Out-of-School Time STEM:
Building Experience, Building Bridges

Trends, Questions, and Findings from the Field
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STEM in Out-of-School-Time Settings

This report reviews patterns, challenges, and questions developing in the field of out-of-school-time (OST) science, technology, engineering and mathematics (STEM) programs by drawing on the efforts of some two dozen federally funded programs that participated and presented their work at a conference held in Washington, DC in October of 2009. Reflecting the questions and concerns of both practitioners and researchers in the OST STEM field, the report is intended to inform the work of OST educators, researchers, and funders.

The recent *Learning Sciences in Informal Environments* (2009) report from the National Research Council suggests that learning science is a complex and multi-faceted process. It entails not only the development and mastery of conceptual knowledge and skills, but also insight into the epistemologies of science, as well as understanding the ways in which science is enacted in everyday and professional settings. Interest in and affiliation with fields of scientific practice develop through, and also drive, learning in science. The American Association for the Advancement of Science (1991) similarly concludes that learning science entails "being familiar with the natural world and respecting its unity; being aware of some of the important ways in which mathematics, technology, and the sciences depend upon one another; understanding some of the key concepts and principles of science; having a capacity for scientific ways of thinking; knowing that science, mathematics, and technology are human enterprises, and knowing what that implies about their strengths and limitations; and being able to use scientific knowledge and ways of thinking for personal and social purposes" [1]. In short, there is a broad consensus that science literacy is more than knowing, and even more than knowing and doing, but involves acts of knowing, doing, and being that occur over multiple timeframes and settings [2, 3].

The National Context

There is growing interest and investment in OST STEM programs. Federal agencies such as the National Science Foundation, NASA, and NOAA have dramatically increased funding and access to these programs. More than 90% of leaders of afterschool programs would like to increase science programs for children [4]. It is widely held [2, 5, 6] that out-of-school-time programs such as summer camps, afterschool programs and Saturday classes provide students with important opportunities to

- Spark, sustain, and deepen their interest in science, technology, engineering, and mathematics (STEM).
- Develop and expand their understanding of STEM.
- Advance an awareness of and commitment to pursuing academic, career, and lifelong pathways in STEM-related fields.

The development of growing interest in OST STEM has been accompanied by a growing concern about the need to align, document, and assess OST science programs goals and outcomes for students [2, 7-10]. But there are tensions in the field about the best ways to do this. How can the subject matter learning in OST settings be developed in ways that enable and encourage further learning in other settings and timeframes, including in schools, without adversely affecting the developmental qualities of the OST setting that make it accessible, inviting, engaging, and intellectually, socially, and emotionally empowering for a broad and diverse array of students? This report has been developed to inform decision-makers who are involved in funding, designing, and evaluating such programs and their future trajectories.

OST STEM Program Types

Supporting a rich and multi-faceted conception of science learning is a rich and multi-faceted field of OST science programs. OST science programs vary from science-specific summer or weekend programs, often set in science-rich institutions like museums or zoos, to brief activity units offered as part of a broader and more generic afterschool program. Sometimes OST STEM activities are organized around extended inquiries in the field, such as local wetlands or urban ecologies. At other times, they might involve using kits or worksheets in classroom-like settings. In some cases, children commit to consistent participation over sustained periods of time; in other cases, programs are offered as drop-in opportunities and are subject to widely varying attendance patterns. Some programs aim to develop children's conceptual understanding in particular science domains, others emphasize epistemologies of science (e.g., inquiry) through supporting student research projects; yet others emphasize STEM careers and endeavors.

Despite these variations, there are typically some general differences between OST STEM and school STEM. For example, OST STEM activities tend to be less verbal and abstract, and more tactile and situated in or connected to everyday settings. They are more often experienced through group inquiries or collaborative investigations, rather than through individualized activities. Because they are not subject to covering mandated curricular topics, they can be characterized by a flexible use of time that permits children to pursue new ideas as they come up or linger on particularly motivating ones when there is interest. They often build on firsthand experiences with science-related places, people, phenomena, data, and tools -- resources that may be more difficult to integrate into the school classroom.

Above all, because most OST environments are low-stakes (non-evaluative) environments, they provide opportunities for students to play or experiment with science, taking on new roles and stances that may be less accessible or possible in school settings -- where there is often more pressure to follow particular procedures or arrive at specific answers. This may be especially important for students who have been discouraged by school science and might have self-identified as not competent or interested in science; such students, it has been shown, are disproportionately female or from non-dominant cultural communities [11]. As developmental spaces, OST STEM programs can reinforce and expand children's experiences with school STEM, both supplementing and complementing it through supporting children's interest, understanding, capacity, and identity with respect to STEM learning.

This variation of OST STEM program goals, design, and participation patterns might suggest that adopting a singular way to design, document, and evaluate such programs could operate adversely to homogenize the conceptual -- and diminish the developmental -- potential of the OST setting. Indeed, from a policy perspective, providing and ensuring a rich and diverse science learning ecology within our communities may be one of the most important contributions OST science programs can make toward ensuring more accessible and equitable science education for all [12].

NSF AYS: Designing, Documenting, and Assessing OST STEM

In response to the growing interest in the OST field, the rich diversity of programs, and a relative lack of evidence about how such programs impact student interest and learning in science fields, in 2006 the National Science Foundation (NSF) created a new program, the Academies for Young Scientists (AYS). This program was designed specifically to support and test the potential of OST projects to build student interest in STEM fields and practices with the goal of contributing to the body of literature regarding the design and assessment of OST STEM programming.

The NSF AYS program funded 16 projects, each of which had a distinct program design and addressed different science-based disciplines. In common, all 16 projects provided students opportunities to deepen their interest in, understanding of, and career awareness of science, technology, engineering, and mathematics fields. All formed partnerships among school districts, universities, businesses, and community-based-organizations. All offered approximately 100 hours of programming, over one to two years, to children attending afterschool, weekend, and/or summer programs. All experimented with ways to incorporate pre-service, in-service, or community-based organization educators as lead teachers in the afterschool programs.

The AYS program contributed to NSF's existing efforts to expand the knowledge base regarding OST STEM projects, which already included projects funded by the Informal Science Education (ISE) and the Information Technology Experiences for Students and Teachers (ITEST) programs. NSF AYS placed a particular emphasis on children in K-8 and was designed to support research into the ways in which these programs supported student interest in science and science fields. The program also awarded a grant to the Learning and Youth Research and Evaluation Center (LYREC) headed by the Exploratorium's Center for Informal Learning and Schools (CILS) with SRI, International. LYREC used both quantitative and qualitative measures to document (a) whom the NSF AYS projects served, (b) what each project provided, and (c) whether and how they built student interest in, understanding of, engagement with, and opportunities to persist in STEM learning.[1] LYREC was charged with analyzing and synthesizing local project evaluations and research studies that addressed program impacts on students. LYREC also examined the role of classroom teachers in leading these out-of-school-time programs. Analysis of the data collected over the past three years is currently underway.

Out-of-School Time STEM: Building Experience, Building Bridges Conference

The NSFAYS projects were implemented during the 2007-2010 academic years. Towards the end of 2009, as projects were beginning their data analysis phase, LYREC worked with project leaders from NSFAYS, as well as from ITEST and ISE, to design a conference that would bring together leaders from the field to share what they were learning with respect to design, documentation, and assessment of OST STEM programs. The *Out-of-School Time STEM: Building Experience, Building Bridges* conference met on October 19-20, 2009. Over 115 educators and researchers attended. The goal of this conference was to surface issues, challenges, and solutions related to OST science; to provide opportunities for cross-pollination, particularly as projects were reaching their

[1] LYREC defines understanding of STEM to encompass the strands of STEM learning described in the NRC (2009) volume *Learning Science in Informal Environments*.

data analysis phase; and to identify emerging findings or questions that could inform a larger research agenda in the OST science field.

The two-day conference was organized around five strands:

1. OST STEM Program Design, Partnerships, and Implementation
2. Research and Evaluation of OST STEM Programs
3. Student Learning in OST STEM Programs
4. Teacher Learning in OST STEM Programs
5. OST STEM Program Sustainability

Additionally two data analysis workshops were offered, one led by Tina Cartwright of Marshall University, focusing on analysis of video data using the TOPS protocol to analyze teacher inquiry practices. The other, led by Judith Stull of Temple University, focused on quantitative data reflecting student participation and interest measures.

Keynote talks were provided by Kevin Crowley, University of Pittsburgh, and Philip Bell, University of Washington. Crowley spoke about the need to maintain the rich, localized variety of science in OST settings. Bell discussed the recently published National Academies of Sciences report *Learning Science in Informal Settings*, stressing the six different strands of what constitutes capacity to engage with science, and how OST settings may be especially strong in supporting children's interest in science and identity as science learners.

There were a total of 13 workshops offered in the five strands. Each of the workshop sessions was facilitated by two discussants, representing a wide array of professional fields, including educational research, youth program leadership, academia, and museums. Discussants later led reflective sessions, with conference participants, about emergent themes and pressing questions. These sessions were then synthesized in a whole group panel session with the entire 115+ participants. The results of these reflective sessions and panels are represented in this report. Conclusions and recommendations can be found on page 30.

Conference Program

MONDAY OCTOBER 19, 2009

9:00 WELCOME
Bronwyn Bevan, *Exploratorium*
Janice Earle, DRL *National Science Foundation*

9:15 KEYNOTE AND SMALL GROUPS
Local Learning: Why OST science is better for you. Kevin Crowley, *University of Pittsburgh*

10:45 WORKSHOPS SESSION ONE

Strand 1: Program Design and Implementation Partnerships and Progress

Strand 2: OST STEM Research & Evaluation Frameworks Student Motivation and Interest

Strand 3: Scaling & Sustainability Making Hard Choices about What to Scale, When, and Why

Strand 4: Student Learning & Development in OST Academics, Affect, and Career Interest

Strand 6: Hands-On Data Workshop Video Data and OST Impact on Pre-Service Teachers

12:45 LUNCH REMARKS

Wanda Ward, *EHR, National Science Foundation*

2:00 WORKSHOPS SESSION TWO

Strand 1: Program Design & Implementation Recruitment, Retention, and Ramping It Up

Strand 2: OST Research & Evaluation Frameworks Evaluation Frameworks

Strand 3: Scaling & Sustainability Beyond More: Unpacking What it Means to "Scale Up"

Strand 5: Teacher Learning & Development in OST Teacher Development in OST I

Strand 6: Hands-On Data Workshop Quantitative Data Analysis

TUESDAY OCTOBER 20, 2009

9:00 PLENARY SESSION
New methods and approaches to understanding learning across formal and informal settings.
Philip Bell, University of Washington

10:15 WORKSHOPS SESSION THREE

Strand 1: Program Design & Implementation Building Staff Capacity to Implement High Quality OST STEM Programs

Strand 2: OST Research & Evaluation Frameworks Research Frameworks, Methods, and New Findings

Strand 3: Scaling & Sustainability Beyond Program Sustainability: Sustaining Impacts for Students During and After Program Experiences

Strand 4: Student Learning & Development in OST Field-Based Research, Complexity, and Advanced Science for Students in OST

Strand 5: Teacher Learning & Development in OST Teacher Development in OST II

12:15 LUNCH/OPTIONAL DATA SESSION
Larry Gallagher, *SRI, International*
Robert Tai, *University of Virginia*

1:15 STRAND SYNTHESIS SESSIONS
Emerging, Converging, and Confusing Issues, Challenges, and Promises:
- Program Design and Implementation
- OST STEM Research & Evaluation
- Scaling and Sustainability
- Student Learning and Development in OST STEM
- Teacher Learning and Development in OST STEM

3:00 SYNTHESIS PANEL

Strand One: Design and Implementation of OST STEM Learning Environments

The workshops in this strand focused on features of design and implementation that impact projects' challenges and successes. Strand Discussants were Joyce Malyn-Smith, from Education Development Center, and Diane Miller, from the Saint Louis Science Center. There were three workshops in this strand; themes that emerged included:

(1) OST STEM programs are especially well positioned to help children make connections between science and real world contexts, needs, applications, and communities.
(2) OST STEM programs pose unique opportunities for teachers and other program staff to experiment with new ways of interacting with the scientific phenomena and with new pedagogies.
(3) OST STEM programs need to cultivate partnerships carefully, with attention to the capacities and expectations of each collaborator within the practical context of implementation.

Workshop One. Partnerships and Progress: Crossfire and Compromise at Institutional Boundaries

OST programs often occur at the boundaries of school and community. Funders therefore frequently require OST programs to form partnerships. Yet as discussed in this workshop, strong partnerships can be difficult to form and maintain, particularly with respect to issues of expectations, contributions, and trust. The presentations in this session highlighted points of difficulty and the ways in which efforts to resolve these difficulties ultimately contributed to the advancement of project goals.

- ***Finding, losing, and building trust in new partnerships (AYS: Joe Heimlich, Ohio State University, Columbus, OH***). This presentation described the collapse of a partnership, as well as the eventual reconfiguration of the program. Eight critical incidents that shaped program development were identified and expounded through interviews. The interviews indicate that a lack of clarity about project roles and expectations led to misunderstandings and compounded problems to such an extent that the project needed to undergo a complete redesign.

- ***Partnering with local underserved communities: (Re)Building relationships and understanding (ITEST: Travis Southworth-Neumeyer, Oregon Museum of Science and Industry, Portland OR).*** This presentation shared challenges and significant problems that occurred during the initial year of establishing a partnership aimed at providing education, cultural programming and direct support to a local First Nations community. Challenges included: rebuilding the partnership after a previous attempt was unsuccessful in several key ways; establishing shared expectations and goals; and establishing a collaborative communication dynamic. This presentation emphasized the need to understand and take into account different organizational or community cultures.

- ***Partnering with schools and community groups: One size does not fit all (AYS: Kevin Cuff, Lawrence Hall of Science, Berkeley, CA).*** This project reported on challenges in establishing partnerships as they varied across the types of resources and levels of commitment brought to the program by different partners. The project organizers worked with three types of partners: one that used the project resources to advance their own agenda, one committed to STEM education reform but without the capacity to act, and one that shared project goals and actively engaged in efforts to deliver high-quality programming. OST programs seeking to replicate and scale up their programs need to take into account local variations in resources and institutional cultures.

Workshop Two. Keeping Students Engaged: Recruitment, Retention, and Ramping It Up

Attendance and participation patterns widely fluctuate in OST programs, where participation is voluntary, and time periods compete with doctor's appointments, team sports, and other kinds of commitments. This workshop focused on the ways in which programs sought to recruit and retain students through designing programs and activities that engaged children not only intellectually but also socially and emotionally, increasing student involvement over short and ling time frames.

- ***Bridging the elementary-middle school gap through STEM engagement. (AYS: Susan Brown, Courtney Harmon and Laura Tomlinson, New Mexico State University, Las Cruces, NM).*** This presentation emphasized the critical importance of teacher liaisons and family involvement in developing students' interest in project activities promoting awareness of STEM fields, industries and professions in a local region. Project leaders described the multiple avenues they experimented with to reach and involve parents from primarily Latino communities in the border regions of New Mexico. They found that the parents who were more engaged and involved in the project activities were also those who believed most strongly in the benefits the project had for their children.

- ***Student engagement through parent motivation. (AYS: Traci Ballard and Jason Lee, Detroit Area Pre-College Engineering Program (DAPCEP), Detroit MI)*** This project provided multi-year programming to children from the City of Detroit and surrounding communities. The program required and supported parental involvement through a range of efforts aimed at building parent awareness of STEM career and academic pathways that their children could choose to pursue. This presentation shared some of those efforts and what was learned about making them productive, such as creating a level of prestige associated with student and parent participation in educational programming; setting up a separate parent support organization; administering parent workshops; and inviting parents to serve as advocates of DAPCEP.

- ***Sustaining multi-year engagement of first generation college-bound high school students in out of school time learning experiences. (DOE: Judy Brown, Mickael Charles, and Cheryl Juárez: Miami Science Museum, Miami, FL).*** This presentation described an out-of-school project serving diverse, low-income, urban students in grades 6-12 who are the first generation in their families to attend college by providing them with exposure to STEM fields. The project found that year-long programming helped to sustain high levels of student motivation, as did hiring staff and mentors with similar backgrounds, exposing children to new technologies, and providing a level of choice and learner-directedness.

Workshop Three. Building Staff Capacity to Implement High Quality OST STEM Programs

Presenters in this session focused both on the types of activities that programs provided for teacher professional development and the responses they have received from teachers, communities, and others involved. The implications of practices that involve teachers and students learning simultaneously were of particular interest to programs aimed at integrating teachers in their systematic efforts and goals.

- ***Building an integrated teacher development/student learning community. (AYS: Vivian Hoette, Yerkes Observatory, Williams Bay, WI).*** This project created a learning community that focused on teachers learning side-by-side with students, and included after school clubs, observation nights at the planetarium, field trips, summer academies, and more. The project's impacts included making more teaching resources available to classroom teachers, for use both in and after school and building relationships among the partner institutions.

- ***School and community: Building the team (AYS: Linda Gilbert, Leigh Gostowski, Kim Sadler, Middle Tennessee State University, Murfreesboro, TN).*** This presentation described how the OST project leveraged programming for children to serve as a test bed for teachers to design and test classroom activities related to their own summer professional development with local STEM industries. Children tested the activities and provided teachers with formal feedback on the activity designs. Teachers explored new pedagogical approaches and were able to experience first-hand how these affected children's engagement and opportunities to learn.

Synthesis of Findings and Recommendations of the Program Strand

(1) OST programs help students to make connections between science and real-world contexts, problems, needs, and communities. Rooting programs in experiences involving real world contexts, problems, needs and communities can be highly appealing and motivating to children, especially to children who are underrepresented in STEM fields, and can bridge their prior and everyday experiences with disciplinary STEM concepts, practices, and future trajectories.

  - OST programs offer opportunities to link science with local community sites and industries; these linkages worked best when accompanied by inquiry-based activities that allowed children to connect the science with solving real world problems, and included work with other scientists and engineers.

  - Research shows that linking STEM to community settings can make STEM more appealing to children who are otherwise uninterested or disaffected from school STEM. Maintaining a diverse set of community-based STEM learning opportunities may be critical for making STEM more accessible to children and diversifying the STEM workforce.

  - OST programs provide opportunities for children to experience science in the context of *novelty*: new places for field trips, new technologies and tools, and new relationships with fellow students and also adults.

  - Extending beyond the child to the family and the community is a critical part of OST program implementation and requires continuously engaging parents and other caregivers as co-partners, using multiple communication methods throughout the life of the program (e.g. newsletters, meetings, calls, and others, such as family days or taking families on field trips).

(2) OST STEM programs pose unique opportunities for teachers and other program staff to experiment with new ways of interacting with the scientific phenomena and with new pedagogies.

- Designing outreach, recruitment, or dissemination by building on the relationships that teachers bring to the OST setting can help to expand the depth and reach of the projects. Scientists and university staff can be part of this network of trusted co-participants, but participating scientists often need to learn what are appropriate expectations of what can be accomplished in schools.

- It is important to create incentives to involve teachers. These might include professional development through credit bearing courses as well as stipends. Teamwork, family friendly environments, and genuinely interesting experiences can also serve as incentives. Particularly important are resources teachers can take back to their schools.

- Time is a significant factor in teacher professional development, especially when teachers are learning new science content as well as new pedagogical strategies. Close communication and realistic expectations need to be shared among partners and stakeholders to avoid an over-commitment of in-service teachers. Including core management staff that maintain the projects but do not have teaching responsibilities can reduce burden on program teachers.

(3) OST STEM programs need to cultivate partnerships carefully, with attention to the capacities and expectations of each collaborator within the practical context of implementation.

- Effective partnerships usually begin with people who want to work together leveraging the skill sets of teachers, scientists, and students, and taking care not to work at cross purposes.

- Effective partnerships develop a comfortable, safe "inter-culture" that includes a shared mission, and the establishment of shared values based on an understanding of each other's use of language, time, deadlines, ways of working. Sharing practical management tools (logic models, matrix management processes) appropriate for large complex partnership activities (such as projects) will ensure transparency and define commitment.

- It is often in the early stages of implementation, when details must be decided and problems arise, that partnerships become tested and require frequent negotiation and renegotiation in order to, on the one hand, stay true to the project's goals, while, on the other hand, also accommodate the realities of the situation. Sufficient time for meeting and working through these issues should be budgeted from the outset.

NB: There was a feeling that three years is not long enough to design, test, and demonstrate a program's impact, especially when research shows that 12-24 months is needed to establish strong working partnerships. It was felt that programs funded for a minimum of 5 years have greater opportunity to demonstrate their impact and to lay the foundation for sustainability and scale-up.

Strand Two: OST STEM Research and Evaluation Frameworks

In this strand, AYS, ITEST, and ISE projects presented their research and evaluation methodologies and designs. Strand Discussants were Drew Gitomer, from ETS, and Kevin Crowley, from the University of Pittsburgh. There were three workshops included in this strand. Emergent themes include:

(1) There is a need to design data collection methods that do not interfere with the students' experience of the OST program.
(2) There is interest in capturing changes that may be more strongly related to the development of long-term dispositions, understanding, and trajectories than they are to short-term effects.
(3) There is a need to clarify intended outcomes (at both a policy-funding level and at the level of program design) and aligning data collection strategies in ways that take into account the highly idiosyncratic and contingent nature of the programs as they vary across settings.

Workshop One. Researching Student Motivation and Interest in STEM

This session tackled the broad problem of how to support student motivation to engage with STEM, and moreover how to develop methods to measure the effectiveness of such efforts. Presentations ranged from the theoretical, to the methodological, to the practical.

- ***Conceptual frameworks for researching student motivation (AYS: Mike Barnett, Boston College, Newton, MA).*** This presentation provided a theoretical model for documenting and understanding student motivation. In particular, the model applied to an OST STEM program used self-determination theory by Ryan and Deci (2000) which highlights the role of choice or autonomy and its relationship to interest development. The study also looked at relatedness and self-efficacy. The project studied how these features related to students development of interest and also persistence, accounting for the phenomena of some children reporting high interest but choosing not to persist in science activities.

- ***Teacher change and its impact on student motivation (ITEST: Ruth Kermish-Allen, Shey Conover, and Karen Peterman, Island Institute, Rockland, ME).*** This presentation described an OST program's efforts to introduce teachers in a rural setting to technologies that could ensure an OST program's sustainability. The project developed non-hierarchical learning models, used place-based education, and provided technology support to the participating teachers. Challenges of supporting teacher buy-in and persistence were discussed.

- ***Investigating how motivation and interest develop: A ten-year retrospective study (ISE: Lynn Dierking, Oregon State University, Corvallis, OR).*** This presentation shared the design of a retrospective study that asked young women, 10 years out, to reflect on their lifelong engagements with STEM and how their participation in an OST girls science program related to motivations and choices they had made with regard to academic, professional, and leisure decisions.

Workshop Two. Evaluation Frameworks: What Counts and Why?

This session addressed the ways in which OST evaluations struggle with developing formative and summative results that can be useful in the design and sustainability of a project. Issues raised included the importance of developing flexible designs that could change as projects matured, of designing methods that did not adversely interfere with participant experiences, and with tracking the contributions of all project partners.

- ***Evaluation as Educative Practice (AYS: Alexis Kaminsky: Kaminsky Consulting, LLC, Albuquerque, NM).*** This presentation focused on the importance of developing evaluation strategies that were able to evolve as the project matured and evolved, and also that did not intrude into or unintentionally alter the student experience.

- ***The challenges of measuring impact of OST STEM programs on students. (AYS: Rita O'Sullivan: University of North Carolina, Chapel Hill, NC).*** This presentation focused on the results of student assessments that combined surveys and focus groups, and included discussion about forming and assessing partnerships.

- ***Invisible evaluation: Using embedded assessments to evaluate OST programs (ITEST: Karen Peterman: Durham, NC).*** This presentation focused on the design and implementation of "invisible assessments" designed to capture student capabilities while they engaged in project activities, including culminating group-based competitions.

Workshop Three. Research Frameworks, Methods, and New Findings

This session shared two different approaches to evaluating effects of OST programs on student's development of understanding about the relevance and nature of science.

- ***The impact of an OST program on middle school students' science reasoning skills & strategies (AYS: Crystal Bruxvoort: Calvin College, Grand Rapids, MI).*** This presentation shared a model to test, using a treatment and control design, children's development of understanding of the nature of science and experimental designs, after a year-long program where students engaged in small and longer term controlled investigations into local environmental conditions.

- ***Frameworks for evaluating OST impact on students (ISE: Kirsten Ellenbogen, Science Museum of Minnesota).*** This presentation included two models for evaluating informal learning programs, one embedded and one participatory. Evidence was presented that highlighted the benefits of the participatory model for securing buy-in to programs actually making use of outcomes. Also discussed were benefits of embedded assessments in the web context.

Synthesis of Findings and Recommendations of the Research and Evaluation Strand

(1) A major concern of the group was the need to develop embedded and performance assessments that could document students' development of skills or understanding in ways that did not interfere with students' experience of the OST STEM programs.

- The group generally agreed that both students and teachers tend to participate in OST STEM programs because they are seeking appealing, enjoyable, and "low-stakes" opportunities to engage with STEM, and that many paper-and-pencil and other types of assessments disrupt the pace and patterns of social interaction that are common to the OST setting. Such assessments are associated by many with school-like experiences that involve rating or judging performance or proficiency.

- To promote better and embedded assessments, there was a call for involving staff in the goals and evaluation data collection process, to develop OST educators' capacities to see, communicate, and respond to evidence about student learning and experiences.

(2) It was notable that project presenters were generally more concerned with, but also challenged by, a desire to capture long-term effects on students interests, dispositions, and lifelong choices, including decisions to pursue STEM in academic and career contexts, than they were in capturing short-term gains in content or skills.

- There was a general consensus that the field has not yet developed adequate methods to capture the potential and power of OST programs. Measurements are too frequently tied to school-type questions, instruments, and values, despite the significant differences in treatment, dosage, and context.

- The localized and diverse nature of OST programs (including treatment, duration, and audience) may make consolidating evaluation strategies across programs difficult.

- While all of the presentations focused on researching effects of OST STEM on students, it was noted that many programs also sought to support or impact the teachers working in OST settings or community partners engaged with OST.

- Although many studies presented their work within specific theoretical frameworks, less clear were the ways in which the study results were designed to advance knowledge in the field, with regard to both theory and practice. Often the results seemed to inform only immediate program-related issues.

(3) The group articulated a pressing need to clarify, at the level of policy and funding, intended and feasible outcomes for OST STEM programs in general. At the program design level, intended goals and outcomes need to take into account particular local resources and needs. Once goals and intended outcomes are decided, there is a need to align program treatments, evaluation strategies and nature of evidence with the intended outcomes.

- There was a question about whether OST evaluations should be designed to inform projects about program outcomes or to build knowledge within and regarding the field. There was a consensus that funding solicitations usually required evaluations to assess impact rather than to build knowledge.

- There was a concern that in cases where projects are expected to design and test innovations (as opposed to replicating proven models) there was insufficient time built in to refine models before impact data was collected.

- There was agreement that as programs matured, outcome measures would often need to shift; as such, there was a call for establishing (and adequately funding) relationships between project directors and evaluators that could ensure sufficient contact so that evaluation designs could evolve as programs matured and evolved. One goal of such evaluations would be to determine how to best conduct useful evaluations once programs are mature.

- It was noted that frequently funders adopt an additive model, expecting that a particular experience in OST settings will transfer and "add to" experiences in school settings, but the research on transfer does not support this assumption. Alternative ways of positioning OST experiences are needed to guide the field.

Strand Three: Scaling and Sustainability

This strand focused on issues related to (a) sustaining programs beyond their NSF funding cycles and (b) scaling programs beyond their initial scope. Synthesizers of this session were Julie Johnson of the Science Museum of Minnesota and Gil Noam of the Program in Education, Afterschool & Resiliency (PEAR) at Harvard Medical School. There were three workshops in this strand. Presentations and discussions focused on the following three themes:

(1) There is a need to bring greater complexity to notions of sustainability and scale-up; rather than expanded replication, there is a need to consider isolating features or elements that are (trans)portable and scalable.
(2) There is a need for more adequate and reasonable timelines to allow for project innovation, project maturation, and, then, project scale-up and sustainability. There are many problems associated with the pressure to act quickly because of funding requirements and expectations.
(3) There is a need to design project evaluations with sustainability and scale-up in mind and then to use these evaluations to inform decisions about sustaining and scaling the projects in future phases of the work.

Workshop One: Making Hard Choices about What to Scale, When, and Why

The presenters in this session gave examples of systematic approaches to decisions concerning the suitability of programs for scale and the need for redesign of program elements as part of scale up.

- ***Identifying robustness in OST STEM programs (AYS: Susan Yoon, University of Pennsylvania, Philadelphia, PA).*** This presentation introduced the complex systems principle of robustness as a promising lens through which to understand scaling and sustaining OST programs. This included discussion about what it means for an OST program to be robust, what are the trade-offs, how to deal with program fidelity, adaptations, and self-organized/regulated activities, and what variables might be considered to harness robustness.

- ***Issues of trialability and observability impacting two cohorts of student participants in the ITEST CoastLines Project (ITEST: Steve Moore, Science Approach, Tucson, AZ).*** This study applied Roger's (2003) framework for the diffusion of innovation to understanding whether or how to scale OST science projects. The research found that many schools' capacities to adopt complex technologies is limited due to insufficient technological support in the school buildings, narrow bandwidth, and permission problems. There is a need to allow OST teachers and students to test and modify technologies for use in the OST setting before undertaking any scaling.

- ***Project WetKids 2010: Expanding eco-education across the Gulf Coast (AYS: Julie Cwikla, University of Southern Mississippi Gulf Coast, Long Beach, MS and Christopher Barry, University of Southern Mississippi, Hattiesburg, MS).*** This presentation discussed current efforts to replicate Project Wetkids in a nearby school district. Important considerations for this scaling effort include feasibility, generalizability, and costs-benefits. For example, identifying both short-term and long-term benefits is necessary for considering the feasibility of scaling up.

Workshop Two: Beyond More: Unpacking What it Means to "Scale Up"

The examples of scaling discussed in this session included expansion of programming over time and space. Attention was given to organizational structure and partner roles and relationships that support scale up.

- ***Scaling-up the 4-H robotics and GPS/GIS intervention for informal learning environments (ITEST: Bradley Barker, University of Nebraska-Lincoln, NE).*** This presentation described the scale up efforts of Nebraska 4-H to move a STEM program centered on robotics and geospatial technologies from a state-based intervention to a national program. The five dimensions of scale (depth, sustainability, spread, shift, and evolution) developed by Coburn (2003) and Dede (2006) were applied to the Nebraska 4-H scaling plan, concluding that projects needed to consider each of these issues and their relative impact on localized interests and needs.

- ***Photonics Leaders II: Bridging the participatory process and program sustainability (ITEST: Pamela Gilchrist and Joyce Hilliard-Clark, North Carolina State University, Raleigh, NC).*** This presentation described the evolution of the ITEST Photonics Leaders program model. These presenters discussed the challenges of institutionalizing a program and leveraging resources from various stakeholders over time. The project discussed its participatory model for assessing and ensuring purposefulness in sustainability efforts, including analyzing the dimensions of and steps for scale-up (Dede, 2006) . The project found that engaging all stakeholders in the process of analysis and planning supported project efforts to achieve both scaling up and sustainability.

Workshop Three: Beyond Program Sustainability: Sustaining Impacts for Students During and After Program Experiences

This session focused on fundamental elements of program design that influence scalability and sustainability, particularly as these affect student learning and ongoing STEM participation.

- ***Designing OST STEM programs for sustainability (ITEST: Len Annetta, North Carolina State University, Raleigh, NC).*** Drawing on the experiences of the HIFIVES ITEST project, these presenters discussed leadership models and relationships between IST and OST programming that make programming more sustainable. They considered the roles and complementary goals of the school and out of school partners as components of sustainable OST programming.

- ***Researching and evaluating OST STEM programs for sustainability (ITEST: Tirupalavanam Ganesh, Arizona State University, Tempe, AZ and Beverly Parsons, InSites, Fort Collins, CO).*** This presentation discussed the sustainability of the middle school design challenge Learning through Engineering Design and Practice (LEAP) as an example of iterative program design in which learning principles are integrated into an OST program design that is tested and refined.

Synthesis of Findings and Recommendations of the Scaling and Sustainability Strand

(1) There is a need to complexify notions of sustainability and scale-up. Too often people confuse replication of projects with sustainability and scale-up. Sustaining and scaling projects are two different processes with concerns regarding sustainability usually those associated with scaling.

  - The forms that scaling-up take depend on the evolution of program goals, and often involve building on newly developed local interests, needs, or resources, that might include expanding to new audiences, increasing the program duration, or building new partnerships.

  - Strategic scaling-up involves analyzing specific program features or elements and possibly redesigning them to fit new conditions.

- Dede's (2006) five dimensions of scale (depth, sustainability, spread, shift, and evolution) were found to be a particularly useful framework for breaking down the processes involved in designing programs for scale.

(2) There is a need for adequate and reasonable timelines to allow for project innovation, development to maturity, and consideration of scale-up and sustainability. Funding constraints and life cycles put pressure on projects to accelerate this timeline.

- Participants discussed the challenges of developing new projects and making them sustainable within the short NSF funding cycles. The short funding cycles sometimes contribute to hasty replication or the need to shift gears to new projects.

- Analysis of impact data needs to be done before issues of scale-up and sustainability can be fully addressed.

- Efforts to continue and scale successful programs, including the transition from grant to institutional support, would be enhanced and facilitated by relationships with a community of like-minded projects even after the funding cycle is completed. For example, project leaders expressed a desire to continue relationships and access to technical assistance, conferences, etc. provided by the NSF-funded resource centers.

(3) Project evaluations should be designed with sustainability and scale-up in mind and used to inform decisions about sustainability and scaling.

- Project evaluations need to address issues that vary with scale such as student self-selection, attrition, recruitment and training of teachers, parent involvement, geographic factors, political climate and program management.

- Not every project is appropriate for scale-up. There is need for deliberate decisions around what kinds of projects should be scaled and if scaled, what parts of the project can go to scale.

- Cost-benefit ratios for sustainability and scaling need to be considered and documented

NB: There was variation among the strand participants about the definition of the terms sustainability, scale-up, and replication. The group discussed the need for the community to better understand and articulate what people mean by these terms so that appropriate comparisons can be made.

Strand Four: Student Learning and Development in OST

In this strand, project leaders shared their goals and evaluation methods related to their programs' impacts on students. Synthesizers of this session were Rob Semper from the Exploratorium, Stephanie Robinson from the Education Trust, and Phillip Bell from the University of Washington. There were two workshops in this strand. Presentations revealed that programs had a wide variety of goals for student learning as well as different approaches to documenting program impacts. Themes that emerged included:

(1) A diversity of approaches seems to be the strength of OST programs, appealing to different children with different interests, frequently by tapping into local resources, settings, and authentic questions and needs.
(2) There is a need to better understand and build coherence across OST and school settings in order to spark, sustain, and develop students' interests and understanding in STEM fields.
(3) There is a need to build understanding in both OST and school communities about the needs, interests, resources, and potential power of each.

Workshop One: Developing Student Interest in STEM Careers: Academics and Affect

This session shared two different approaches to developing student awareness of and interest in STEM careers, arguing that in addition to exposure to fields, interaction with professionals, and work in the subject matter, programs needed to be designed to support children's affective engagement with the subject matter and professions.

- ***Informal OST experiences' impacts on students' interest in STEM careers (AYS: Dianne Jass Ketelhut, Temple University, Philadelphia, PA).*** This presentation reported on gains in student interest in science careers during a voluntary after-school science program for grades 5-8 with attention to the complex role of student participation factors. The project found variations by gender, with boys benefiting most from more continuous program treatment, which suggest a need to study trajectories longitudinally to see if these variations hold and what they might mean.

- ***The role of affect in OST's support of student interest in STEM careers (ITEST: Gerald Knezek and Rhonda Christensen, University of North Texas, Denton, TX).*** This presentation reported changes in 6th and 7th grade student interest in STEM and motivation toward STEM careers over the course of an applied science project focusing on electricity consumption in the home. The project shared a new instrument it had developed to measure students' affect towards STEM careers. The measure was found to be statistically robust, but how career interests leads to career paths, in the long term, remains to be investigated.

Workshop Two: Field-based Research, Complexity, and Advanced Science for Students in OST

This workshop sought to highlight the ways in which OST STEM programs tackle advanced subject matter in relationship to local community issues in order to provide transformative learning experiences for youth. The session also posed questions about the need or potential of these OST community experiences to relate to classroom science learning and achievement.

- ***Complex Systems, Complex Community Problems (AYS: Irene Lee, Santa Fe Institute, Santa Fe, NM).*** This presentation used the work of project GUTS (Growing Up Thinking Scientifically) to explore how the use of advanced science topics and processes (complex systems, models and simulation) can encourage children to explore their world, connect with their community and think scientifically. Children learned computer programming and complex systems concepts through studying issues such as traffic patterns in their communities and creating computer games and simulations that modeled complex systems.

- ***High school students learning science through community environmental research and action (AYS: Will Snyder: University of Massachusetts, Amherst, MA).*** Using the example of the Massachusetts Envirothon competition, this presentation described community research as an opportunity for students to construct science knowledge, apply new science concepts, and engage with their communities.

Synthesis of Findings and Recommendations of the Student Learning Strand

(1) A diversity of approaches is a strength of the OST setting and frequently taps into local resources, industries, settings, as well as community issues to create authentic contexts for developing students' science capacities and interests.

- It was noted that student-centered approaches to teaching and learning that draw upon novel and local resources allow OST programs to build on both intrinsic and extrinsic motivation.

- Understanding the ways in which OST programs can be designed specifically to engage and encourage students from communities underrepresented in the sciences was seen as an urgent need.

(2) A major issue taken up by the group related to the coherence of learning opportunities that students encountered in different settings.

- There is a challenge and a need to design OST programs for students that bridge classroom science with local community issues that are of concern to students.

- Understanding the role of OST settings in supporting children's identity as science learners, and bridging those identities to school settings was also seen as an area for further research, particularly (but not exclusively) with respect to career identities.

- Discussants explored the possibility of developing new kinds of partnerships involving new players and visions in the OST space, such as social media organizations, libraries, churches, and others.

(3) It is important for leaders from both school and OST settings to come to understand the different goals, structures, and strategies of each other's organizations.

- There is a need to undertake an analysis of the affordances of both in- and out-of-school settings and understand how they can be designed to complement, supplement, and overlap.

- There was discussion about the ways in which OST settings can support new research and design approaches that take into account the ubiquitous nature of learning (anyone, anytime, anyplace).

- There is a need to develop different measures for OST learning that can be related to, but not tied directly to, school measures.

Strand Five: Teacher Learning and Development in OST

This strand focused on how the OST setting could be used to support teacher learning and development in STEM content and pedagogy. Strand Discussants were Mark St. John from Inverness Associates and Patrick Shields from SRI International. There were two workshops in this strand. The core assumption underlying these efforts is that in order to provide children opportunities for authentic science learning in school, teachers need similar opportunities, which they can receive in OST settings. Emergent themes included:

(1) OST programs can provide classroom teachers opportunities for professional development and growth that they would not have otherwise.
(2) There is a need to explore whether the use of OST settings as a practicum site for new or continuing teachers is a sustainable model that can be brought to scale.
(3) There are challenges associated with developing a robust theory of teacher change in and through the OST setting, and modeling aspects of it sufficiently to support ongoing research. Additionally, the assumption that the impact should be unidirectional—from OST to school—is largely under-theorized and untested.

Workshop One: Teacher Learning and Development in OST I

The presentations in this session addressed the benefits and drawbacks of having classroom teachers in OST STEM, effective approaches to preparing and involving teachers in OST programs, and types of outcomes that are possible for teachers' classroom practice and their relationship with other STEM professionals and resources. The session provided multiple perspectives on what is known and needs to be known about integrating classroom teachers in OST programs.

- ***Exploring impact of the Yerkes Astrophysics Academy for Young Scientists on participating teachers (AYS: David Beer, University of Chicago, Chicago, IL).*** This presentation focused on the program's challenges and successes in supporting teachers' professional development, noting the potential for teachers to learn new content and implement new activities with their students. Specific approaches to connecting teachers in an active network of scientists and educators were presented.

- ***Teacher learning of science content and research methods in OST science clubs (AYS: Allan Feldman, University of South Florida, Tampa, FL).*** Teachers in the STEMRAYS program engaged in authentic research projects across multiple areas, increasing their knowledge of scientific processes and experimentation, their ability to develop meaningful lessons with students, and their own identification with scientific practice and working scientists.

- ***Challenges and benefits of integrating classroom teachers into OST STEM experiences (ITEST: Cat Stylinski, University of Maryland Center for Environmental Science, Frostburg, MD).*** A review of ITEST projects shows that K-12 teachers in OST settings can enhance their confidence and understanding of STEM and support informal learning experiences for students. Teacher roles in informal science include: (1) instructor, leading youth through curricular materials; (2) mentor, guiding youth through open-ended inquiries; and (3) partner, working with youth as equals.

Workshop Two: Teacher Learning and Development in OST II

This session addressed the basic question: How can informal learning opportunities promote growth for pre- and in-service teachers? Presentations identified important issues for ongoing research, including how an OST practicum can support teacher learning, how variations in previous experience and training affect teacher outcomes, and what impacts on student learning result from pre- and in-service OST professional development programs for teachers.

- ***Teacher capacity and student learning experiences (AYS: Bob Coulter, Litzsinger Road Ecology Center, St. Louis, MO).*** The LIONS program supported teachers' development of STEM capacities, including their curiosity to learn more, the ability to guide students in explorations, their comfort with scientific reasoning, and their understanding of key concepts. Variations in teachers' prior competence and disposition affected program outcomes and the impact of the program on their regular teaching assignments.

- ***OST programs as practicum for pre-service teacher preparation (AYS: Tina Cartwright, Marshall University, Huntington, WV).*** COMETS provided pre-service teachers continuing opportunities to gain experience in science instruction, emphasizing inquiry practices, peer collaboration, lesson development, critical feedback, and time for reflection. Outcomes showed improvement in self-efficacy, multi-cultural science teaching outcome-expectancy, and reform-oriented teaching practices.

Synthesis of Findings and Recommendations of the Teacher Learning Strand

(1) OST programs can provide classroom teachers opportunities for professional development and growth that they would not have otherwise.

- OST programs, particularly those that draw on community resources, places, and people, offer teachers opportunities to expand their content understanding.

- The OST setting provides a low-stakes opportunities for teachers to participate in and facilitate new types of STEM learning experiences, experimenting with new and more inquiry-based teaching strategies.

- Promising practices include programs in which teachers and students learn together, which create a "research community" among teachers in connection with informal science institutions or scientists, and which connect teachers in a network of professional scientists and educators for ongoing support and learning.

(2) There is a need to explore whether the use of OST settings as a practicum site for new or continuing teachers is a sustainable model that can be brought to scale.

- Theoretical frameworks for understanding how the OST experience might translate into change in the formal environment are largely unarticulated and undeveloped. Only limited evidence has been gathered regarding actual impacts on in-school teaching practices and student outcomes.

- Similarities and differences with professional development in the school setting should be investigated.

(3) A more robust theory of change is needed to further develop and study the utility of OST settings for teacher preparation and development.

- Early stage findings from the projects included evidence that many teachers are more confident and capable with scientific processes and knowledge based on their OST experiences.

- Outcomes for teachers in OST settings may vary depending on teachers' backgrounds, the nature of the OST programming, and how they frame or value the OST experience. Issues of scale and equity have been largely unconsidered, e.g., the "volunteer effect" may mean that teachers in particularly difficult school circumstances would benefit the least from OST experiences.

- A focus on pre-service teachers is called for.

- Frameworks for conceptualizing teacher professional development across settings need to be developed and tests; e.g., Feldman posits a trajectory of development in which teachers build on a foundation of "core values" (progressing through "vision, mission, strategies, tactics, and activities"). Efforts to measure impact, such as teacher self-efficacy assessments and classroom observations, can be better validated and shared to support the development of a more robust research base

- The assumption that the impact should be unidirectional—from OST to school—is largely under-theorized and untested. For example, more research is needed on the effects of bringing classroom teachers into the OST setting: in what ways are classroom norms imported and how does this change the developmental nature of the OST setting?

Conclusions and Recommendations

Looking across the strands, the following big picture trends or needs emerge that have implications for program design, funding, and research. Further detail on these trends can be found in the description of the strands and the syntheses of their findings.

(1) **There is no one model of OST STEM. Most programs are designed to reflect local resources, needs, and communities and therefore program goals, design, and outcomes vary widely. This diversity enriches the science learning landscape, providing multiple points of entry for many different learners.** This diversity has implications for funding, research, assessment, and scaling up.

(2) **OST STEM programs offer important developmentally supportive environments for children to develop their interest in, affinity with, understanding and pursuit of STEM.** The low-stakes nature of these programs can provide all students with learning opportunities and activities that legitimate them as productive science learners. What developmental science settings look like, and what outcomes they promote, vary across particular programs and participating groups.

(3) **There is a need to develop new research and evaluation questions, methods and instruments** that can take into account the nature of the OST STEM setting, program treatment and dosage, and analyze and document how the experiences contribute to children's lifelong, as well as immediate, engagement with STEM.

(4) **Most OST STEM programs are not extensions of school STEM. They draw on different resources, have different timeframes, and therefore have different potentials and outcomes**. They must be researched and evaluated differently. On the two ends of a spectrum, they can both attract and interest children who are not engaged in school STEM and they can provide advanced experiences for children who are deeply engaged in school STEM. They can also be accessed at different times as children's engagement in STEM ebb and flow.

(5) **There is a need to better understand the complex connections between school and OST experiences in STEM and how they contribute to lifelong engagement with science, including career pursuits**. This work will require longitudinal and ethnographic studies that take into account the developmental power of the OST setting as well as the nature of the STEM that is experienced in school, OST, and home or community settings. Reflecting the complex interacting parts and systems in which the work is taking place, no one pathway will prove right for all communities or participating groups or at all times.

(6) **There is a need to better understand the ways in which OST STEM programs can provide important professional development sites for classroom teachers, both pre-service and in-service:** (a) for learning STEM subject matter; (b) for

experimenting with new STEM teaching materials and approaches; (c) for seeing their own students: as capable engaged STEM learners; and (d) for engaging with children and STEM in the context of joy and excitement, thus (i) "inoculating" new teachers against narrow conceptions of what science education can look like and (ii) rejuvenating seasoned teachers' enthusiasm for teaching STEM.

(7) **Funding for OST programs should provide sufficient time and resources** for these complex spaces to develop partnerships, programs, and evaluation strategies that can test innovations, investigate sustainability, and support strategic scale-up efforts.

Towards a Focused OST STEM Research Agenda

There is a need to develop and maintain a focused research agenda that takes into account these trends, needs, and challenges. Overarching questions that emerged from this conference that might help to frame such an agenda include the following:

(1) What are the important ways that OST programs build children's capacities to engage in science?

(2) What features of high quality OST STEM programs can or must be maintained in efforts to introduce STEM into a broad array of OST settings at scale?

(3) What research methods can be employed in the OST setting that can document program impacts on students and teachers without altering the typically low-stakes and child-centered nature of the setting?

(4) In what ways can the OST space support new and veteran teachers' views of science and science teaching and learning?

(5) In what ways do high-quality OST STEM programs differ from and relate to high-quality school STEM programs, and how do these differences and relationships operate to strengthen student engagement with STEM?

(6) How can schools become aware of and build on the capacities and interests that students develop in OST STEM programs?

The participants in this conference are making progress in addressing many of the issues these questions represent. The field as a whole is beginning to gather momentum to specify the terms, tools, and concepts that will generate more appropriate methods, more salient questions, and more meaningful results for use in the OST setting. Much work, using approaches as diverse as the OST programs and the children they serve, is needed to understand the many ways that OST experiences fit within the lifelong trajectories of children who participate in them and the larger educational landscape that they enrich.

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Profile of AYS, ITEST, and ISE Afterschool Projects

AYS Program Description

In 2006, the Academy for Young Scientists (AYS) program was funded by the National Science Foundation to support and document the impacts of out-of-school-time programs designed to build K-8 student interest in STEM fields and careers. The 16 projects funded through the program have taken a variety of approaches and have addressed a range of STEM disciplines. The projects all have provided students opportunities to engage in hands-on inquiry and each has conducted its own research and evaluation. The funded projects primarily targeted children in grades 6-8, although some also served children in grades 3-5 as well as 9. More than 80% of children served came from urban communities, almost 40% were on free or reduced lunch programs. The projects addressed one or more of physical, life, environmental, earth and space sciences, as well as technology, engineering, and mathematics.

ITEST Program Description

The Innovative Technology Experiences for Students and Teachers (ITEST) program was established by the National Science Foundation in direct response to current concerns and projections about the growing demand for professionals and information technology workers in the U.S. and seeks solutions to help ensure the breadth and depth of the STEM workforce. ITEST supports research studies to address questions about how to find solutions. It also supports the development, implementation, testing, and scale-up of implementation models. A large variety of possible approaches to improving the STEM workforce and to building students' capacity to participate in it have been implemented and studied. Most funded projects served children in grades 9-12, but they also served large numbers of middle school aged children, as well as children in elementary grades. Almost 80% of children served came from urban communities, more than 70% were on free or reduced lunch programs. The projects addressed one or more of life or environmental, as well as technology and engineering.

Presenting Project Descriptions

CoastLines is a three-year, comprehensive professional development project for teachers funded by the National Science Foundation's Innovative Technology Experiences for Students and Teachers (ITEST) program. Conducted by Science Approach, LLC, a small research and development business located in Tucson, Arizona, and in collaboration with scientists and staff from the National Science Foundation's Long-Term Ecological Research (LTER) network, the goal of the CoastLines project is to facilitate efficient deployment of geographic information systems (GIS) in grade 7—12 schools located in urban and suburban regions, and with high populations of low-income families and an

ethnic makeup not highly represented in the science and engineering fields. Webinars and a summer institute presented by the project involve teachers and students in using geographic information systems (GIS) and Global Positioning System (GPS) technology to conduct scientific studies of coastal ecosystems and watersheds in the LTER network.
Presenter: Steven Moore

COMETS (Communities Educating Tomorrow's Scientists) worked with existing community afterschool organizations and teacher education programs to provide elementary grade students inquiry-based earth and space science activities in summer camp and afterschool settings. The program provided training on inquiry-oriented instruction for pre-service teachers who led the afterschool programs. The partners for COMETS include Community Centers in Charleston and Dunbar; Kanawha County Schools; The Clay Center science museum; NASA/Goddard Space Flight Center, Bayer Corporation, Globe Program headquarters and local school districts.
Presenter: Tina Cartwright

CREST (Communities for Rural Education, Stewardship and Technology) a comprehensive project for students and teachers, currently networks the Island Institute, University of Maine-Machias, Bowdoin College, and 11 island and coastal schools in a learning community that directly impacts 55 students and 44 teachers, and indirectly impacts 1,700 additional students. CREST focuses on delivering data- base development, GIS mapping, web design and ethnographic research skills to students and teachers in Maine's most remote locations. This interdisciplinary, standards-based approach is reconnecting students to their communities and pro- viding insight into applicable IT and STEM careers through local service-learning projects based in the surrounding Gulf of Maine ecosystem. The two-year renewal of CREST, with technology as a tool and place-based education as a vehicle, will expand to 16 schools with 168 participants and a new regional collegiate partner, continuing to demonstrate more ways in which IT and STEM studies and careers can diversify and support natural resource-based communities and economies.
Presenters: Shey Conover and Ruth Kermish-Allen

CyberBridge is an ITEST funded project seeking to expand the use of media and cyber-infrastructure (CI) in the classroom; to improve science instruction and student experience with IT technologies within an interdisciplinary construct; to increase teacher and student understanding concerning the relevance of science and role(s) of technology in future careers; and, to strengthen the relationships between K-12 schools/students and the science community. The CyberBridge Program is a collaborative among UC San Diego, San Diego State, and the Sweetwater Union High School District.
Presenter: Karen Peterman

DRITA (Dan River Information Technology Academy) is a three-year program for high school students from underserved populations who are interested in pursuing IT or STEM careers. The overall goal of DRITA is to provide opportunities for promising African American or Hispanic youth to (1) develop solid IT skills and (2) acquire the background and encouragement needed to enable them to pursue higher education in STEM fields, including IT itself and other fields in which advanced IT knowledge is needed. A total of 96 students will be recruited over the course of the three years. Each DRITA participant will receive 500 hours of project-based content. The project includes both school-year modules and a major summer component. Delivery components will include a basic IT skills orientation; content courses in areas such as animation, virtual environment modeling, advanced networking, programming, GIS, robotics, and gaming design; externships; a professional conference/trade show "simulation," and college/career counseling. Parent involvement is an integral part of the program and includes opportunities for parents to learn from participants, joint college visits, and information sessions and individual assistance in the college admission process.
Presenter: Karen Peterman

DigitalWAVE is an ITEST Strategies project that will create and test a new model for engaging and preparing youth to pursue IT-intensive science careers. The project will address workforce needs in digital design, modeling and visualization as well as IT-intensive environmental science fields including climatology and marine science. In collaboration with University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS) and Miami Dade College (MDC), the Museum will design and implement a program targeting youth in grades 10 —12 who are traditionally underrepresented in STEM fields. Youth will acquire 3D graphic design and computer animation skills during Saturday Design Studios to be held at MDC's School of Entertainment and Design Technology. They will then take part in a summer Academy during which they will collaborate with an experienced virtual world exhibit fabricator to create a series of science-rich virtual world simulations.
Presenters: Judy Brown, Mikael Charles, and Cheryl Lani Juarez

EBAYS (East Bay Academy for Young Scientists) provided afterschool and summer programming focused on investigation of local environments using scientific instruments, digital resources, and reasoning skills. The partners include the Emeryville Unified School district, Oakland Unified School District, West Contra Costa Unified School District, Lawrence Hall of Science, Lawrence Hall of Science ESITA program, Communities for a Better Environment, Mills College Educational Talent Search, and Tesito Enterprises.
Presenter: Kevin Cuff

EEC (Energy, Earth, and Civilization) created afterschool and summer programs for students that focused on content knowledge and experiential learning, group problem solving, and analytical process skill development. It also provided professional development to in-service and OST teachers who led EEC, leveraging projects partnering with local businesses that rely on the STEM capacities of their workers. The partners included the Middle Tennessee State University, Chamber of Commerce Business Education partnership, three school districts, informal science organizations (e.g., Discovery Center) and Fisk College.
Presenters: Linda Gilbert, Leigh Gostowski, and Kim Sadler

GRADUATE (Games Requiring Advanced Developmental Understanding and Achievement in Technological Endeavors) is a pilot partnership between educational researchers, scientists, and engineers from NC State University, UNC Chapel Hill, and Duke University and teachers and administrators from Durham County Schools, Lee County Schools, the NC Business Committee for Education, and an international gaming company. The project builds a model based on the evaluation results of a current ITEST grant (HI FIVES) and targets 40 teachers and 100 disadvantaged rural and urban students from two redesigned "New Tech" high schools. The focus is on creating STEM-related games and investigates the effects of student-created games on their attitudes towards STEM subjects, achievement in learning content, and motivation to enter STEM careers. GRADUATE is unique in how it involves a very coherent systematic approach combined with a thorough and well-organized evaluation plan. The student-created games stem from scientific research and serve as the product and presentation components to the newly implemented North Carolina graduation requirements. Because of this integration into the curriculum, the project helps retain students through HI FIVES and into high school, thereby addressing a serious concern with the North Carolina high school dropout rate.
Presenter: Leonard Annetta and Karen Peterman

KAYSC (Kitty Andersen Youth Science Center), at the Science Museum of Minnesota, was created in 1996 to commemorate Katherine B. Andersen's career in science by encouraging young people – in particular girls and young women –d and to engage in experiential learning that develops their confidence in and appreciation for STEM fields. The mission of the KAYSC is to engage youth 12—18 years old in STEM educational and professional opportunities, thereby empowering them to pursue their potential, experienced in the world of science, committed to serving the community, and grounded in their awareness of young people's ability to impact our institutions and communities. The KAYSC is built on a belief that youth are active participants in their own learning and that discovery, ownership, and responsibility instill a positive attitude toward the sciences. Participants take an active role in the planning, research, design,

implementation, and evaluation of their own program and projects. The youth work as either museum volunteers or part-time, paid staff in small teams facilitated by adult program managers. Youth educate museum visitors, build exhibits, develop community STEM projects and presentations, and do scientific research.
Presenter: Kirsten Ellenbogen

Learning through Engineering Design and Practice: Using Our Human Capital for an Equitable Future engages ninety-six, 7th and 8th grade female and minority students traditionally underrepresented in the STEM fields in multi-year out-of-school technological design and problem solving experiences. STEM teachers from project sites receive professional development on project content. Student participants simulate desert tortoise behaviors, research and develop designs to mitigate the urban heat island, build small-scale renewable energy resources, design autonomous rovers capable of navigating Mars-like terrain, and develop a model habitat for humans to live on Mars. Participants and families gain firsthand knowledge of IT/STEM career and educational pathways. Research effort is aimed at understanding what strategies are successful in enhancing middle school students' interest in STEM education and career pathways.
Presenters: Tirupalavanam Ganesh and Beverly Parsons

LIONS (Local Investigations of Natural Science) focused on students conducting scientific investigations of local ecologies, including bird populations and water tables and resources, during afterschool and summer programs. The project also aimed to expose participating teachers to inquiry-based science curriculum to promote greater use of hands-on activities in the classroom. The partners included the Missouri Botanical Garden, an MIT faculty member and his staff, Missouri Association of Soil and Water Conservation, Metropolitan St. Louis Sewer District, River des Peres Watershed Coalition and Environmental Systems Research Institute.
Presenter: Bob Coulter

Math Achievers, led by the Detroit Area Pre-College Engineering Program (DAPCEP), was a Saturday morning program that provided students with a mix of hands-on and classroom-based activities to develop their mathematical problem solving and reasoning skills as well as opportunities to learn about STEM careers. Children studied and used mathematics to build small musical instruments and also small battery powered cars. Additionally, the program provided parents information about STEM careers and strategies for supporting their children's learning and motivation. Classroom teachers leading the Saturday programs received professional development in methods of integrating technology in math and science instruction. The partners included Lawrence Technological University, The University of Detroit Mercy, Chrysler Group LLC, Ford

The program serves 120 students from the Detroit Area in hands-on academic programming coupled with technology utilization designed to instill confidence and prepare students for the challenges of high school mathematics and science curriculum. In addition to student engagement, the project has invested significant resources in teacher development and technology in-servicing.
Presenters: Traci Ballard and Jason Lee

M-SOS-W (Middle Schoolers Out to Save the World) is a project with approximately 600 sixth graders from seven middle schools in Louisiana, Maine, Texas and Vermont monitoring home energy use under supervision of their 11 teachers. The data are being used to develop optimum scenarios for conserving energy and reducing production of greenhouses gases in local communities. The teachers are receiving professional development to carry out the project. Students and teachers are using online software tools to re- cord and analyze their data and create projections of future energy use based on assumptions of policy changes. They are communicating their results within the project via information communication technology. Research is being conducted on the effects of the project on students' and teachers' changes of attitudes and interests in science and in students' gains in science content knowledge through comparisons with matched, untreated schools.
Presenters: Rhonda Christensen and Gerald Knezek

National Robotics in 4-H: Workforce Skills for the 21st Century, is a program developed through the Nebraska 4-H, with grant funding from the NSF, to increase science, technology, engineering and mathematics (STEM) achievement and interest using robotics and geospatial technologies. The program is based in part on the successful 4-H Robotics curriculum developed in collaboration with Carnegie Mellon University using the previous version of the LEGO Educational Robotics kit (Barker & Ansorge, 2007). The widespread availability of technologies such as the LEGO NXT Mindstorm robotics kit, handheld Global Positioning System (GPS) receivers, and geographical information systems (GIS) software like Google Earth and ArcMap make it possible for youth (ages 10 to 15) to explore and practice STEM concepts through the integration of these technologies. The original project is titled Nebraska 4-H Robotics and GPS/GIS in 4-H: Workforce Skills for the 21st Century, and is an intensive two-year program that begins with a 40-hour summer camp experience. The camp activities include the building and programming of robots, working with handheld GPS receivers to explore and collect georeferenced information, and the development of GIS maps. Youth then receive an additional 80 hours of hands-on robotics and GPS/GIS training during the school year in their afterschool programs or 4-H clubs. In year two, youth attend an advanced summer camp followed by 80 more hours of hands-on instruction

during the school year. In total, participating youth receive at least 240 hours of focused hands-on experience over two years.
Presenter: Bradley Barker

Photonics Leaders II is a Strategies project for 80 underrepresented minority and rural 10^{th} grade students, their parents or caregivers, and 60 teachers. The project nurtures interest in optics, electronics, computer hardware and software, while building the intellectual, communication and personal skills needed for success in the STEM workforce. NCSU researchers from Physics, Engineering, Distance Learning and Education will partner with The Science House (at NCSU) and industry leaders to develop, implement, and evaluate the activities. Students and teachers will participate in hands-on and virtual learning, career and personal counseling, and field experiences at universities and Research Triangle Park, a Center for technological innovation. The project will engage parents to be effective champions for students by offering information about college-funding resources, college entrance requirements, and connections between coursework and career opportunities.
Presenters: Pamela Gilchrist and Joyce Hilliard-Clark

Project GUTS used StarLego TNC to enhance students' understanding of complex systems concepts and advanced computational tools in summer workshops and afterschool clubs. Additionally, project teachers were trained in computational science, complex systems, and team building skills to develop their capacity for inquiry-based instruction. Topics ranged from public health to traffic patterns, most of which could be studied empirically in local schools and neighborhoods. Partners included Santa Fe Institute, Massachusetts Institute of Technology, New Mexico Institute of Mining and Technology, New Mexico Supercomputing Challenge, Santa Fe Public School District, Santa Fe Independent Schools, Science Related Businesses in Santa Fe area, Supercomputing Challenge, NM Tech, Los Alamos National Laboratories, University of New Mexico and Local Science Centers.
Presenter: Alexis Kaminsky and Irene Lee

Project Wetkids engaged students in investigations focused on wetlands ecosystems that were designed to developed their scientific reasoning skills. Students studied marine life systems in the Gulf Coast, estuaries, and the Mississippi Delta. The partners included three Pascagoula School District (PSD) schools; local scientists, mathematicians, and engineers from Stennis Space Center and Audubon Mississippi; industry partners including Chevron-Texaco and Northrop Grumman Shipbuilding; and academics at the University of Southern Mississippi.
Presenters: Christopher Barry and Julie Cwikla

Promoting STEM Career Interest in the Classroom: An Exploratory Study Linking Teacher Professional Development with Changes in Teaching Practices is a research study exploring IT-immersion professional development strategies that lead to changes in teaching practices and IT integration in K—12 classrooms. We are using ITEST projects as a study group because they share a common design that was implemented in unique ways. We are examining these projects through the lens of two commonly used professional development models (teachers creating new versus adapting existing curriculum materials) and frequently cited characteristics of effective in-service teacher education. Our study consists of a review of current and past ITEST professional development activities, a broad survey of ITEST teachers, and an in-depth study of IT use of ITEST teacher com- pared to non-ITEST teachers.
Presenter: Cathlyn Stylinski

ROBOTS (Robotics: Opportunities for Building Outstanding Talent in the Sciences) provided robotics activities for students attending Saturdays and summer programs led by classroom teachers. Students also had opportunities to be mentored by STEM professionals. Professional development focused on preparing teachers to engage students in rigorous and challenging hands-on, inquiry-based experiences; leading classes in astronomy, physics and robotics; providing access to mentoring opportunities with scientists; and enabling online access to galactic radio astronomy. The partners included Pisgah Astronomical Research Institute (PARI); NC Technology Association (NCTA), Internet Community Action Network, Inc. (I-CAN), NC Public School Districts, NC Grassroots Science Museums Collaborative, and UNC System / NC-MSEN Pre-College Program (PCP) sites, and Tyco Electronics.
Presenters: Rita O'Sullivan

Salmon Camp Research Team: A Native American Technology, Research and Science Career Exposure Program supports Native American students to better understand the world around them and to research careers in a variety of science and IT-related fields. Salmon Camp provides a pipeline into both higher education and careers in science and resource management. Students gain hands-on experience working with federal, state, and tribal resource managers as well as university researchers, and they receive training in the newest technology revolutionizing the field of re- source management. Salmon Camp was funded in the first ITEST cohort and was awarded a renewal during the fifth cohort.
Presenter: Travis Southworth-Neumeyer

The Science and Mathematics Education Department, College of Science, Oregon State is creating the first comprehensive Science and Mathematics Education graduate program (MS and PhD) in the country focused on lifelong STEM learning. It includes

concentrations in K—12, collegiate teaching and free-choice/informal learning. Core courses in the program are taken together by all students (K-12, college teaching, free-choice learning) building a community of researchers that crosses settings, ages and backgrounds, fostering cross-disciplinary and cross-institutional learning. Students also build a specific knowledge base and expertise in their area of concentration. Our program has strong ties with SMILE (Science and Math Investigative Learning Experiences), a 21-year-old university-school partnership that collaborates with 13 primarily rural Oregon school districts with large under-served populations to offer STEM after-school programs. Several of our students are conducting research in after-school programs.
Presenter: Lynn Dierking

Science in the Circle was based upon the JASON interdisciplinary investigation model and was designed to give students hands-on experiences studying local ecosystems through programs offered at several local informal learning institutions. Teacher professional development focused on working with STEM content experts who study the structure and function of wetlands in northeast Ohio. The partners included Cleveland Municipal School District, University Circle Incorporated (UCI), Cleveland Botanical Garden (CBG), Western Reserve Historical Society (WRHS), the Nature Center at Shaker Lakes (NCSL), and the Cleveland Museum of Natural History (CMNH).
Presenter: Joe Heimlich

SICA (Science in the City Academies) developed and implemented inquiry-based STEM activities, in partnership with local informal science institutions, that improved students' science knowledge and helped them develop effective learning strategies. The program also provided professional development to the project teachers, better preparing them for science teaching and providing effective and useful classroom materials. The project was led by Temple University science educators and researchers from the Colleges of Science and Technology and the College of Education in collaboration with administrators from the School District of Philadelphia. The partners included four schools (Dunbar, Duckrey, Ferguson, and Mead) and various informal science education institutions: NJ Academy for Aquatic Sciences in Camden, Philadelphia City Water Works, Wagner Free Institute, Philadelphia Crime Lab, and the Philadelphia Art Museum.
Presenters: Diane Jass Ketelhut and Judith Stull

Spark! focused on engineering design in after-school, Saturday, and summer enrichment programs with the aim of supporting children's ability to understand how the STEM concepts and engineering could be applied in real world settings. Classroom teachers who led the sessions were provided professional development to enhance their STEM

content knowledge and use of effective practices to maintain their students' interest and motivation in STEM activities. The program partners included Philadelphia Zoo, Science and Engineering Center, scientists at University of Pennsylvania, and principals and IST teachers in the School District of Philadelphia.
Presenter: Susan Yoon

STEM Pathways provided an urban ecology curriculum that included field studies modules such as bird biodiversity and water quality and other supplemental environmental education lessons and curriculum. The partners included: Lynch School of Education and Urban Ecology Institute (UEI) at Boston College; Boston Public Schools' (BPS) Science Office, master teachers, and DELTAS office OST program; Onset Computer Corporation; Boston's Museum of Science; Centro Latino; and Salvation Army Youth Corps.
Presenter: Mike Barnett

STEMRAYS (Franklin County Research Academies for Young Scientists) centered on opportunities for students and teachers to collect and analyze data used by scientists and engineers in research projects on five environmental research themes: arsenic measurement, Pioneer Valley Watershed studies, Weather RATS, air quality and birds. Partners included University of Massachusetts Amherst, Greenfield Community College, 8 school districts in Franklin County, Northeast Utilities, Western Massachusetts Electric, Franklin Regional Employment Board, PAX Analytics, Pioneer Photovoltaic, and Australis Aquaculture LLC.
Presenters: Allan Feldman and Will Snyder

Stone Age to Space Age (Southern New Mexico Academies for Young Scientists) gave students and families the opportunity to attend field trips to parks, nature centers, museums, and other science-related venues that engaged students in hands-on experiences in a variety of STEM fields from archeology to aerospace. The partners include Las Cruces Public Schools, the New Mexico State University College of Education, the X-Prize Corporation, Starchasers, and the following informal science institutions: Southern New Mexico Science Engineering, Mathematics, and Aerospace Academy; The Asombro Institute for Science Education (formerly the Chihuahuan Desert Nature Park); Pre-Freshman Engineering Program; Suborbital Center of Excellence Mobile Laboratory; and the Science Engineering Mathematics Aerospace Academy.
Presenters: Susan Brown, Courtney Harmon and Laura Tomlinson

Technology at the Crossroads is a youth-based program that will engage middle school youth (with particular emphasis on girls) in the use of Geographic Information Systems

(GIS), Geographic Positioning Systems (GPS) and HTML programming for use in conducting environmental research in Boston. The program comprises a spring after-school component, a three-week summer camp (held on the campus of Simmons College), and a fall after-school component. Science skills to be learned include posing questions, making observations, collecting, and analyzing and interpreting data. The context for the IT and science skills development will be environmental research projects that incorporate mathematics, biology, botany and chemistry. Six Boston area organizations with after-school programs will take part in the project and include: Washington Irving Middle School, Department of Youth Services, Mother Caroline Academy, Codman Academy Charter School, New Boston Pilot Middle School and the Patriot's Trail Girl Scouts Council. Each after-school program team will include one teacher, one undergraduate student, and one high school student. These teams will be trained in the use of the technologies and the IT curriculum and will work with youth as well as local scientists and GIS specialists to deliver the program. Near the end of the project additional after-school program staff will be trained so the program can continue beyond the grant-funded period. Goodman Research Group, Inc., will conduct formative, process and outcome evaluation of the project. This project will reach a total of 235 middle school youth and employ six high school students, six undergraduate students, and six to twelve teachers/program facilitators during its implementation. The intellectual merit of the program resides in the ability of youth to contribute to the under- standing and solution of environmental issues in their communities.
Presenter: Karen Peterman

TRIAGE (Team Researchers in a GLOBE-al Environment) helped students develop and refine their understanding of scientific experimentation through a series of short and then later extended children-directed inquiry-based investigations in the areas of biology/life sciences, chemistry, earth sciences/geology, and ecology/environmental sciences. The program was led by undergraduate pre-service teachers, coordinated by an experienced high school teacher. The partners include 5 school districts, Calvin College Science Department, The Bunker Interpretive Center and Ecosystem Preserve (Bunker), Frederik Meijer Gardens and Sculpture Park, West Michigan Environmental Action Council, Pierce Cedar Creek Institute, Timmermans Environmental Services, and West Michigan Sustainable Business.
Presenter: Crystal Bruxvoort

YAAYS (Yerkes Astrophysics Academy for Young Scientists) provided astronomy activities that developed students' scientific reasoning skills. Project participants included many students who are visually and hearing impaired. The project was led by classroom teachers who formed small YAAYS afterschool groups at their respective schools and developed their content knowledge, pedagogical skills, and professional

community through project activities. For the special-needs student population, an additional goal was to develop sign language for science as part of this multi-sensory learning experience. The partners included Geneva Lake Area School Districts, Adler Planetarium, Tokyo Science Museum, George Williams College of Aurora University, Lake Geneva Environmental Agency, Lake Geneva Fishing Guide Service, Williams Bay Businesses, University of Chicago Scientists, and Illinois Math Science Partnership.
Presenters: David Beer and Vivian Hoette