K-12 Students

Museums, Science Centers, Aquariums, Zoos

1) **National Research Council (2009) *Learning Science in Informal Environments: People, Places, and Pursuits*. Washington, D. C.: The National Academies Press. http://www.nap.edu/catalog.php?record_id=12190**

   Learning Science in Informal Environments: People, Places, and Pursuits synthesizes the learning science literature on learning in informal environments to demonstrate the learning does occur in non-school environments and provide a framework on how to make this learning successful.

2) **Stevens, R. & Bransford, J. (2007). The LIFE Center's Lifelong and Lifewide Diagram. In Banks, J. A. (ed.), *Learning in and out of school in diverse environments: Life-Long, Life-Wide, Life-Deep*. Seattle, WA: UW Center for Multicultural Education.**

   This report consists of four major parts. Part 1, the Introduction, describes the educational implications of significant changes related to demographics and globalization that are occurring in the U.S. and around the world. Part 2 explicates life-long, life-wide, and life-deep learning and states why these concepts should guide learning inside and outside of schools and other educational institutions. Part 3, which constitutes the main part of this report, focuses on the four principles listed below. Part 4 provides conclusions and recommendations. This report also contains a checklist that educational practitioners can use as a tool to generate dialogue about the four principles identified by the LIFE Diversity Consensus Panel.

3) **National Research Council (2009) *Surrounded by Science*. Washington, D. C.: The National Academies Press. http://www.nap.edu/catalog.php?record_id=12614**

   Practitioners in informal science settings—museums, after-school programs, science and technology centers, media enterprises, libraries, aquariums, zoos, and botanical gardens—are interested in finding out what learning looks like, how to measure it, and what they can do to ensure that people of all ages, from different backgrounds and cultures, have a positive learning experience.

   Surrounded by Science: Learning Science in Informal Environments, is designed to make that task easier. Based on the National Research Council study, ¬_Learning Science in Informal Environments: People, Places, and Pursuits_, this book is a tool that provides case studies, illustrative examples, and probing questions for practitioners. In short, this book makes valuable research accessible to those working in informal science: educators, museum professionals, university faculty, youth leaders, media specialists, publishers, broadcast journalists, and many others.

4) **McCallie, E., Bell, L., Lohwater, T., Falk, J.H., Lehr, J.L., Lewenstein, B.V., Needham, C., and Wiehe, B. (2009) *Many Experts, Many Audiences: Public Engagement with Science and Informal Science Education – A CAISE Inquiry Group Report.* Washington, DC: Center for Advancement of Informal Science Education. http://caise.insci.org/uploads/docs/public_engagement_with_science.pdf**

Science and technology are embedded in every aspect of modern life. This report describes how Public Engagement with Science (PES), in the context of informal science education (ISE), can provide opportunities for public awareness of and participation in science and technology.

5) **Brody, M., Bangert, A., & Dillon, J. (2007)** ***Assessing learning in informal science contexts*****. Washington, DC: National Research Council.** **http://informalscience.org/research/show/3672**

This paper discusses assessment of outcomes in informal learning settings. Informal learning environments can include museums, nature centers, after school programs and other types of environments. The authors review 25 published evaluations of informal science contexts that have used phone surveys, personal journals, qualitative analysis of transcripts of verbal interactions, pretest-posttest designs, online surveys, and a variety of other methods to assess the impacts of informal science education programs. Both quantitative and qualitative data can be useful when evaluating the impacts of these types of settings. There is no single method that works 'best' in assessing the impact of a program; the appropriate methodology will depend on the particular context. Qualitative studies can include data gathering tools such as personal meaning or concept maps, which provide a visual representation of individuals' understanding of scientific concepts, such as extinction or climate change. Open-ended questions in focus group or individual interviews can allow for more in-depth responses. Observation may be used to examine individual or group behaviors within the context of an informal learning location where multiple activities may be available. The article also addresses proposals for funding based on such evaluations. Evaluations that are submitted for funding often lack technical information about the purpose and methodology of the evaluation. The article recommends that in writing grant proposals, authors should clearly state the purpose of the research proposal and the methods used to gather the data. Additionally, data from the studies reviewed indicated that while many were grounded in theory, theory around science learning in informal environments is limited and emergent rather than fully formed. Results from evaluations can be reapplied to the theoretical constructs in which the research was based to confirm, reject, alter, build on or expand existing theories. The ideology (the What?), the epistemology (the How?) and the axiology (the Why?) of each study must be aligned in order for conclusions to be valid and provide data to support a theoretical foundation.

6) **Friedman, A.J. (ed.), Allen, S., Campbell, P.B., & Dierking, L.D., et al. (2008)** ***Framework for evaluating impacts of informal science education projects*****. Washington, DC: National Science Foundation.**

This report provides a foundation for evaluating, specifically, NSF-funded informal science education projects, but the information is also applicable to other types of out-of-school science projects. Chapters review planning and evaluation for various types of informal education, such as youth and community programs, mass media, exhibitions, collaborations, and learning technologies. The authors recommend a framework for evaluation focusing on six types of impacts that science education projects may have on the audience the projects are reaching: (1) Awareness, knowledge, or understanding of science, engineering, or technology concepts and processes; (2) Engagement or interest in STEM-related concepts or careers; (3) Attitudes towards STEM topics and their own abilities; (4) Behaviors around STEM concepts and careers; (5) Skill development in STEM; and (6) Other project-specific impacts. Behavior change is often intended for projects related to environmental science; for example, reduction of energy use, or increased recycling. The first steps in developing a non-formal science education project are determining what impacts the project team wishes to have on the audience, and allowing those goals to determine the type and scope of the project. Some examples of goals could be creating awareness of STEM-related careers, increasing STEM-related interest and competencies in a target audience (for example, girls, underserved youth, etc.), or increasing knowledge of specific

STEM processes; for example, attendees will understand key aspects of plant chemistry and ecology. Once the goals have been articulated, the program can be designed to achieve those goals and an evaluation can be conducted to examine the effects specific to those goals. A variety of measures may be considered, such as key informant interviews, self-reports, surveys, observations, and documentation reviews. The heterogeneous audiences in informal education can present a challenge in evaluating the impacts of the program, and should be considered in planning programs and evaluations. Evaluations of youth programs should consider the audience; "what works" for one subgroup may not work with other youth. This report provides information that may be of use for practitioners as well as researchers and evaluators interested in informal science education.

7) **Heath, S.B. (2007)** ***Diverse learning and learner diversity in "informal" science learning environments*****. Washington, DC: National Research Council.**
http://informalscience.org/research/show/3670

The author proposes that science learning in informal contexts needs to be understood as a cultural socialization process through: i) understanding how within families and communities the coherence of cultural socialization practices tie together (especially those tying language, self-agency, and a sense of the future); ii) identifying the larger socialization context of institutions and organizations which is tied to national and international economic growth; and iii) acknowledging the connections between practices, models and opportunities to play multiple roles that enable young learners to learn to think like scientists. The concept of a (re)generative learning environment which includes the following features is described: i) a range of roles available to members; ii) multiple agents with diverse skill sets and knowledge bases; iii) collaborative practices with goal agreement on desired outcomes and standards to assess attainment of these; iv) high valuation on iterative learning; v) learning that draws upon observation and trial-and-error opportunities; and vi) focused study of printed materials and targeted attention to instruction from experts. In order to establish these features, there also needs to be an acknowledgment of felt needs and incentives to set goals that meet these needs and a recognition of diverse talents, backgrounds and paths of socialization that are essential for the learning pool. This concept of creating (re) generative learning contexts is more meaningful than the distinction between informal and formal learning. The author compares middle and upper class families' socialization in science learning with lower income families. The former group tends to have greater access to out of school environments that can provide the necessary enrichment for learning in regenerative ways. Lower income families tend to access after-school opportunities that tend to be within school-based settings and are often an extension of the school day with respect to the kind of learning that takes place. The author suggests that community-based settings that are targeted towards lower income youth are especially important in bridging this gap by providing the type of context where, through the language and communities of practice in these settings, young people learn from experts. The author provides a case example of a program in Boston that teaches young people entrepreneurship as young artists but in the process also engages them in learning scientific concepts that are integral to the trade. The article provides a framework for thinking about learning through culturally embedded praxis. It also emphasizes the importance of community based positive youth development settings that can provide the type of learning environments that youth from underserved communities generally do not have access to in their daily lives.

8) **Renninger, K.A. (2007)** ***Interest and motivation in informal science learning*****.**
http://www7.nationalacademies.org/bose/Renninger_Commissioned_Paper.pdf

This article examines the role of interest and motivation in informal science learning (ISL) settings by highlighting how these constructs have traditionally been defined and contribute to the practice and support of participants' science learning and program development. ISL programs engage participants through science learning opportunities in settings such as museums, enrichment programs, clubs and groups. The article analyzes XLAB (ISL setting) and 2 participants' experience (composite of past research participants) within current studies of interest and motivation in ISL settings. In addition to ISL settings' diverse programs, agenda, focus, goals, expectations, and experience, participants also engage in ISL settings with different science interests and motivation; hence programs' attention to development, implementation and evaluation is important to facilitate participants' engagement in science learning. Generally, ISL settings focus on the enjoyment of science experiences with expectation that "fun" activities influences science interest and/or learning. Interest in ISL studies have been conceptualized as participation or engagement with science and are fueled by questions, whereas motivation is defined as decision-making and goal setting. This article analyzes studies that document interest and motivation separately or in settings that are evaluated by curriculum achievement; however, Renninger concludes that research documenting the interrelationship between interest, enjoyment, engagement and motivation in inquiry-based settings without grades can potentially highlight how these components affect participants' learning experience and interest. The article makes suggestions for future research that acknowledges the interrelationship between motivation and interest, and poses possible research questions such as, *What does the shift from exploration of science content to science literacy look like? What characterizes interest for science and does this differ among disciplines?* And *What is the relation of interest to goals, self-regulation, and effort in ISL settings—is it a mediator and/or outcome of their development?*