Informal STEM Education: Resources for Outreach, Engagement and Broader Impacts

A report by the Center for Advancement of Informal Science Education (CAISE)

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About CAISE

The Center for Advancement of Informal Science Education (CAISE) is a National Science Foundation (NSF) Advancing Informal STEM Learning (AISL) program-funded center based at the Association of Science and Technology Centers (ASTC) in Washington, D.C. CAISE is charged with providing resources and connectivity for those designing, evaluating and researching informal STEM learning experiences and settings. Since 2012, the Center has been collecting, curating and cataloging project descriptions, evaluation reports and research materials on the InformalScience.org website, the largest and most diverse repository of Informal STEM education field knowledge in existence. As a steward of the growing knowledge base derived from projects implemented and studied across the many sectors of organizations and professionals working outside of the formal classroom, CAISE seeks to highlight and disseminate success stories as well as provide in-person and online opportunities to catalyze new thinking and relationships.

About the CAISE Broader Impacts and Informal Science Education Initiative

Over the past four years, CAISE's audiences have broadened to include natural, physical and social scientists, as well as directors of outreach and education who work with scientists to reach and engage new audiences through innovative strategies with the broader impacts of their research. CAISE's goal is to help the STEM research community become more aware of the depth and breadth of the ISE field as well as to access and draw from examples of work that has been informed by evaluation and learning research. In service of that goal, CAISE convenes Principal Investigator sessions and workshops where scientists, educators, evaluators and other stakeholders come together to share ideas, findings and challenges, and to identify new directions. One such gathering resulted in the idea of creating a snapshot of the expanding, overlapping landscape of activity in outreach, public engagement, science communication broader impacts and informal STEM education. In response, this report has been written with the participation and input of a core group of CAISE co-principal investigators, advisors, staff, and NSF program officers who strategize, plan and evaluate CAISE's activities and resources designed to serve, support and advance the informal STEM education and the STEM research communities writ large.

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Over the past ten years, investments in infrastructure for informal STEM education and science communication have resulted in significant growth in the number and variety of resources and depth of expertise available to members of the STEM research community wishing to develop outreach, engagement and broader impacts activities.

Introduction

Informal Science, Technology, Engineering and Math (STEM) education (or ISE) is an expanding field of learning activities that range from professionally-designed settings and experiences to everyday, self-directed opportunities taken up by individuals, families and other social groups. It is increasingly recognized as an important part of the national STEM education ecosystem, as evidenced by events like the White House Maker Faire and organizations like the congressional STEM Education Coalition, which have embraced informal and out-of-school strategies and settings. This recognition is reflective of the reality that there are ample opportunities for learning outside of formal classroom settings, where, over the average lifetime, Americans learn most of their science (Falk & Dierking, 2010).

Growth in infrastructure for the ISE field over the past 10 years has created new resources, capacity and expertise that can be leveraged to engage public audiences with the products and processes of research. With parallel growth in the science communication field, the menu of what is available to the STEM research community as they plan, implement and assess the effectiveness of their outreach and broader impacts activities is rich with resources and potential collaborators.

This report recounts some of the developments that led to the existing synergy between ISE, science communication and STEM research, provides examples of infrastructure and resources that support this work and identifies areas of opportunity to close existing gaps between the ISE, STEM research and science communication communities. It is not intended to be a comprehensive description of the wide range of activities in these areas; rather, it outlines recent growth in capacity, provides rationale for ISE strategies and collaborations, describes advancements in evaluation and research and highlights key networks, organizations and resources that can be leveraged by those seeking new and innovative approaches. As the resource center for the NSF AISL program CAISE has focused the report on NSF-funded projects as examples that represent a wider landscape of activity that is supported by other federal, local and private sources. The document ends with some recommended areas of future activity and research.

The primary audience for this report are those in the STEM research community, i.e. natural, physical and social scientists, technologists, engineers and mathematicians who are interested in exploring and leveraging informal STEM learning strategies or collaborations to create innovative programs, projects and activities that engage and educate a range of audiences with the broader impacts of their work. Additional audiences may include policymakers, funders and other stakeholders who wish to enhance the accountability of funded research, strengthen the national STEM education ecosystem and cultivate a scientifically literate society.

Why ISE, Why Now?

Whether planned, opportunistic or spontaneous, most ISE experiences are "free-choice" and not adequately measured by high-stakes assessments of school-aged individuals' retention of factual knowledge. Nonetheless, there is a growing body of evidence of the impacts of these experiences on learners—e.g., valuing science and the natural environment, increasing self-efficacy, making scientifically influenced decisions and developing 21st century skills. Recent reports have synthesized findings from research and evaluation studies conducted in informal settings and identified specific learning strands, as well as made recommendations for design and implementation practices (NRC 2009, 2015 & 2016). Knowledge about what attracts and engages participants of all ages and backgrounds in informal learning experiences is published in the fields of science education, the learning sciences, communication studies and other disciplines, and has become increasingly accessible to the STEM research community[1] in repositories such as InformalScience.org. The settings for these types of experiences available to learners are wide and varied (see the partial list in Figure 1).

- Informal STEM education institutions, including science and technology centers, natural history museums, visitor centers connected to National Labs/Large Facilities, botanical gardens, nature centers, park visitor centers, zoos, aquaria, and planetariums.
- Media, e.g. television, radio, film, social media, science journalism.
- Youth, community and afterschool programs, e.g. out-of-school and youth development programs.
- Citizen science organizations, events, and programs.
- Festivals, cafes, and other live public events
- Cyberlearning platforms.
- Libraries.
- Adult-serving organizations.
- Environmental and conservation-related organizations.
- Health-related organizations.

Figure 1. Informal STEM Learning Settings.

ISE institutions, programs, projects and individuals with expertise and experience in collaborating with the STEM research community to co-design and evaluate outreach, engagement and broader impacts experiences have been growing in number and variety. The NSF and other funders have invested in national-level ISE networks and partnerships that are extending their reach and professional development offerings to organizations, programs and projects on regional and local levels. Many of these efforts have established "hubs" throughout the country, with infrastructure and staff to help broker, cultivate and maintain connections between the ISE and STEM research communities and distribute resources, materials and knowledge to practitioners, evaluators and researchers.

Concurrently, membership-based scientific professional organizations have been expanding their activities and expertise in the areas of outreach, engagement and education through the creation of staff positions, web infrastructure, communication training, inter-association coordination and other professional development resources. The National Alliance for Broader Impacts (NABI) is a research coordination network formed in 2013 with the goal of developing sustainable and scalable institutional capacity in broader impacts activity at universities. Informing these efforts is a growing knowledge base from research in science communication and public engagement that is identifying factors that influence public audiences' attitudes and behavior (Nisbet & Markowitz, 2016; Fischhoff & Scheufele, 2014) as well as scientists' beliefs, goals, and motivations with regard to outreach, engagement and communication activities

[1] Natural, physical and social scientists; mathematicians; engineers; and other STEM-based professionals and graduate students who plan, propose, develop, and/or implement outreach, engagement, education, communication and "broader impacts" activities.

(Besley, Dudo & Storksdieck, 2015). Collectively and cumulatively, these developments in ISE, science communication and academia have created an ecosystem of actors and evidence-based resources that can be of use to the STEM research community when proposing, implementing and evaluating activities for public audiences.

Informal STEM Education: An Evolving, Expanding Landscape

Over the past ten years, museum and science center-based infrastructure projects such as the Nanoscale Informal Science Education Network (NISE Net), Portal to the Public, and the National Living Laboratory Initiative have been developing, implementing and scaling activities that connect scientists and STEM-based professionals in academia and industry with informal STEM learning institutions in mutually beneficial ways. Educators and scientists in these networks exchange expertise, engage a variety of audiences with STEM research, and disseminate professional development resources for wider use. Other networks (such as the Science Festival Alliance, Teen Science Café Network, Star Library Education Network, SciGirls and QUEST) provide models in which participating organizations and professionals beyond cultural institutions serve a diversity of audiences by bringing STEM learning activities and STEM-based professionals into public spaces, libraries, homes and other non-traditional settings. All of these networks, as well as other collaborations, programs and individual projects are contributing data to knowledge about what works, for whom and under what conditions by evaluating and disseminating the impacts of the experiences and settings that they are designing.

Historically, the ISE settings identified in Figure 1 have evolved and aligned more naturally with particular STEM disciplines. For example, classical collections-based science and natural history settings have often addressed subjects like archeology, paleontology, anthropology, geology, biology and astronomy, while the standard for the contemporary science center grew from early models that focused primarily on physical science demonstrations. Citizen science has its roots in environmental science, astronomy and weather monitoring but has rapidly expanded into a variety of disciplines (e.g. genetics). Cyberlearning platforms are particularly adaptable to topics that benefit from visualization and modeling, such as chemistry, mathematics and the material sciences. Technological advancements have made it possible for television, film and other media to expand beyond classic nature programs to explore and present nanotechnology, genetics, string theory and other more abstract and 3-D phenomena and concepts. Maker, tinkering and do-it-yourself (DIY) spaces and strategies, which have increasingly become components of many of the settings listed above, are particularly well suited to engineering-based activities.

Broadening Participation of Audiences

Through outreach experiences of its own, the ISE field has also grown in knowledge and sophistication about engaging a diversity of audiences in STEM settings and experiences. What motivates an audience to engage with a particular STEM subject or activity, or the cultural sensitivities to be considered when designing for equity and the participation of underrepresented groups in STEM are questions currently being addressed in the ISE research literature (Dancu & Garcia-Luis, 2016; Dawson *et al.*, 2015). Museum-based projects like Exhibit Designs for Girls' Engagement (EDGE) and broad national outreach efforts like SciGirls Connect, for example, are producing findings and aggregating general principles to apply when developing experiences and settings for girls, such as designing for collaboration, personal relevance and creativity.

Over its ten years of work NISE Net has developed professional development resources and guides for working inclusively with a range of audiences taking into account such factors as language spoken, race/ethnicity, income and universal design for accessibility that can be applied to a range of science disciplines and topics. NISE Net has also created guides for developing and evaluating partnerships with community-based organizations. Other individual ISE projects like Ciencia Publica and Connecting Cultures, for example, target Latino audiences in the co-creation of learning activities in urban areas and national parks, and ScienceMakers celebrates the STEM achievements of African Americans through a growing database of video interviews.

Informal STEM Learning: What Do We Know?

Key reports and documents on evaluation and research in informal STEM learning are useful resources for those who wish to explore, apply or understand how to approach the design, implementation and assessment of informal STEM learning experiences and settings. These include reports from the National Research Council at the National Academies of Science, Engineering and Medicine, as well as guiding documents developed by NSF and the U.S. Department of Education, among others.

Evaluation of the impacts of informal STEM education strategies has played an important role in the maturation of the ISE field. Drawing on knowledge gained from this body of work, the NSF-funded, widely used *Framework for Evaluating Impacts of Informal Science Education Projects* (Friedman *et al*., 2008) report outlines categories of impact that ISE activities have been demonstrated to have on their intended audiences. These impacts can be measured at various stages of project/program development, from the front end (project planning) through formative (project implementation) and summative (end of project). Impacts can be assessed internally, through a relationship with an independent evaluator, by external review board or using other means.

Another evaluation resource is *The Principal Investigator's Guide to Managing Evaluation in Informal STEM Education Projects* (CAISE, 2012) designed by CAISE and the Visitors Studies Association for project leaders, designers and implementers to use when working with evaluators. The Guide takes a step-by-step approach to integrating evaluation into all phases of project design, development, implementation and reporting. CAISE's InformalScience.org website also aggregates and links to a variety of evaluation resources created by other organizations within the ISE evaluation community.

Generalizable principles from learning and social science research are contributing to the knowledge base for the ISE field. A review of that growing body of literature informed the *Learning Sciences in Informal Environments* (NRC, 2009) report, which identifies and describes six strands of informal science learning in everyday experiences and designed settings. Since the release of the report and its companion *Surrounded by Science* volume that contains examples of the strands in action (NRC, 2010) these documents have influenced how practitioners, researchers and evaluators design and implement experiences, settings and studies, while providing ISE stakeholders and policymakers with concrete exemplars and evidence to reference. A recent follow-up to these publications, entitled *Identifying and Supporting Productive STEM Programs in Out-of-School Settings* (NRC, 2015), emphasizes the changing nature of the learning landscape, the importance of cultural responsiveness and the need to support formal- and informal-learning connections in the design of educational experiences. This report further recommends that evaluation efforts take into consideration

impacts at the individual, program and community levels, and are attentive to the accumulation of experiences that happen across multiple dimensions of the STEM learning ecosystem.

In order to help scaffold deeper understanding of the types of research that can be conducted in informal and formal learning settings, NSF and the U.S. Department of Education's Institute of Education Sciences released the *Common Guidelines for Education Research and Development* (NSF & IES, 2013). This document distinguishes between foundational, early stage/exploratory and design and development research, and defines their purposes, justifications and potential contributions to knowledge generation.

Another recent NRC report, *Effective Chemistry Communication in Informal Environments* (NRC, 2016), explores how the concepts and applications of one discipline are being addressed and communicated through a variety of informal strategies and settings. Part A (*The Evidence Base for Enhanced Communication*) summarizes evidence from communications, ISE and chemistry education on effective practices to engage publics outside of the classroom; presents a framework for the design of chemistry communication activities and identifies key areas for future research. Part B (*Communicating Chemistry: A Framework for Sharing Science*) serves as a practical guide intended for chemists in the design, implementation and evaluation of public engagement efforts.

These reports and documents contain descriptions and examples of the application of learning strands and impacts in informal settings and experiences. Some also offer design considerations and recommendations that can be used to develop programs, projects and activities. An additional important body of knowledge about what works for whom and under what conditions is the practical wisdom that ISE and science communication practitioners, i.e. those on the front lines of design and implementation are developing through experimentation and cumulative experience. Project descriptions, *Spotlights* of exemplary work and blog posts that reflect this knowledge can be found on the Projects, Views and Knowledge Base pages of the InformalScience.org website. Professional development resources for science communication and engagement practitioners are available and regularly updated on the American Association for the Advancement of Science (AAAS) Center for Public Engagement with Science web page.

Field-generated research agendas are good sources for discovering what is currently being studied in informal STEM learning settings and experiences. The Zoos and Aquaria, Giant Screen Cinema and Children's Museum sectors, for example, are designing studies and investigating research questions based on areas and trends identified through an iterative process with practitioners working in these settings. CAISE tracks the progress of these efforts on the Research pages of the InformalScience.org website.

Science Communication: From Understanding to Engagement and Participation

PES & ISE

The relationship between ISE and Public Engagement with Science (PES) was addressed in a CAISE Inquiry Group paper (CAISE, 2009a), which traced the origins of PES to Science, Technology and Society studies and acknowledges the multiple meanings of "engage" and "engagement." In the informal STEM education field the term "engagement" is often used by developers of experiences and settings to refer to a learner's attraction to and degree of

participation in designed activities (Gutwill & Thogersen, 2005) while "public engagement with science" is defined by the AAAS Center for Public Engagement with Science and Technology and others as "intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public." This definition represents an evolution of the Public Understanding of Science (PUS) concept sometimes associated with a model of (public) knowledge deficits, towards one of increased public participation input and expertise (Bauer, 2009; Falk, Storksdieck & Dierking, 2007).

An article on InformalScience.org (Lewenstein, 2012) further distinguished between "educational engagement" and "engagement for participatory democracy. Informal STEM education settings such as science centers and museums have traditionally designed offerings to facilitate educational engagement and have become increasingly involved in engagement for participatory democracy through strategies like public forums and deliberative dialogue. The Museum of Science, Boston, for example, is producing scholarship on a range of PES activities that they have been implementing and the impacts those activities can achieve (Kollmann *et al*., 2013).

PPSR, Citizen Science, Crowdsourcing & ISE

Another CAISE Inquiry Group paper (CAISE, 2009b) introduced the term Public Participation in Scientific Research (PPSR), defined as "intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge." This participation can take a range of forms in different contexts, including volunteer monitoring, community science, participatory action research, and citizen science (Lawrence, 2006; Cooper *et al.,* 2007; Ely, 2008). Citizen science has its origins in traditions of the public contributing to scientific processes, which may include formulating research questions, conducting experiments, collecting and analyzing data, interpreting results, developing technologies and applications and solving complex problems. PPSR has also evolved to include crowdsourcing, where projects or organizations submit an open call for voluntary assistance from a large group of individuals for online, distributed problem solving.

ISE institutions, organizations and providers are increasingly collaborating with STEM researchers working in academia, industry and other settings to co-design citizen science experiences for diverse audiences. The potential learning outcomes from these programs, projects and activities range from gaining skills in scientific inquiry to increasing self-efficacy. One NSF-funded project based at the Cornell Lab of Ornithology (NSF DRL- 836351) has developed a guide for evaluating outcomes in citizen science projects for use in any setting or discipline and a growing suite of evaluation instruments to measure learning. .

Another rapidly growing area where public, non-expert audiences are participating in processes that create learning opportunities is in the making, tinkering and DIY movement. In "maker spaces" at museums and science centers, maker fairs and more recently in libraries, educators, practitioners and librarians are designing activities with materials and tools chosen for their potential to facilitate STEM learning through investigation, creative construction and sense making. These informal activities and strategies are also taking root in formal classrooms at a time when the learning research is evolving hand in hand with the development of settings and experiences. The InformalScience.org Research repository and Knowledge Base mentioned previously in this report are places where this emerging scholarship is being curated and characterized.

Broader Impacts: A Field of Opportunity

In the mid-1990s, the National Science Foundation added the "broader impacts" criterion to its proposal merit review criteria. The stated purpose of Broader Impacts is to help assess the "potential of the proposed [research] activity to benefit the nation." NSF recently reaffirmed the importance of broader impacts through a special report (NSF, 2013) entitled *Broader Impacts: Improving Society*, which provided descriptions of exemplars and suggested strategies for addressing the criterion beyond the traditional methods of researchers training graduate students, for example. In fact broader impacts activities vary widely, and may include outreach, engagement and STEM learning opportunities for a diversity of non-expert audiences.

Broader impacts is an area ripe for further synergy between the STEM research, informal STEM education, and science communication communities. Free from the constraints of formal education, yet not lacking in rigor, practitioners who design ISE and PES experiences and settings are experimenting with innovative approaches that are being tested, documented and disseminated through professional development networks, resource centers and infrastructure projects. Reaching the public through ISE and public engagement with science strategies offers unprecedented opportunities to reach learners of all ages. Working in collaboration with the NSF-funded NABI research coordination network mentioned above, informal STEM educators and science communication practitioners are contributing enhanced connectivity and knowledge-building among those forging new paths in the creation of broader impacts activities.

A View of the Landscape: A Range of Resources and Expertise

There are many examples of networks and organizations that have resources for and expertise in designing innovative outreach, engagement and broader impacts activities. Figure 2 on page 11 provides an overview of some established ones that have developed evidence-based best practices and cultivated sustained relationships (described in further detail in Appendix B). Awareness of these can help the STEM research community identify experienced practitioners and appropriate, innovative strategies. The three cases below also provide examples of ways that the STEM research and science communication communities are leveraging ISE organizations, practitioners and strategies to serve their diverse audiences.

Case #1: SciGirls Tallahassee & the National High Magnetic Field Laboratory

SciGirls Tallahassee is a summer STEM camp for girls that is a partnership between the National High Magnetic Field Laboratory (MagLab) in Tallahassee, Florida and WFSU, the local PBS station. *SciGirls* is a NSF-funded national PBS television series developed by Twin Cities Public Television (TPT), and *SciGirls CONNECT* is an accompanying broad national outreach effort to encourage educators, both formal and informal, to adopt new, research-based strategies to engage girls in STEM. *SciGirls* provides video, online and hands-on activities that are based on a quarter-century of research findings that TPT has aggregated about what works to connect girls to STEM studies and careers. The MagLab puts this research into practice through the camp, which serves 5th to 8th grade girls every summer.

The summer camp, along with all other educational and community outreach at the MagLab, is facilitated by the Lab's Center for Integrating Research and Learning (CIRL), which seeks to engage the local community surrounding the MagLab with the STEM research that occurs there. WFSU is the local conduit to the *SciGirls* CONNECT program, which provides partner organizations—like the MagLab—with training and resources to support evidence-based, high-quality outreach about STEM subjects.

Figure 2. Networks and Organizations with Resources and Expertise to Support Outreach, Engagement & Broader Impacts.

Organization	Scope	Audience(s)	Activities and Resources	Means of Delivery	Ways to Connect
American Association for the Advancement of Science (AAAS) Center for Public Engagement with Science	Professional science society that is proactive about promoting evidence-based public engagement with science, science communication training and connecting with ISE.	STEM research community; science communication / engagement community; ISE research and practice community	Training on science communication; public outreach events; facilitation of communication-based partnerships between scientists and public and/or policymakers	Website (including social networking site Trellis); presentations, workshops, trainings; presence at annual conference	Attend a training or conference session; participate in Fellowship program; join Trellis; participate in online discussions
Citizen Science Association (CSA)	Emerging professional membership organization to advance the growing and interdisciplinary field of public participation in scientific research, promoting evidence-based practices for research and broader impacts in ISE (and other education sectors)	Citizen science practitioner community including STEM and social science researchers, educators, volunteers	Journal; biannual conference; website with professional resources	Website; listserv; annual conference	Join association; read and/or submit to journal; attend conference; download and use web resources
Living Laboratory	Network of professionals at science centers, children's museums, universities and other research organizations. ISEs provide highly visible venues in which social science researchers conduct cognitive and behavioral studies with children. Cross-sector collaboration develops content (exhibit-based and programmatic) for adults who visit ISEs with young children.	Social science researchers, early childhood education professionals; children's museums, science centers and other ISEs, universities colleges and other research organizations; families / the public.	Library of open-source resources to support two strands of collaborative effort: museum-academic partnership development to conduct social science research within ISEs, and creation of hands-on activities that demonstrate methods and results of research and which can be implemented in any ISE institution.	Website; sample activities; conference presentations; online networking / communication; stipends to support implementation of model. Public outreach events.	Connect with hub leader at a conference or project event; access and use web-based resources to support partnership development between ISE and research organizations; apply for stipend program / educational assistance.
Nanoscale Informal Science Education (NISE) Network	Networks of ISE providers who used one area of interdisciplinary content (nanoscale science) to develop a variety of tools, guides and formats for communicating the underlying basic scientific content; in the process, developed a robust network of 600+ institutions that have drawn on the network's resources.	ISE research and practice community; STEM research community (particularly those working in disciplines that overlap with nanoscience); general public	Online library on programmatic design (e.g. evaluation, partnering between researchers and practitioners); outreach kits and activities; public exhibits	Robust website and toolkits; conference presentations and trainings; public outreach events / exhibitions	Download and use web resources (particularly as organization transitions to be the National Informal STEM Education Network to include multiple STEM disciplines)
Portal to the Public	Network of ISE organizations that provide venues where the STEM research community can communicate about their research, and get professional development in science communication	STEM research community; ISE practitioners within brick-and-mortar venues (e.g. science centers)	Guiding Framework document to support implementation of science-public communication strategies	Website; in-person trainings	Facilitate partnership between ISE institution and STEM researchers
Science Festival Alliance	Collaborative network that increases the number and quality of public science events, festivals, and fairs.	STEM research and industry community; ISE practitioners; P-16 education community; general public	Showcase examples of event structures and activities; professional community of practice; aggregated evaluation and research data	Annual conference; website	Organize or participate in single- or multi-day local science event
***SciGirls* Connect**	Multiplatform collaborative network that partners with educational organizations across the U.S. to engage girls in STEM through television, online media, and in-person learning experiences that include hands-on activities and connections to STEM role models	STEM research and industry community; media producers and educator practitioners; late elementary- and early middle-school aged girls; families and parents, the general public	Stipend and training for partner outreach sites; educational resources to support outreach including activity guides, webinars, and ongoing programmatic support	Television series for general public; website for general public including videos, games, and community discussion and sharing; in-person trainings and activity guides for outreach partners	Apply to become network partner and implement *SciGirls* activities at site.

The goal of *SciGirls* is to expose young women to STEM careers and role models at a critical age when girls often lose interest in STEM subjects (US Dept. of Education, 2006). Scientists at the MagLab and from the local community work with educators to develop the summer program. Activities focus on exposing campers to a variety of science disciplines, career options within those disciplines and female role models. At tours of facilities, university and industry labs, and research sites, scientists facilitate hands-on activities with input and guidance from educators.

The campers work with staff at WFSU to learn how to communicate the science that they encounter. The program culminates in an evening reception on the final day of the camp where panels of female STEM professionals share their own career trajectories with campers and their families. The girls also reflect on what they have learned about STEM and STEM careers, and how it has influenced their plans for the future.

SciGirls Tallahassee has been in operation for over a decade, and each summer program managers evaluate the impact of the camp on girls, families and mentors through surveys. Data from these surveys has informed ongoing program improvement. As with many out-of-school time STEM learning opportunities of this type, supply struggles to keep pace with demand and the MagLab and CIRL would like to increase space and staff capacity to be able to accept more applicants. The program also seeks to recruit more girls from low-income families through scholarships and targeted marketing (including seeking additional funding to create a school-year *SciGirls* program at local Title I schools). Although challenges remain, *SciGirls Tallahassee* summer camp at the MagLab serves as an example of a sustainable, partnership between informal STEM learning organizations—in this case, a local television station and national media initiative—and a large, cutting-edge research facility.

Case #2: The American Society for Biochemistry and Molecular Biology (ASBMB)

Founded in 1905, the ASBMB serves its members by offering professional development services, publishing scientific journals and sponsoring scientific-themed meetings. Though individual ASBMB members have a long history of involvement in STEM outreach, informal STEM education (ISE) done under the banner of the ASBMB has historically existed almost as an afterthought, being an unintentional side-product of various activities sponsored by the society's different departments (such as Congressional Hill Days).

In order to consolidate and formalize the society's outreach efforts, the ASBMB established a Department of Public Outreach in 2012 and hired a full-time coordinator to manage the department's activities and programs. The newly-formed ASBMB Public Outreach Committee, made up of volunteer society members with backgrounds in outreach and informal science education, defined science outreach as "any activity in which scientists translate their research or broader scientific concepts to those outside of the academy" (Burns, O'Connor, & Stocklmayer, 2013). The committee then developed a strategic series of programs designed to facilitate member's participation in outreach using multiple approaches, including science communication training, promotion of public engagement participation and collaboration with ISE entities.

As a way to raise interest in outreach amongst its members the ASBMB began offering a variety of activities at the society's annual meeting, attended by more than 15,000 scientists. Activities include an outreach-themed poster session and an informal STEM learning event (such as a science café) that is open to attendees and the public as a way of demonstrating the effectiveness and potential of such strategies.

The ASBMB also oversees programs that facilitate member participation in public engagement and ISE activities. Recognizing that proficient science communication skills are required for effective outreach ASBMB initiated an online course, "The Art of Science Communication," that provides fundamental training, mentoring and practice opportunities for those seeking to engage non-expert audiences with science. The online course is unconstrained by the limits of geography and number of participants. The final project for the course is to develop and conduct an engaging, interactive presentation for a lay audience.

For members seeking to do outreach, the ASBMB also provides small (≤ $2000) seed grants to develop programs and activities. These grants are large enough for programs to gain footholds in their local communities, but small enough to incentivize them seeking further financial support. Applicants are required to establish partnerships with local ISE providers and to leverage existing resources, venues and strategies to ensure the sustainability of their funded program.

Having a professional society like the ASBMB visibly demonstrate its commitment to outreach, education and science communication raises the stature of these activities in the STEM research community, especially as they and parallel departments at other societies like AAAS, ASM, ACS, APS and AGU now meet regularly to share successes and challenges. Competing demands for time and resources, as well as members' declining identification with individual professional societies, presents opportunities for closer collaboration with other societies, universities, ISE organizations and industry to maximize greater collective impact.

Case #3: Centers for Chemical Innovation

The NSF-funded Centers for Chemical Innovation (CCI) Program supports research centers focused on major, long-term fundamental chemical research challenges. In 2012, supplemental NSF funding through the CCI and Advancing Informal STEM Learning (AISL) programs at NSF was made available to catalyze partnerships between CCIs and professional informal science education providers. Five centers were funded, each of which has a distinct education and outreach program designed to engage specific audiences. Some examples include:

- ***CCI Solar Fuels and the Westside Science Club.*** The California Institute of Technology CCI Solar's research is on the efficient and economical conversion of solar energy into stored chemical fuel. They collaborated with Wildwood High School in Santa Monica and the Westside Science Club to develop making and tinkering and other hands-on inquiry-based experiences designed to introduce pre-high school participants to basic chemistry and related STEM concepts such as physics and plant biology. The program's target audience was children aged 8-14 from a low-income neighborhood, who reported that they found their experiences memorable. Scientists and graduate students reported that their understanding of their audience's needs and their own communication skills improved from participating in the program.

- ***Center for Chemical Evolution and independent radio producer Ari Daniel.*** The scientific objective of the Center for Chemical Evolution is to study the chemical origins of life using models of prebiotic chemistry that can self-assemble into polymers that resemble RNA and proteins. Researchers and educators at Georgia Tech and Emory University in Atlanta, Georgia partnered with independent media producer Ari Daniel to engage the public in chemistry via public radio storytelling and live performances. The resulting *Small Matters* series is a collection of stories aimed at enriching public science literacy, especially within the chemical sciences designed to be

accessible to people of all ages, incomes, and places. Small Matters goal is to communicate the idea that chemicals and molecules all around us, and that tiny aspects of the world are very important. The stories are crafted in a public radio narrative style and have been disseminated through the Public Radio Exchange, the Small Matters website, the nationally distributed program Living on Earth and local Atlanta public radio station WABE.

- ***Center for Enabling New Technologies through Catalysis (CENTC) and various partners.*** The Center for Enabling New Technologies Through Catalysis (CENTC) brings together researchers from across North America to collaboratively address the economic, environmental and national security needs for more efficient, inexpensive and environmentally friendly methods of producing chemicals and fuels from a variety of feed stocks. CENTC partnered with the Liberty Science Center in Jersey City, New Jersey, Blue Telescope (game producer) and the College of New Jersey to develop an interactive multi-touch tabletop game: *Molecule Magic: Turning Crude Oil and Cool Stuff!* The game highlights critical petrochemicals found in common materials such as plastics, medicines, clothes and toys. It was installed in the Liberty Science Center's Energy Quest Gallery in August 2013 and has reached thousands of children and adults of diverse backgrounds throughout the country. It is now featured in an exhibition at the Pacific Science Center that opened in March 2016.

In addition to the above efforts supported by the NSF AISL program, the CCIs are also actively engaged in a broad range of other activities and collaborations aimed at achieving broader impacts within ISE contexts. For example, several of the CCIs have active partnerships with their local science centers, museums and other informal venues. Through these collaborations, CCI scientists and staff engage the public in chemistry through science cafés, interactive programming and exhibits and scientific inquiry-based demonstrations. Some of the CCIs also participate annually in science festivals throughout the country (including the Atlanta Science Festival, Bay Area Science Festival, Cambridge Science Festival, San Diego Science and Engineering Festival). A recently published chapter in the volume *Intersections of Formal and Informal Science* examines the strengths and challenges of the CCI/ISE collaborations and reflects on conditions that led to success on a range of dimensions (Knutson & Crowley, 2016).

Conclusion and Looking Forward: Areas for Growth and Opportunity

CAISE recognizes that informal education and public engagement activities represent only one type of strategy that the STEM research community may consider when addressing their outreach, engagement or broader impacts needs. Many investigators have ongoing, successful collaborations with schools and formal classrooms, for example. However, as the ISE and science communication fields mature, there are opportunities to develop innovative activities that impact tens of thousands of individuals through the networks and dissemination mechanisms mentioned in this paper. The ISE community is well positioned to support such efforts and has developed an evaluative and research tradition that serves as the foundation for achieving intellectually rigorous best practices.

In preparing this report, and through cross-community convenings and NSF AISL Principal Investigator meetings, CAISE has identified steps that those working in STEM research, ISE and Science Communication can take to raise awareness, enhance connections and build knowledge for this work.

For the STEM research community:

- **Build greater awareness of the resources, expertise and connections** that informal STEM education and science communication networks, associations, resource centers and other entities have to offer for developing and strengthening outreach and broader impacts proposals and activities.
- **Include informal STEM education and science communication collaborators** early in outreach/education/engagement/communication/broader impacts planning.
- **Build greater awareness of the learning sciences, evaluation and other social science disciplines** that are conducting studies on the impacts and learning outcomes of informal STEM education and communication/engagement experiences.
- **Build greater awareness of opportunities for supporting** collaborative education/engagement/outreach/communication activities through supplemental funding intended for such purposes.

For the ISE and science communication communities:

- **Build greater awareness of federal and private foundations** that have mechanisms for supporting informal education, communication, engagement and outreach efforts, including through broader impacts requirements as part of the normal course of funded research.
- **Create clear, accessible mechanisms and pathways** for the STEM research community to connect with ISE and science communication.
- **Build greater awareness of STEM researchers' concerns**, such as tenure, funding, comfort level with the complexities and nuances of learning, communication and outreach.
- **Be prepared to meet scientists where they are** and be open to unplanned opportunities, such as when scientists hear about solicitations later than ideal to begin building partnerships, but still want to collaborate.
- **Build greater awareness of the values and goals of universities and academia**, e.g. graduate student professional development and undergraduate enrichment experiences.
- **Build greater awareness and inclusion of scientists working in non-academic settings** such as national parks and industry, a growing number of whom are engaged in education, engagement and outreach activities.
- **Conduct more research on the impacts and outcomes of collaborations between ISE and science communication organizations and practitioners and STEM-based professionals**. This includes impacts on target audiences, as well as on designers and implementers of experiences and settings.

For all stakeholders:

- **Facilitate and support more "spaces" and opportunities where the ISE, PES and STEM research communities can come together** to make progress on common challenges such as broadening the participation of underrepresented groups in STEM fields, integrating learning and communication research with practice and developing common understandings of outcome and impact measures. Be proactive in "finding" each other!
- **Conduct more high quality evaluations** of professional development and training programs for scientists on communication and engagement skills and approaches.

- **Encourage social scientists to study the impact** of outreach/education/communication activities on STEM research directions and questions.

All of these actions rely upon infrastructure and support for collaborations between the STEM research, ISE and science communication communities. For its part, CAISE will continue to track and disseminate the efforts of those mentioned in this paper and others and continue to build the knowledge base on informal STEM education so that current and future findings are accessible to inform and improve practice, deepen learning and broaden participation in STEM for all. To learn more about, or become involved in these efforts, please contact CAISE at caise@informalscience.org.

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Appendix A: Additional Resources

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Appendix B: Networks and Organizations with Resources and Expertise to Support Broader Impacts

AAAS Center for Public Engagement with Science

Since 2004, the American Association for the Advancement of Science (AAAS) Center for Public Engagement with Science and Technology has worked to further awareness of science and the scientific process and increase public input into scientific research and policy agendas, encouraging and facilitating dialogue between policymakers, the general public and the scientific community.

The Center's vision is to convene and facilitate dialogue between science and society through ongoing conversations in which science and society draw on relevant information and expertise from multiple perspectives. The Center's activities focus on providing scientists and scientific institutions with opportunities and resources to have meaningful conversations with the public by:

Increasing awareness and understanding of public engagement and its benefits. The Center participates in and disseminates research about science communication and public engagement, including:

- The Communicating Science program works closely with social scientists to inform training curriculum in science communication and public engagement.
- Center staff present talks on the value of public engagement, and coordinate with colleagues at professional societies and other public engagement practitioners.

Demonstrating excellence in public engagement.

- The AAAS Early Career Award for Public Engagement with Science and Technology recognizes and rewards early-career scientists and engineers for excellence in public engagement.
- Family Science Days (including Meet a Scientist!) is held during the AAAS Annual Meeting in collaboration with local universities, science centers, and other pertinent organizations. Thousands of families attend this free, two-day public event, and scientists attending the meeting have opportunities to see public engagement with science in action.
- What We Know supports improved climate change communication between scientists, policymakers and the public. The Center convened a panel of experts to develop and disseminate a report and conversations on the realities, risks, and responses to climate change.
- Building with Biology involves teams of synthetic biology scientists and informal science education (ISE) practitioners co-developing public engagement activities about the science and societal implications of synthetic biology. The project is led by the Museum of Science, Boston and is funded by NSF DRL-1421179.

Training scientists to communicate with non-scientific audiences.

- Communicating Science workshops provide communication skills, resources and practice for scientists and engineers in the U.S. and beyond.

- The Leshner Leadership Institute trains and empowers 15 Public Engagement Fellows each year to be agents of change in their communities and institutions. Each year's cohort focuses on a science and society issue with opportunities for public engagement.

Building capacity for conducting public engagement with science activities.

- The Communicating Science Seminar at the AAAS Annual Meeting convenes hundreds of scientists, public engagement researchers, and communication practitioners to discuss research and practice in science communication.
- Trellis is a new scientific communication and collaboration platform developed by AAAS. To join discussions with scientists, public engagement professionals and communication researchers in the Public Engagement with Science Group on Trellis, email public_engagement@aaas.org to request an invitation.

The Center focuses on connecting research about science communication and public engagement—what works and what doesn't, the benefits of engagement and why scientists engage—with scientists and practitioners who can put related research into practice.

Citizen Science Association

The Citizen Science Association (CSA) aims to build collaboration, community and credibility across the many research disciplines that are using and investigating citizen science. CSA serves an international community of practitioners who work—whether as volunteers or as professionals—to design, support and implement projects; manage and use data; and evaluate and research individual initiatives or the practice itself.

Much of the formative work of building this community of practice derived from the field of Informal Science Learning. A 2007 Citizen Science Toolkit Conference (NSF DRL-1020909), held at the Cornell Lab of Ornithology, brought together 60 practitioners and launched the first website and suite of best practices for the field. The CAISE Inquiry Group Report on PPSR (CAISE 2009a) further characterized the scope and diversity of projects and outcomes, opening the door to a field-wide conversation that engaged multiple project types and traditions. More recently, in February 2015 600 individuals convened for the CSA's first Citizen Science Conference held in San Jose, California with a particular focus on "Integrating Citizen Science into the STEM Learning Ecosystem" (NSF DRL-1501158).

Whether for science learning, learning research, or for scientific research itself, the Citizen Science Association compiles, shares, and supports the use of evidence-based practices in order to advance deliberate and effective design and implementation of citizen science. Although still a young organization, CSA already has a broad reach—the almost 4,000 members represent over 70 different countries and a wide range of scientific disciplines. CSA's leadership is equally dispersed—the organization is managed by a Board of twelve and supported by volunteer Working Groups that advance thinking on topics such as ethics, education, research and evaluation, and integrity, diversity and equity. A new open access journal, *Citizen Science: Theory & Practice*, will share peer-reviewed articles on best practices from public participation in scientific endeavors in any research discipline and biennial conferences will continue to engage practitioners. More information about CSA and its services can be found, as of March 1st 2016, at CitizenScience.org.

National Alliance for Broader Impacts

The National Alliance for Broader Impacts (NABI) was formed in 2014, with support from the NSF (MCB-1408736, MCB-1313197 and IIA-1437105) to develop institutional capacity and engagement in Broader Impact (BI) activity. A network comprised of universities, professional societies and informal science organizations, NABI is a community of practice focused on the development, implementation and evaluation of science communication and public engagement programming—generally designed to meet NSF's BI criterion. As of Spring 2016, there are over 420 individual members of NABI from more than 150 institutions.

The core objectives of NABI include:

- Identify and curate promising models, practices, and evaluation methods for the BI community.
- Expand engagement in and support the development of high-quality BI activities by educating current and future faculty and researchers on effective BI practices.
- Develop human resources necessary for sustained growth and increased diversity of the BI community.
- Promote cross-institutional collaboration on and dissemination of BI programs, practices, models, materials and resources.
- Promote broad dissemination of BI programs, practices, models and resources, and catalyze cross-institutional collaborations.

NABI plans for the future include to continue to facilitate communication between researchers and federal funding agencies around the realities of implementing the BI criterion; to grow the BI support community, and encourage graduate students to consider this as a profession; and to provide training and resources for researchers so they can better understand the BI criterion and how to effectively address it.

Membership in NABI is free of charge. An ongoing benefit of NABI membership is the sharing of BI resources and knowledge. The increased emphasis on the BI criterion has led to the creation of university-wide, or otherwise strategically situated, BI offices on several campuses. BI offices are charged with aiding researchers in concept design, program implementation, and evaluation of their BI activities. However, not all institutions have centralized BI offices, and NABI resources are available to anyone who needs them—regardless of affiliation.

Involvement with NABI also gives members the chance to contribute directly to the national discussion on the future of BI, including speaking to NSF as a unified voice on issues and challenges surrounding BI. One such example is the recent *Broader Impacts Guiding Principles* document (NABI, 2016) created by a sub-committee of NABI members. The document is a user guide for both researchers and reviewers to evaluate the quality of their BI plans.

NABI also provides periodic, in-depth BI trainings that are open to anyone interested in BI in theory and in practice—including students, faculty, staff, administrators, and non-academic individuals and organizations.

NISE Network

The Nanoscale Informal Science Education Network (NISE Net), funded by the National Science Foundation (DRL-0532536 and DRL-0940143), is a national community of researchers and informal science educators dedicated to fostering public awareness, engagement and

understanding of nanoscale science, engineering and technology. NISE Net was launched in 2005, and during its 10-year trajectory has reached 30 million people through its programs, events and exhibitions.

NISE Net brings together scientists and informal educators to develop activities and exhibits that engage the public in learning about cutting-edge nanoscale science. The Network's signature NanoDays kits provide informal educators with ready-to-use activities and demonstrations designed for multiple and diverse publics. Small footprint exhibitions in around 150 sites across the country provide hands on learning to millions of visitors annually. The kits and exhibitions are disseminated through a network that includes around 600 museums, universities, and other institutional partners, which are connected through regional hubs. To support its partners, NISE Net developed an online library that includes public engagement materials, as well as professional development resources on topics such as museum-university partnerships, local collaborations, and conversations about science, technology, and society.

The NISE Network has conducted evaluation and research studies that closely examine the public, professional and field-wide impacts of NISE Network activities. Over the course of the project, over 250 front-end, formative and summative evaluation studies have been conducted about products, practices and reach. Research studies have focused on museum-scientists interactions, organizational change, and public learning and decision-making. More about the studies are available on the NISE Net website.

The Network is now transitioning to a new identity as the National Informal STEM Education Network, and expanding its focus to other STEM topics beyond nanoscale science. This ongoing NISE Net will leverage existing relationships among Network partners, apply successful models for public engagement and professional development, and continue Network strategies to raise the capacity of informal science educators and scientists to engage the public in STEM learning. Affiliated projects include:

- A supplement to the original NISE Net award focusing on nanoscale science, engineering and technology, which promotes local partnerships between museums and community and youth-serving organizations;
- *Building with Biology*, focusing on synthetic biology (funded by NSF and led by the Museum of Science, Boston) (NSF DRL-1421179);
- *Sustainability in Science Museums* (funded by Walton Sustainability Solutions Initiatives and led by Arizona State University);
- The Transmedia Museum, focusing on science-in-society issues raised by Mary Shelley's *Frankenstein* (funded by NSF and led by Arizona State University) (NSF DRL-1516684); and
- Space and Earth Informal STEM Education (funded by NASA and led by Science Museum of Minnesota).

Living Laboratory®

The National Living Laboratory (NLL) initiative, developed at the Museum of Science, Boston (NSF DRL-0714706 and DRL-1113648), is a scalable, flexible model for integrating scientists who study children's learning and development on the museum exhibit floor to educate the public about the "science of kids." Living Laboratory researchers recruit visitors as participants and conduct their studies within exhibition spaces at their local museum, rather than behind closed doors. Families visiting the museums are invited to participate in fun, quick research projects, and to engage in face-to-face conversations with researchers. Collaborating scientists

work closely with educators to communicate the questions and methods of their work to parents and other caregivers via conversations and hands-on activities.

The National Living Lab (NLL) network supports a community of informal science educators and researchers in collaboration efforts that foster public awareness, engagement and understanding of the scientific study of children's learning and development. More than 650 scientists and museum professionals have joined the NLL community in an effort to share best practices for on-site research and child development education collaborations. The community includes 350 organizations in 48 states and 21 countries, representing 245 informal science learning institutions (science centers, children's museums, libraries and other ISE organizations); 95 research institutions; and 10 professional organizations that serve informal science education or research professionals.

In 2014, the NLL team launched a stipend program that provides support to organizations working within the Living Laboratory model. Forty collaborations across the US have received stipends to support a wide range of projects to create educational resources for adult visitors, facilitate professional development opportunities between scientists and museum staff, and create museum-style "research toy" activities that share methods and results of completed studies. Stipend awardees and other members of the NLL community have developed and contributed dozens of open-source resources to the Living Laboratory Toolkit, providing guidance on common challenges and describing the wide range of opportunities that have emerged in Living Laboratory partnerships—all of which are accessible via the Living Laboratory website. Community members also share best practices through annual meetings, conference events and on-line communication opportunities.

The reach of the Living Laboratory project has grown beyond the original professional audiences—science center and children's museum staff and university researchers—to include professionals at libraries, botanical gardens, zoos, undergraduate-only colleges and other types of research organizations. Community members have drawn upon the Living Laboratory model to facilitate collaborations that integrate cognitive research with adult participants, as well as research and education around other people-focused scientific disciplines including behavioral economics, genetics and occupational therapy. The project team is currently considering opportunities to further expand the impact of Living Laboratory to additional audiences, with a particular focus on the potential to leverage the model in order to involve high school students directly in conducting research and communicating about science with the public.

Portal to the Public

Led by Pacific Science Center (PSC) in Seattle, Washington, the Portal to the Public Network (PoPNet) helps organizations connect public audiences with the research and innovation happening in their own communities through dialogue with local STEM professionals. Institutions that adopt the approach use PoP's guiding framework, which is designed to be adaptable for a wide range of individual institutions' needs and desired impacts. The framework focuses on three key components:

1. Building relationships between informal science education institutions (ISEs) and scientific research organizations
2. Leading professional development that prepares STEM professionals to have conversations about their work in informal learning environments
3. Holding public events that feature face-to-face interactions with STEM professionals

The NSF provided the initial funding for the project that started in July 2007 (NSF DRL-0639021). Subsequent funding from the Institute for Museum and Library Services (IMLS) and a second NSF award supported further growth and expansion of PoPNet, a collection of informal science education institutions (NSF DRL-1224129). Originally focused on science museums, PoPNet has expanded to include zoos, aquariums, botanical gardens, and university groups. As of April 2016, 52 organizations nationwide are members of PoPNet. Members of the PoPNet community meet in person and communicate virtually to share successes and work through challenges around their own regional PoP efforts.

Early evaluation demonstrated positive impacts for ISE staff and participating STEM professionals in addition to the benefits for public audiences. ISE staff gained increased confidence in their ability to engage with scientists, provide them with training in communication strategies and build meaningful relationships. Scientists reported improvements in their science communication skills and continued interest in participating in public outreach. Future evaluation will focus on how the Network's impacts have extended or grown since the project's inception and to what degree implementation of the PoP framework and intended outcomes vary at non-science center institutions (e.g., zoos and aquariums).

Although each institution develops its own unique adaptation of the framework, PSC's implementation of PoP typifies what PoP looks like at many Network institutions. Professional development workshops and public programs for scientists have been crafted into a formalized "Science Communication Fellowship" program with clearly stated requirements and benefits for scientists ("Fellows"). To become a Fellow, a scientist participates in a series of fun, hands-on professional development workshops focused on building the skills to effectively engage public audiences. Scientists refine key messages related to their areas of expertise and practice simple techniques for talking science with non-scientists. With the help of museum staff, scientists create an educational activity based on their research to be used at PSC public programs or at other outreach events.

Science Communication Fellows participate in a wide range of programs and events at PSC that showcase current and local research, including exhibits, live science stage shows, and podcasts. Monthly "Meet a Scientist" events feature 10-25 trained communication fellows, and are a popular featured program among PSC members. PSC also hosts four large-scale "Research Weekends" take place several weekends per year and feature over 100 scientists and research organizations from across the region.

Science Festival Alliance (SFA)

The SFA (DRL-1223256) is a collaborative network that fosters a professional community dedicated to an increasing number and quality of science and technology festivals and events. Science festivals are public celebrations that typically span from several days to a couple of weeks. They usually involve many unique events in different venues across a region. Individual festivals vary greatly in scale, scope, and style. Typically, a science festival establishes a highly visible presence in a community and offers a wide range of activities and events. One hallmark of science festivals is collaboration with many different stakeholders, and each celebration depends on scores of local collaborating organizations to provide programming and resources. By generating a large burst of activity over a short period of time, science festivals act as living laboratories for the development of new and innovative science programming. Taken together, these festivals directly involve many thousands of STEM professionals in public outreach.

Since its inception in 2009, SFA membership has grown to include dozens of independently organized festivals collectively serving millions of people every year. These members benefit

from being a part of an international conversation about how to best serve our communities through public science events. Member-generated resources, as well as third-party evaluations and independent research related to public science events are all publicly available on the SFA website. The SFA convenes professionals at various in-person meetings throughout the year, including the International Public Science Events Conference.

The SFA has led to several affiliated new projects, including:

- EvalFest (DRL-1423004): An NSF-funded multi-site evaluation project gathering data from 24 festivals.
- Just Add Science: A project supporting festival activity that "reaches people where they are," with support from the Simons Foundation.
- Science Live: A project driven by the recognition that it is time to take a sector-wide approach to public science events, funded by the Science Learning+ program.

SciGirls CONNECT

SciGirls is a multiplatform STEM education program that integrates television, online media, and hands-on activities to drive STEM curiosity and learning for girls (primarily between the ages of 8 and 13, although resources exist for younger and older students as well). The goal of the SciGirls suite of resources is to connect girls to the many education and career opportunities that the STEM fields have to offer. At the core of *SciGirls'* programming is a television show of the same name that airs on PBS. Each episode of the show focuses on a real group of girls mentored by a female STEM professional. Showcasing female mentors and role models is a key component of *SciGirls*, and their programs reinforce a supportive professional and educational environment for girls. *SciGirls* further emphasizes a sense of community through their website, which includes videos, games and opportunities for users to share their own science projects and interests. All SciGirls programming is supported by a quarter-century of research and evaluation showing the most effective methods for reaching their target audiences.

Since 2010, *SciGirls* has sought to expand their reach through the *SciGirls* CONNECT program. This educational outreach network has provided resources and training to over one hundred partner organizations, including over 2,000 educators and reaching nearly 40,000 youth in diverse communities across the United States. Partner organizations represent many ISE and other sectors including schools, museums and science centers, community organizations, and universities (among others). Programming is implemented in a variety of settings including afterschool, during summer, and during school, and may involve families and/or community members.

Participation in *SciGirls* CONNECT connects organizations to research-based outreach materials and methods, and builds the partner organization's internal capacity to do educational outreach. After applying and being accepted to the program, partner organizations receive a $200 stipend to support staff and programming at their site. A certified *SciGirls* trainer provides training on outreach strategies—centered on role modeling and mentoring—at the partner organization site. After the training, staff members at the partner organizations receive access to videos, activity guides, webinars, and ongoing program support to implement *SciGirls* programming. Additionally, staff becomes eligible to receive Train-the-Trainer certification whereby they can provide training to new staff at their own site, as well as at new partner organizations. In this way, partner organizations build up their own capacity for future high-quality educational outreach experiences.