



## Informal STEM Learning: A Roadmap For Research and Practice

Journal:	<i>Journal Research Science Teaching</i>
Manuscript ID:	JRST-2014-06-0257
Wiley - Manuscript type:	Editorial
Conceptual Area:	Informal Learning
Methodology:	Review (includes meta-analysis, research briefs)
Grade Level:	Elementary (age 5-11), Middle School (age 11-14), Secondary (age 14-18)
Science Content Area:	General Science
Research Focus/Suggested Keywords:	informal science, lifelong learning, museum education

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## Informal STEM Learning: A Roadmap For Research and Practice

Guest editorial submitted to JRST  
June 25, 2014

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### ABSTRACT

The publication of the National Academies of Science consensus study, *Learning Science in Informal Environments* (2009), was an important marker in the history of informal STEM learning (ISL). With five years hindsight, we pause to reflect upon how far ISL has come as field, what we have achieved, and what the future might hold. The impetus to do so came via our participation on a panel at a symposium at the 2014 NARST meeting in Pittsburgh, PA. Our session was framed by overarching questions about the kind of research currently being conducted in ISL – and for what purpose. Some of the specific questions we considered include: What kind of research would help us better understand learning in informal environments? To better support practice? To illustrate the value of ISL? Is there a need to frame extant research differently, or do we need to collect different kinds of data to address different questions specific to ISL? How should we build connections to the broader field of STEM education so that we get beyond the old, and increasingly less useful, distinctions between in and out-of-school learning?

Keywords: Informal Learning; Research and Practice; Research Agendas

The publication of the National Academies of Science consensus study, *Learning Science in Informal Environments* (2009), was an important marker in the history of informal STEM learning (ISL). Those of us working inside the informal or afterschool science education and learning communities were aware of our own rich history of innovative practice and of rigorous research, but also of our gaps and challenges. However, those in the broader field of science education were often confused about who and what we represent and how our research informed practice in meaningful ways. The LSIE study, which drew upon empirical work up to late 2008, characterized the history of research on ISL, summarized extant findings, and identified gaps in the evidence base. Perhaps the study's most influential contributions were (1) to present unequivocal evidence that learning occurs in informal environments, (2) to describe learning as a life-long contextual process involving in and out of school experiences, and (3) to redefine learning as being composed of six intertwined strands that span from traditional notions of learning (e.g., understanding scientific explanations) to contemporary views of learning as involving interest, motivation, and identity. The volume energized the ISL world by providing a highly visible argument for the role of informal settings in the broader field of science education and by starting a conversation about learning that involves researchers and practitioners from across a wide range of ISL settings.

With five years hindsight, we pause to reflect upon how far ISL has come as field, what we have achieved, and what the future might hold. The impetus to do so came via our participation on a panel at a symposium at the 2014 NARST meeting in Pittsburgh, PA. Our session was framed by overarching questions about the kind of research currently being conducted in ISL – and for what purpose. Some of the specific questions we considered include:

- What kind of research would help us better understand learning in informal environments? To better support practice? To illustrate the value of ISL?
- Is there a need to frame extant research differently, or do we need to collect different kinds of data to address different questions specific to ISL?
- How should we build connections to the broader field of STEM education so that we get beyond the old, and increasingly less useful, distinctions between in and out-of-school learning?

To help take the lessons of LSIE into the future, the Center for Advancement of Informal Science Education (CAISE) drafted a roadmap for ISL research and practice that was used to help frame the call for proposals for the informal learning strand at this year's NARST meeting. The roadmap is the result of a two-year process of meetings and online fora that has, as of May 2014, benefited from the input of more than 230 ISL professionals. The idea of the roadmap was to identify a small number of hot topics and categories within the field that represent core challenges that would likely lead to innovation and improved practice; are sufficiently tractable so that a coordinated effort by the field over the next few years; would have a high probability of leading to breakthroughs; are of interest to both researchers and practitioners; and highlight what is unique, most valued, and most impactful about ISL. We describe the eight research roadmap categories we discussed in our session below.

In large part to LSIE, the notion of *learning ecologies*, where individual, family, community, and institutional influences are part of the learning is becoming more central to the work of ISL researchers. But as discussions at a May 2014 National Research Council Summit on out-of-school STEM learning vividly revealed, we still have a very incomplete understanding of how to design educational programs with a learning ecologies perspective, how to assess impact of experiences over time and across settings, or of why some learners' trajectories are more successful than others. The diverse audiences, experiences, and contexts that make up ISL provide a powerful laboratory to study this emerging theoretical learning ecologies perspective in the social sciences.

*Identity* is a challenging construct in a variety of academic disciplines, including psychology, sociology, anthropology, cultural studies, and increasingly more in education and learning. In the LSIE volume, identity is described as both an influence and an outcome important to learning. Out-of-school settings are particularly good places to test innovative approaches for supporting identity development towards becoming a more "scientific" kind of person. In these contexts, there are opportunities to explore how values are created by and during learning experiences, to see how and why people choose to become connected to a community, or how students decide to become engaged and resilient in the diverse, available pathways towards STEM. This research is especially relevant for engaging underrepresented audiences.

Many ISL experiences are designed to spark *interest, curiosity, and motivation* to drive further engagement with STEM. Future research can focus on what occurs in learners to evoke these feelings. How do different kinds of experiences coalesce into moving interest from an initial state to a deeper engagement with STEM? And, how can we measure these constructs in ways that are

meaningful to practice because they reflect an observable difference in learners' engagement with these disciplines? Curiosity, interest, motivation, and learner choice also need to be better linked to other learner traits and states, such as resilience, persistence, and determination. Additional research can go beyond the question of how interest and motivation can be used to support free-choice learning, to also investigate learners' broader STEM trajectories in light of obstacles and developmental change.

Because ISL targets a wide variety of audiences, it is a particularly rich area in which to design and study contrasting learning experiences that help us *understand learners and learning* more generally. ISL settings can provide access to peer groups, families, adult groups and other audiences that are difficult to reach through formal learning settings, rendering them ideal test beds to answer some of the many fundamental questions about learners and learning within sociocultural contexts. Research can shed light on how learning that occurs in family contexts or peer group contexts changes the experience and its impact. How are the experiences of learners distinct? For whom do certain structures of ISL work effectively and under what conditions?

Across the world, *21<sup>st</sup> Century citizens* need to grapple with issues such as climate change, resource scarcity, biodiversity loss and other concerns that require lifelong attentiveness to science in order to distinguish scientific arguments from non-scientific ones, to know what sources of information to trust about science or STEM, and to realize where value, policy, or ethics considerations start and science considerations end. ISL is the most visible part of STEM education that is concerned with adult learners (as opposed to students in school). What are the best strategies for adults to continue their life-long learning about science? How do we support adults who get involved in STEM-related hobbies or civic activities? Is there a role for ISL to support workforce skills for those already in non-STEM careers? How do adults use STEM learning to make personal or civic decisions? What are reasonable expectations for "science literacy" in adults and how can we measure and document science literacy? Such questions raise the possibility that we can expand beyond the "usual suspects" in STEM education, engaging a diversity of social scientists, perhaps adding a sociologist lens, for example, to study what counts as learning, economic and behavioral lenses around what causes people to act, and an anthropologic lens around how culture mediates STEM learning experiences.

*Identifying design principles to support ISL* can be thought of as cutting across the five topics above, reflects the traditional ISL strength in research and practice collaboration: we are especially concerned with the direct application of understandings that have emerged from theoretical and empirical work into daily practice among a range of practitioners. ISL is diverse in sectors, topics, and audiences, and additional research is needed to identify the extent to which design principles are general to STEM education, general to ISL, and/or specific to certain settings such as museums or after-school clubs. Optimizing each individual experience is not the only goal of this field; more research is needed to understand how design decisions can influence learning ecosystems by creating cross-setting experiences that connect to support learners over time.

The diverse contexts of ISL experiences and audiences necessitate continued development of *methods, instruments, and assessments* that are sensitive to informal STEM learners and learning environments. The community of people doing assessment in informal science education has become increasingly aware and knowledgeable about each others' efforts (e.g., by visits to [informalscience.org](http://informalscience.org), publications in journals such as JRST, and presentations at conferences such as NARST). As an interdisciplinary community, ISL can leverage diverse expertise to continue to develop tools to work together, share knowledge, and help each other further develop our items, instruments, and study designs.

Finally, for research and practice to flourish and have impact, it will require that we engage in *capacity building* to be a field of learners who are always working to get better at doing research and practice as well as integrating the two. What would make our field come together around common research/practice problems? How do we conduct effective professional development across the range of sectors and professionals in our field? What are the best and most sustainable models for research/practice partnerships? How do we link policy, decision-making, and evidence in ISL? Just as people have studied professional development and policy implementation in the formal education world, the ISL field can learn about, implement, and share best practices for working with the many kinds of informal educators.

A final consideration for our field-generated roadmap: if we are all taking this trip together, we need to develop consensus to answer the question: *Are we there yet?* In our NARST session, the discussion suggested that some in our field think that the measure of credibility of ISL should be taken from how it has influenced and/or been accepted by the formal education sector. Others think that additional indicators (e.g. the degree to which we have influenced communities and societies directly in the form of attitudes, behavior, literacy) relevant to STEM should be considered. Still others express the belief that ISL's success lies in its appropriateness for facilitating STEM learning in a manner close to the ways in which professional STEM is actually conducted.

This leaves a challenge to ISL professionals: How should we define ourselves as a field with unique strengths while at the same time including the broader fields of science education, science communication, learning sciences, and educational and developmental psychology? How do we connect to other important STEM learning conversations – especially conversations about learning in schools? The broader STEM education field also includes policy makers and funders, not just researchers and practitioners. The first step in connecting to the broader field would be to understand their agenda(s) and to learn to speak their language(s). If accountability, career pipelines, and innovative workforce are the current hot topics in the national STEM education conversation, the ISL world will advance further by demonstrating that we can contribute significantly to these issues than if we neglect those concerns as being outside of our comfort zones. The ISL Roadmap is one attempt to frame at least some of our work (and hence the stories we can tell with our results) in terms that make sense broadly—to practitioners, policy-makers, school board members, teachers, parents, and researchers in other fields.

As we look back on the influence that the LSIE volume has had on our field, we look forward as well to the upcoming publication of another National Research Council study that focuses on the contribution of out-of-school settings to the STEM capacity (broadly speaking) of school-aged children. The new NRC committee is operating under the assumption that new educational reform efforts in the USA (e.g., Next Generation Science Standards, Advanced Placement redesign, evidence-based undergraduate education) are putting additional pressure on the formal system. This pressure creates an opportunity for ISL field. We have experience conceptualizing, supporting, and studying the kinds of engaged, interest-driven, learner-centered STEM experiences valued most in these reforms. The next few years are a crucial time for ISL to learn about, share with, and collaborate with the worlds of formal STEM education, learning research, and educational policy. To return to the *Are we there yet?* question: Maybe we'll know we've arrived when we stop worrying about delineating the differences between formal and informal STEM learning and get on with the urgent business of improving STEM education through research and practice work revolving around ideas like those suggested in the roadmap which we offer here for readers' consideration.