Informal Science Learning and Education: Definition and Goals

Anita Krishnamurthi, Afterschool Alliance
Leonie J. Rennie, Curtin University

Learning involves change in knowledge and understanding; capabilities and skills; ways of thinking – values, feelings and attitudes; and/or ways of acting – behaviors. It is a lifelong process that occurs in many different environments. Learning is often described as *formal* learning (such as that occurring in schools, colleges, and universities) and *informal* learning (that occurs everywhere else). Although the learning *process* is the same, there are qualitative differences between formal and informal learning *contexts* that hinge on the degree of choice participants have to engage in learning activities and with whom, and whether or not there is a formal curriculum and/or assessment process.

What is Informal Science Education?

Informal science education (ISE) is learning related to science that occurs in informal, out-of-school contexts. These contexts vary from visiting science centers and engaging with the exhibits and programs offered there, to watching a science program on TV, to researching a nature topic in the library or online, to participating in structured afterschool programs, and so on.

More than a decade ago, and after considerable input from members, the Informal Science Education Ad Hoc Committee of the Board of the National Association for Research in Science Teaching (NARST) concluded that learning in out-of-school contexts means “learning that is self-motivated, voluntary, guided by the learner’s needs and interests, learning that is engaged in throughout his or her life” (Dierking et al., 2003, p. 109). This implies that ISE learners are self-directed, pursuing things that they need to know and hence of value to them, or things that are interesting and entertaining or amusing. Not all of these experiences result in learning at a conscious level. Some of them may result in “ah-ha” moments when an understanding suddenly falls into place, but many times these experiences will lay dormant until a reminding experience at a later time results in conscious understanding. This is why learning about science (including learning about technology and other cognate disciplines[1]) in informal contexts, ideally, is a continuous, life-long process.

Outside of school there are many opportunities to participate in science-related experiences that are designed to provide science-based explanations to the people who engage with them. Science museums, science centers, zoos, aquaria, and similar places are designed for people to pursue their interests and engage in science-related activities. Other opportunities for science-related experiences are available in afterschool programs. We define "afterschool" as programs that provide an array of safe, supervised, and structured activities for children and youth that are intentionally designed to encourage learning and social development outside of the typical school day. Programs generally operate during the hours immediately following school dismissal; however, they also include activities that occur before school, on weekends, over school breaks, and during the summer. They may be located at a school or off-site. Programs may be delivered through partnerships between public and private entities and may employ credentialed teachers and/or qualified community educators. They may be supported by parent fees or subsidized by federal, state, and local governments, grants, or philanthropic gifts, or any combination of these resources. A common element across these programs is an engaging, hands-on learning approach and less formal environment that aims to feel different from school.

Afterschool programs in the United States present a significant potential to engage young people in science learning. In the U.S. today, an estimated 8.4 million children participate in afterschool programs for approximately 14.5 hours weekly (Afterschool Alliance, 2012). Children from populations traditionally under-represented in science, technology, engineering, and mathematics (STEM) are more likely to participate than others – 24 percent of African-American, 21 percent of Hispanic and 16 percent of Native American children attend afterschool programs, compared to the national average of 15 percent (Afterschool Alliance, 2009). Girls attend afterschool programs in equal numbers to boys. The afterschool setting thus presents an

[1] Science and its cognate disciplines, Technology, Engineering, and Mathematics, are often collectively referred to by the acronym STEM.

opportunity to reach the very populations we need to include more in STEM fields through experiences that supplement and complement the school day.

Although afterschool programs were originally created with the purpose of keeping children safe while their parents worked or were otherwise unavailable, the goals of most programs have evolved to aim at enriching experiences that contribute to the development of the whole child. The goals of those afterschool programs providing structured learning activities include specific learning outcomes, and most recently, many programs have begun to specifically target STEM learning outcomes.

Comparing Informal with Afterschool Science Learning Environments

All ISE experiences include an element of free choice, but some are more structured than others. Structured ISE programs offered at museums, nature centers, zoos, and other locations may range in duration from short 1- to 2-hour workshops to summer programs with daily sessions over a period of weeks or months. Within the continuum of ISE experiences, afterschool programs tend to be highly structured, to be designed specifically for children or youth, and to be more closely linked to school settings than other ISE experiences.

Afterschool programs provide more extended opportunities for a series of related science learning activities, unlike other informal settings, such as a museum or science center, where learning experiences are typically brief. In addition, afterschool programs offer much more structured learning activities, generally supervised by a program leader, volunteer scientist, or mentor, in comparison to a museum or aquarium, where visitors are free to decide how they spend their time. Finally, attendance in afterschool programs is not always voluntary, as parents enroll their children in these programs and expect them to attend. However, students may have choices about which activities or programs to participate in while attending afterschool programs, allowing a measure of individual choice. This contrasts with learning activities at a museum or science center, where visitors are entirely free to choose what to do, when, and with whom.

Diversity of Goals for ISE and Afterschool Learning Environments

The goals of learning in ISE settings vary widely. The goals of institutions, like science museums, that offer opportunities for informal science learning usually mention something about education in their mission statement; however, learning goals are rarely articulated with clarity. Underlying goals may be expressed as “increasing science literacy” or “increasing interest and participation in science and technology”, although individual ISE providers may have more focused goals and desired outcomes, such as the environmental messages of zoos and aquaria. Nevertheless, visitors choose to attend these places to pursue their own interests, or to involve their families in science-related experiences that are entertaining. Visitors are rarely concerned primarily about their own science-related learning even though research has established that learning often happens anyway (Bell, et al., 2009). Overall, there is a sense that the visit experience should be engaging, interesting, and intrinsically motivated. Rather than achieving short-term outcomes, visitors have the opportunity to build a repertoire of experiences that can be drawn upon, when needed, to build understanding at a later time.

In contrast, afterschool programs are expected to demonstrate more immediate outcomes for the children and youth they serve. The range of reported outcomes for afterschool STEM programs and the language used to describe them varies greatly as a result of sometimes competing goals from various stakeholders. For example, the business community views afterschool programs as a way to teach workforce skills to its future employees, such as “critical thinking” and problem solving skills, whereas educational stake holders expect afterschool programs to support student academic success in some concrete and measurable way. A review of the achievement of afterschool program outcomes (Afterschool Alliance, 2011) identified outcomes that can be described as

1) those that are STEM specific (more interest and awareness, improved attitudes towards STEM fields and careers, developing strong STEM skills);

2) those that impact students' behavior in school (better attendance, improved classroom behavior, more engagement in school work, taking more AP classes, etc.); and
3) those that might be broadly called "21st Century Skills" (learn how to collaborate and work in teams, learn how to communicate more effectively, learn computer/communications/media technologies etc.).

In contrast to other types of ISE experiences, afterschool programs that focus on STEM experiences tend to have two overlapping goals: STEM learning within the larger goal of positive youth development. The desired outcomes of afterschool programs can be defined within these two broad goals and it is often difficult to disaggregate them, even if, at times, they may be in conflict with one another.

Frameworks for the Desired Outcomes of Informal and Afterschool Science Learning

There have been several efforts to organize and clarify the diverse goals of informal and afterschool science learning discussed above, including a framework of the dimensions of scientific and technological literacy (Rennie, 2007); the National Science Foundation's *Framework for Evaluating Impacts of Informal Science Education Projects* (Friedman, 2008); and the National Research Council's 2009 report, *Learning Science in Informal Environments,* which described six strands of science learning in informal environments (Bell, et al., 2009). The strands of science learning and impact categories defined in these documents remain a valid construct and basis for discussion of outcomes and evaluation of learning in informal settings and afterschool programs.

Rennie's (2007) framework suggests that scientific and technological literacy includes three dimensions: knowledge, capability, and ways of thinking and acting. These three dimensions can be teased out into descriptions of behavior, as shown in Table 1.

Table 1. Characteristics of Scientific and Technological Literacy (from Rennie, 2007)

Dimension	Scientifically Literate Persons	Technologically Literate Persons
Knowledge	Are interested in and understand the world around them	Understand the designed world, artifacts, systems, and infrastructure
Capability	Engage in discourses of and about science Are able to identify questions, investigate, and draw evidence-based conclusions	Have practical hands-on skills and fix simple technical problems Are able to identify practical problems, design and test solutions, and evaluate results
Ways of thinking and acting	Are skeptical and questioning of claims made by others Make informed decisions about the environment and their own health and well-being	Recognize risks, weigh costs and benefits Evaluate, select and safely use products appropriate to their needs Contribute to decision-making about the development and use of technology

The behaviors described in Table 1 are neither new nor unique. The six strands of informal science learning articulated in the NRC Report *Learning Science in Informal Environments* (Bell et al., 2009) are consistent with the behaviors described, and these descriptions suggest the kinds of engagement which facilitate learning that contributes toward becoming scientifically and technologically literate.

These three broad dimensions of scientific and technological literacy could be translated into measurable learning outcomes in one of several ways. Three examples follow.

1. The NSF *Framework for Evaluation Impacts of Informal Science Projects* has identified six categories of impact: awareness, knowledge or understanding of STEM concepts, processes or careers; engagement or interest in STEM concepts, processes or careers; attitudes towards STEM-related topics or capabilities; behavior resulting from experience; skills based on experience; and other (as a catch-all for unique projects) (see Friedman, 2008, p. 23).
2. The UK Museums, Libraries and Archives Council developed an agenda, *Inspiring Learning for All*,[2] designed to encouraged museums, archives and libraries to prioritize the learning experiences of their users and to develop a method of showing the impact that they can have upon their users. This resulted in GLO: Generic Learning Outcomes. They are increases in knowledge and understanding; increases in skills; change in attitudes and values; evidence of enjoyment, inspiration and creativity; and evidence of activity, behavior and progression (see Hooper-Greenhill, 2004, for an early assessment of this project).
3. From within a framework of science communication, Burns et al. (2003) classified personal responses to the informal communication of science using the vowels – AEIOU – as a memory aid to refer to changes in Awareness, Enjoyment or other affective responses, Interest, such as voluntary involvement with science, the forming or reforming of Opinions, and evidence of Understanding.

Each of these frameworks provides a list of ISE learning outcomes that could be the focus of measurement. Although they arise from different perspectives and for somewhat different purposes, there are commonalities among these lists of outcomes, and all three remind us of the variety of responses or impacts that can result from experiences of science in informal contexts. Further, the descriptions of behavior in Table 1 give direction to how those attributes might change if the impact is positive, that is, there is progress toward achieving the goals of scientific and technological literacy.

[2] See http://www.inspiringlearningforall.gov.uk/

Conclusions and Challenges for Assessment

Recognizing and quantifying the value of STEM-related experiences from informal and out-of-school/afterschool science learning programs requires an innovative and comprehensive approach to capturing the diversity of potential outcomes from these experiences. These kinds of programs provide opportunities to develop scientific and technological literacy, including a range of knowledge and understanding, capabilities and skills, dispositions and attitudes, and ways of thinking and acting. Clearly, assessments narrowly focused on the kinds of science knowledge currently valued in the school curriculum are inadequate.

Attempts to elucidate a broader set of learning outcomes, such as the six strands of informal science learning articulated in the NRC Report *Learning Science in Informal Environments* (Bell et al., 2009) lend authority to our assertion that a broader framework is necessary to assess the outcomes of informal and out-of-school/afterschool science learning programs. Outcomes from these programs include the development of positive dispositions and attitudes toward science and related disciplines, they provide opportunities to experience science-related activities without the pressure of testing, and they have the potential to enhance learning of science in ways that more closely mirror how science, technology, and engineering work in students' daily lives than do current school curricula. The broader set of outcomes that underpin the recently released *Framework for K-12 Science Education* (NRC, 2012) demonstrate the importance of a more integrated approach to science learning with its focus on science and engineering practices.

As the afterschool field is asked to demonstrate more than evidence of interest and engagement (which traditionally has been a strong focus), it is important to recognize that the broader outcomes we advocate are aligned with the field's strengths and reflect the field's ability to respond to the nation's needs for stronger STEM education. In particular, these broader outcomes include "21st century skills" such as communication, collaboration, and problem-solving; skills that reflect the culture of afterschool programs, and these programs have been shown to develop them (Afterschool Alliance, 2011). Further, such skills are critical to productive STEM engagement and learning (NRC, 2010), they are essential skills for the future STEM workforce, and are intertwined with the kinds of STEM practices promoted in the new *Framework for K12 STEM Learning (*NRC, 2012).

We suggest that carefully designed assessments of the outcomes of informal and afterschool learning programs can reveal the ways in which knowledge, capabilities, and ways of thinking and acting (including the 21st century skills) are developed hand-in-hand with the kinds of learning outcomes traditionally associated with schools (and therefore more easily identified by policy makers), such as conceptual knowledge. A set of specific and meaningful outcomes and measures for such outcomes would be valued by its stakeholders – ISE and afterschool providers, school officials, funders, policymakers, and most importantly, the parents and the children themselves.

References Cited

Afterschool Alliance (2009). *America after 3pm: Key Findings.* (http://www.afterschoolalliance.org/documents/AA3PM_Key_Findings_2009.pdf)

Afterschool Alliance (2011). *STEM Learning in Afterschool: An Analysis of Impacts and Outcomes* (http://www.afterschoolalliance.org/STEM-Afterschool-Outcomes.pdf)

Afterschool Alliance (2012). Afterschool Essentials: Research and Polling. (http://www.afterschoolalliance.org/documents/2012/Essentials_4_20_12_FINAL.pdf).

Bell, P., Lewenstein, B., Shouse, A. W., & Feder M. A. (Eds.). (2009). *Learning science in informal environments: People, places, and pursuits.* Washington DC: The National Academies Press.

Burns, T. W., O'Connor, D. J., & Stocklmayer S. M. (2003). Science communication: A contemporary definition. *Public Understanding of Science, 12*(2), 183-202.

Dierking, L. D., Falk, J. H., Rennie, L., Anderson, D., & Ellenbogen, K. (2003). Policy statement of the "Informal Science Education" Ad Hoc Committee. *Journal of Research in Science Teaching, 40*, 108-111.

Friedman, A. (Ed.) (March 12, 2008). *Framework for evaluating impacts of informal science education projects* [On-line]. (Available at: http://insci.org/resources/Eval_Framework.pdf)

Hooper-Greenhill, E. (2004). Measuring learning outcomes in museums, archives and libraries: the Learning Impact Research Project (LIRP). *International Journal of Heritage Studies, 10*(2), 151-174.

National Research Council (2010). *Exploring the Intersection of Science Education and 21st Century Skills: A Workshop Summary.* Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

National Research Council. (2012). *A Framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Rennie, L. J. (2007). Developing scientific and technological literacy through community projects. In B. Choksi & C. Natarajan (Eds.), *The epiSTEME Reviews: Research trends in science technology and mathematics education* (Vol. 2, pp. 179-196). Delhi: Macmillan India Ltd.