STEM Learning

Panelists were least confident that the afterschool field could demonstrate effects regarding the sub-indicator "pursuit of school STEM learning opportunities." This result is extremely important in light of the fact that many large-scale studies have used school achievement measures to assess the contributions of afterschool programs to children's learning. The relatively low ranking of this sub-indicator may reflect the panelists' feeling that achievement test scores are affected by too many factors that are out of the control of afterschool practitioners and supporters.

Implications and Areas for Further Research

The outcomes, indicators, and sub-indicators identified by participants in the Afterschool STEM Outcomes Study as representative of the field's contributions to STEM learning constitute a good step toward articulating the impact of afterschool STEM programs. The field's continuing challenge is to develop tools and methods that can document outcomes without significantly interfering with the afterschool experience, as, for example, pen and paper tests might do, and without incurring significant cost, as, for example, conducting ethnographic research might do. Besides documenting outcomes, the field is also challenged to show how program activities contribute to those

RELATING THE AFTERSCHOOL STEM OUTCOMES FRAMEWORK TO A MIDDLE SCHOOL STEM PROGRAM

The example of Exploratorium XTech helps to demonstrate how the Afterschool STEM Outcomes framework relates youth leadership, a capacity highly valued in many afterschool and youth programs, to STEM learning.

Exploratorium XTech is a three-year program that works with middle school youth during summer camps and on Saturdays during the school year. XTech students design and construct table-top versions of exhibits or activities on the museum floor. In the process, they engage with phenomena; develop proficiencies with machine and digital tools; and exercise scientific practices including design, experimentation, problem-solving, observing, and analyzing.

As they grow older, XTech students can become XTech facilitators, assisting staff in XTech and in community afterschool programs to lead design-and-build activities with younger students. Exercising leadership in XTech involves developing mastery of STEM concepts, tools, and practices in order first to support incoming students and eventually to take on formal teaching roles with elementary-aged students. In the process, students develop their interests and become local experts on particular tools, such as band saws or video documentation, or on concepts, such as mechanics or optics. Led by their interests, they deepen their engagement and mastery, as evidenced by the increasing complexity of the mini-exhibits they produce over time. Developing participants' capacities to engage in STEM is not the end goal but the means for full program participation and leadership development.

In a focus group, a number of participants shared their reflections on how it felt to teach younger students. One commented:

> I kind of think the whole thing was fun because, in the beginning, we were . . . trying to tell ourselves, "Okay, this is what we can teach," and we would teach. What always came up is, "Okay, but we have to explain this to kids who are way younger than us." That's what made it more interesting, was taking all of these concepts we knew and turning it into a way to explain it to third through fifth graders. (Vossoughi, 2012, p. 8)

Although youth leadership is not included in the Afterschool STEM Outcomes framework, the framework clarifies the ways in which STEM activities provide a context in which leadership can develop.

OUTCOME	INDICATOR	SUB-INDICATORS	XTECH ACTIVITIES
Developing interest	Active participation in STEM learning opportunities	Active engagement and focus in STEM learning activities	Mastering ideas and techniques in order to teach others
Developing capacities	Ability to productively engage in STEM processes of investigation	Demonstration of STEM knowledge; demonstration of STEM skills	Designing and constructing increasingly sophisticated STEM mini-exhibits

outcomes. The nature of children's experience in afterschool programs remains largely unexamined.

The expert panelists agreed that afterschool programs contribute to students' school success, but they expressed lower levels of confidence, relative to other effects, in the field's ability to affect school outcomes such as test scores and course taking. This finding is perhaps unsurprising, given the peripheral relationship of school outcomes to afterschool interventions, but it is notable because programs have often been evaluated on exactly (and sometimes only) these dimensions. Better communication and coordination between school and afterschool, together with a clearer understanding of what each can contribute as a component in an ecosystem of learning, would help to correlate learning between the two.

The study results point to some key areas that could benefit from additional research. For one, the panelists' relative confidence in the field's ability to document immediate as opposed to longer-term effects, along with their lack of confidence about demonstrating impact on school STEM learning, suggest the need for new research and evaluation methodologies and instruments. The field needs ways to investigate STEM learning across settings, showing how immediate STEM learning outcomes in afterschool settings relate to longer-term learning in school or other community settings. New tools may enable the field to articulate and evaluate the value and contributions of afterschool programs.

Another area for additional research is suggested by disparities between how panelists ranked particular learning indicators as opposed to the outcomes the indicators support—for example, indicating that programs do support teamwork but do not support the development of STEM skills. This finding suggests a need for dialogue and professional development that unpack core ideas in STEM learning outcomes. This need is especially relevant and important in relation to the concepts and cross-cutting practices highlighted in the Next Generation Science Standards, which will require an integrated view of teaching and learning. Dialogue about learning outcomes can help afterschool providers understand the many dispositions and practices involved in STEM fields and how programs can support their development.

Finally, variations in perspective between afterschool supporters and afterschool providers—though these did not reach the level of statistical significance—invite further investigation to detect and resolve any real and meaningful differences that emerge between the two groups. For example, supporters felt more confident than providers that programs could support development of students' STEM knowledge. What is the basis of this difference, and how does the disparity in perspectives affect how programs are designed and evaluated? Following up on this issue should yield information to help the field move forward to achieve its full potential. It may also provide guidance to funders seeking areas for high-impact afterschool investments.

The Place of Afterschool in the STEM Ecosystem

An increasingly robust research base points to the need to build an ecosystem of learning that spans school and out-of-school learning (Bevan & Michalchik, 2013; Ito et al., 2013). Concurrently, the ability of the afterschool field to support STEM learning is advancing at a rapid pace. This convergence brings a unique opportunity to cement the role of afterschool programming as an integral component of a re-imagined effort to improve STEM education.

A clear understanding of the outcomes to which afterschool STEM programs can contribute is essential to making this case. The consensus produced by the Afterschool STEM Outcomes Study provides on-the-ground perspectives—from those who lead, design, and fund afterschool STEM programs—about the outcomes the field is best positioned to advance. Policymakers and funders should consider these consensus views in framing the place of afterschool as an important part of the STEM education ecosystem. Furthermore, practitioners and researchers can use these outcomes and their corresponding indicators to design evaluations that document the role of afterschool programs in the STEM learning ecology.

The diversity of afterschool STEM programs is simultaneously a strength and an argument against developing one unifying measure for use across settings. However, using a common language like that provided by the Afterschool STEM Outcomes Study could facilitate a synthesis of results from like programs while enabling description of the range of possible outcomes across diverse programs. This common framework can enable the field to better describe how afterschool programs help children develop interest in, build capacity for, and come to value STEM and STEM learning activities.

References

Achieve. (2013). *Next generation science standards.* Available at http://www.nextgenscience.org/next-generation-science-standards

Afterschool Alliance. (2009). *America after 3PM*. Retrieved from http://www.afterschoolalliance.org/AA3PM.cfm

Afterschool Alliance. (2011). *STEM learning in afterschool: An analysis of impacts and outcomes*. Retrieved from http://www.afterschoolalliance.org/STEM-Afterschool-Outcomes.pdf

Afterschool Alliance. (2013). *Defining youth outcomes for STEM learning in afterschool*. Retrieved from http://www.afterschoolalliance.org/STEM_Outcomes_2013.pdf

Barber, B. L., Stone, M. R., Hunt, J. E., & Eccles, J. S. (2005). Benefits of activity participation: The roles of identity affirmation and peer group norm sharing. In J. L. Mahoney, R. W. Larson, & J. S. Eccles (Eds.), *Organized activities as contexts of development: Extracurricular activities, after-school and community programs* (pp. 185–210). Mahwah, NJ: Erlbaum.

Bevan, B., & Michalchik, V. (2013). Where it gets interesting: Competing models of STEM learning after school. *Afterschool Matters, 17,* 1–8.

Bransford, J. D., Barron, B., Pea, R. D., Meltzoff, A., Kuhl, P., Bell, P., & Sabelli, N. (2006). Foundations and opportunities for an interdisciplinary science of learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 19–34). New York, NY: Cambridge University Press.

Carnegie Corporation of New York & Institute for Advanced Study. (2009). *The opportunity equation: Transforming mathematics and science education for citizenship and the global economy*. New York, NY: Carnegie Corporation of New York.

Eccles, J. S. (2005). The present and future of research on activity settings as developmental contexts. In J. L. Mahoney, R. W. Larson, & J. S. Eccles (Eds.), *Organized activities as contexts of development: Extracurricular activities, after-school and community programs* (pp. 353–371). Mahwah, NJ: Erlbaum.

Friedman, A. (Ed.). (2008). *Framework for evaluating impacts of informal science education projects*. Retrieved from http://insci.org/resources/Eval_Framework.pdf

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*(2), 111–127.

Holland, D., Lachicotte Jr., W., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.

Ito, M., Gutiérrez, K., Livingstone, S., Penuel, W., Rhodes, J., Salen, K., . . . Watkins, S. G. (2012). *Connected learning: An agenda for research and design*. Chicago, IL: MacArthur Foundation.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, U.K.: Cambridge University Press.

National Research Council. (2007). *Taking science to school: Learning and teaching science in grades K–8*. Washington, DC: National Academies Press.

National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits*. Washington, DC: National Academies Press.

President's Council of Advisors on Science and Technology. (2011). *Prepare and inspire: K–12 education in science, technology, engineering, and math (STEM) for America's future*. Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stem-ed-final.pdf

Sefton-Green, J. (2012). *Learning at not-school: A review of study, theory, and advocacy for education in non-formal settings*. John D. and Catherine T. MacArthur Foundation Reports on Digital Media and Learning. Retrieved from http://dmlhub.net/sites/default/files/Learning%20at%20Not-School.pdf

Vossoughi, S. (2012). *Preliminary findings: Youth flight collaboration*. San Francisco, CA: Exploratorium.