A Report on the
NSF ITEST Convening: Defining an Afterschool Research Agenda

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Siobhan Bredin, Caroline E. Parker, Karen Peterson,
Kate Goddard, Wendy Rivenburgh & Tony Streit

ITEST Learning Resource Center
Education Development Center, Inc.
55 Chapel Street, Newton, Massachusetts 02458-1060
770 N. Halsted Street, Suite 205, Chicago, IL 60642

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Advisors

Philip Bell, UW
Bronwyn Bevan, Exploratorium
Patricia Cogley, Adobe Systems
Lynn Dierking, OSU
Jason Freeman, CSAS
Pam Garza, 4-H
Harry Helling, Crystal Cove Alliance
Dale McCreedy, Franklin Institute
Mary Ann Steiner, UPCLOSE

Project Team

Tony Streit, PI
Siobhan Bredin, Co-PI
Carrie Parker, Co-PI
Wendy Rivenburgh
Kate Goddard
Education Development Center, Inc.

Karen Peterson, Co-PI
National Girls Collaborative Project

Beverly Farr
Laurel Sipes
MPR Associates, Inc.

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Introduction

In community centers, labs, and classrooms, young people from around the country are diving into STEM learning experiences. They're devoting some of their valuable out-of school hours to experiment and make discoveries, at the same time building skills in science, math, engineering, and technology.

Why? What do they get out of it? What motivates them to participate, and what would inspire them to further pursue STEM learning and careers?

What program elements most effectively support STEM workforce development?

What partnerships work best? How should staff be prepared? And how can programs be truly responsive to the needs of underrepresented youth?

These questions, among others, were the impetus for a unique convening funded by the **National Science Foundation's** Innovative Technology Experiences for Students and Teachers (ITEST) program. ITEST supports many out-of-school time STEM projects designed to increase and diversify the STEM workforce, and is interested in expanding research designed to identify and validate promising practices.

Convening participants worked to craft a field-informed research agenda to identify gaps and clarify central questions regarding STEM workforce development in the afterschool environment. The June 2010 event included researchers in STEM and informal learning, afterschool leaders and practitioners, and policymakers, funders, and industry professionals. All expressed a commitment to crafting and advancing a collaborative research agenda, through this gathering and beyond. In addition to the discussions that took place both formally and informally at the event, nine authors contributed targeted white papers to help frame some of the key themes.

The **ITEST Learning Resource Center** at Education Development Center, Inc., organized and facilitated the gathering, in partnership with the **National Girls Collaborative Project** and **MPR Associates, Inc**. The **Science Museum of Minnesota** staff and youth graciously served as hosts.

Through the event, this report, and various dissemination efforts, we hope to:

- Advance research on replication and scalability of STEM workforce development in afterschool
- Facilitate knowledge sharing and collaboration amongst participants
- Stimulate discussion and plans around future ITEST study proposals on afterschool issues

We are extremely grateful to all involved in this project who have been working together for the last year to raise the quality and expand the sphere of afterschool STEM workforce development.

The Research Agenda

This STEM Workforce Development & Afterschool Learning Research Agenda is intended to inform researchers of critical questions and appropriate strategies to further describe STEM career exploration and pathways experiences in out-of-school time. The overarching goal is to identify and provide an evidence base for promising, replicable practices that ultimately strengthen and diversify the STEM workforce. A short-term goal is to seed new proposals for research in this area, specifically within the NSF ITEST program. The long-range objective is a robust and competitive STEM workforce within the United States that reflects the diversity and creativity of its population.

The ITEST solicitation (http://www.nsf.gov/pubs/2011/nsf11525/nsf11525.htm) states:

> *The ITEST program responds 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… **Research** projects enrich the understanding of issues related to enlarging the STEM workforce. Research projects may conduct efficacy and effectiveness studies of intervention models, conduct longitudinal studies of efforts to engage students in the STEM areas, develop instruments to assess engagement, persistence, and other relevant constructs of student motivation, or conduct studies to identify predictors of student inclination to pursue STEM career trajectories. The program is especially interested in projects that target students from groups that are underserved and underrepresented in STEM and ICT-intensive careers, including those residing in rural and economically disadvantaged communities.*

Convening Discussion & Recommendations

Over three days of presentations, discussions, and reflection, participants in the ITEST Afterschool Convening explored ways to advance research and practice in afterschool learning that supports STEM workforce development. The convening provided participants with the opportunity to hear white paper authors present their work, discuss with each other the implications of the papers, and consider the many different possible areas of future research. A wide range of topics were discussed, including authentic experiences for underrepresented groups, motivational factors, computational thinking, program design, partnerships, and professional development. Participants also explored how best to build the evidence base for STEM workforce development through assessment, scaling, and longitudinal research.

As a synthesis activity, participants were asked to work together to graphically represent the hopes for future research and the impact it might have on the field. Working in teams, participants creatively illustrated their many assumptions around effective research and practice and presented compelling questions that could inform research

studies. A summary of assumptions and questions from these brainstorms includes the following:

- **Family plays a critical role in determining a young person's interest in and pursuit of STEM careers.** How can we qualify this relationship? In what ways can afterschool influence this relationship by a) building family support for STEM or b) fostering a young person's interest in STEM regardless of family influence?

- **A young person's sense of self – their personal and cultural identity – shapes their academic and career interests.** How do afterschool programs impact this sense of identity? In what ways might they foster a greater self-interest in STEM learning and/or career pathways?

- **Afterschool learning can be one part of a systematic, whole-child development and learning cycle.** How does STEM learning in the afterschool domain intersect with other influences (school, home, street, etc.) on a child's understanding of and interest in STEM careers and educational pathways?

- **Career and life choices evolve over long periods of time, influenced by innumerable intentional and unintentional forces.** Can STEM learning in afterschool have a sustained impact that contributes to a continuum of positive influences toward STEM careers?

- **Learning in out-of-school time takes many forms and may not purposefully impact every child equally in content knowledge development.** How can we assess whether out-of-school time learning contributes to greater STEM knowledge and interest?

- **The STEM industry and academic communities may have distinct or perceived cultures that do not map to the cultural realities of underrepresented young people.** What kinds of out-of-school learning experiences can bridge this divide?

After the event, the conveners synthesized the collective comments and suggestions, and organized the recommendations into three potential areas of investigation, which collectively represent a *Call To Action* for the field. The conveners believe that the best research agenda will come about through a synergy of related interests/influences – the desire of practitioners to improve and validate their practices, the desire of researchers to understand the impact and outcomes of these kinds of programs, and the goal of NSF (and Congress) to build a stronger workforce. The recommendations begin at the micro programmatic design level by calling for *research that describes existing STEM workforce development experiences in afterschool*. They stipulate the importance of individual experiences by calling for *research that investigates the role of participants' culture and context*. Finally, the recommendations address the macro level of long-term, lasting impact by prescribing *longitudinal studies*. The overall goal is to provide researchers and practitioners a vibrant and lasting research agenda to validate approaches, disseminate findings, and have a positive impact on policy and practice over time.

Based on the convening synthesis, future studies on STEM workforce development experiences in afterschool should…

1. Describe STEM workforce development experiences in afterschool:

- Clarify the essential elements of the experiences that have an impact on career interest and pursuits
    - The relationship between positive youth development goals and STEM learning
    - Engagement in real-world scientific inquiry and applied technology
    - Direct or indirect linkages to school-day learning
    - The role of adult mentors, including STEM professionals
    - Partnerships with industry and academia to enrich programs
- Question dosage and the impact of progressive experiences over time from K-12 through college
- Understand the relationship between professional development of afterschool staff and quality programs
- Test strategies for assessing impact specific to informal STEM learning
- Map experiences to related goals in 21st century skills and computational thinking
- Look at existing research on informal science education, effective afterschool learning, professional development methodology, and program assessment

2. Investigate the role of the participants' culture and context:

- Describe the ways that groups which are underrepresented in the STEM workforce come to understand and value STEM content and careers
    - Young women
    - Young people of color
    - Young people with disabilities

- Explore the role of community in forming identity and how an afterschool program can have an impact on a participants' sense of identity and self-efficacy
- Study the role of parents and family, and the ways that they understand, value, and support STEM learning and career pathways
- Look at existing research on engaging underrepresented groups, contextual learning, identity formation, parent/family involvement in education, and cultural studies

3. Follow impact over time:

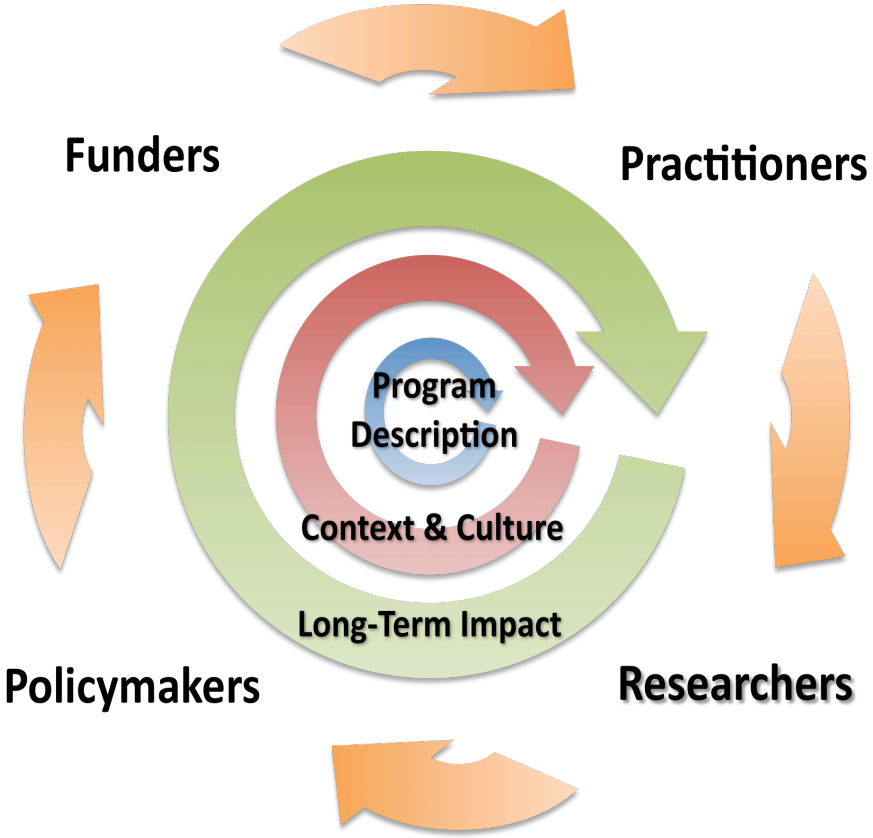
- Design longitudinal research that tracks young people's movement through STEM experiences from afterschool to college and careers
- Explore over time the change in youth understanding and interest with regard to STEM content and careers
- Examine the importance of youth motivation over time
- Investigate how participants follow or abandon career pathways leading to work in STEM
- Understand how a program improves upon and replicates approaches for sustainability and scaling, including organizational culture shifts that may be necessary for success
- Look at existing research on motivation, career pathways, college readiness, and sustainability and scale-up

A Call To Action

In addition to cultivating new research, the participants and conveners believe that the impact of the research agenda will be greatest if stakeholders re-conceptualize the ways that they work together in research and practice. Event participants emphasized the importance of identifying barriers to collaboration across stakeholder communities (e.g. researchers, practitioners, policymakers, funders), in order to clear the barriers and move out of the 'silos' that limit deeper understanding and systematic change. Mirroring an urban planning model, in which stakeholders take a "whole community" approach, collaborate to identify and solve problems, and develop mutually workable solutions, the proposed research agenda requires a long-term commitment from each stakeholder:

- **Afterschool Practitioners** – Develop clear and measureable STEM program goals; establish practices for documenting impact and lessons learned; work with researchers to track results long-term.
- **Researchers** – Partner with the field to address stated needs and current practices; collaborate with fellow researchers and national intermediaries on reporting results and recommending further studies.
- **Policymakers** – Communicate results and needs to leaders and the community at large; work to clarify "what's at stake" and effective models.
- **Funders** – Support investment in research and evaluation that describes STEM workforce and career exploration; aid in disseminating findings; invest in pilot programs built upon research findings.

The diagram below, inspired in part by NSF's Cycle of Innovation, illustrates this collective Call To Action to address each of the three key components of the research agenda.



Convening Project Activities

Background

Our nation faces a dilemma – interest in STEM content and careers is stagnant or waning, yet more jobs than ever before require scientific literacy or technical skills. There is a lack of diversity in both undergraduate and graduate science programs as well as science careers, a challenge that impacts national employment trends and success, the ability of individuals to support their families, and community economics and leadership (CPST, 2004). For example, only 6.3% of the STEM workforce is African-American, 5.3% is Hispanic, and only 26.1% is female – percentages significantly below those groups' overall participation in the labor market (CPST, 2004). Multiple studies suggest that low-income communities, students of color, and girls self-select out of science careers for many reasons, including negative conceptions about those careers, few role models representing diverse cultures and ethnicities, peer pressure, negative reinforcement from teachers, and lack of information about careers in these fields (for example, see NSF, 2004). In addition, we find that a lack of direct experience can be a barrier for teens who may not encounter or recognize IT and science applications at work in their environments (Coalition for Science After School, 2007). Young people need authentic opportunities to explore the relationship between IT, science, math, and engineering knowledge and the occupations that involve these skills. They need authentic opportunities to discover and pursue pathways to college and STEM careers.

ITEST provides opportunities for both young people and teachers to build IT skills and knowledge through intensive hands-on science experiences. A description of the program is included as *Appendix A*. The NSF funded *ITEST Learning Resource Center* (LRC) based at the Education Development Center, Inc. (EDC), is designed to support, synthesize, and disseminate the learning from the ITEST program to a wider national audience. Based on the LRC's review of results from ITEST projects' activities, a number of themes are emerging:

- Youth are highly engaged and motivated to learn by inquiry-driven, project-based activities
- Contextual and experiential learning activities allow young people to discover STEM concepts in their daily lives and surroundings
- Educators benefit greatly by collaborating with local STEM experts and institutions
- Real-world experiences and exposure to STEM professionals encourage young people to make linkages between IT learning and IT careers

In 2006, the LRC drafted a literature review focused on the connection between out-of-school activities in informal environments and STEM career choices. The goal of the review was to find out what was known about the ways informal STEM experiences influence how young people make decisions that keep them on STEM career pathways. Overall, the literature pointed to six key factors that connect informal STEM experiences to the choice to pursue future STEM work: (1) expressed interest in pursuing a STEM

career, (2) academic preparation and achievement, (3) identification with STEM careers, (4) self-efficacy, (5) external environmental factors that are barriers or supports, and (6) motivation, interest, and enjoyment (Dorsen, Carlson, & Goodyear, 2006).

ITEST Project Survey

ITEST projects are ideally situated to demonstrate to the afterschool field new programmatic approaches to STEM learning that address these factors and to support young people's journeys toward STEM careers. The challenge, however, lies in how best to replicate the sophisticated and often costly elements of an ITEST experience in the average afterschool environment. A number of pressing questions need to be addressed, to fully understand and build on the ITEST methods and lessons learned prior to sharing them more broadly.

- *What characteristics are central to the ITEST approach to STEM workforce development in afterschool? How critical is the role of STEM professionals as facilitators and mentors? What are the effective ways to coordinate with and use resources of the community?*
- *What do we know about how successful these programs are at guiding young people toward STEM careers? What program design elements most contribute to these outcomes?*
- *How can these kinds of experiences be replicated in a fashion that is scalable and sustainable for afterschool programs?*

Pursuing answers to these questions will leverage the substantial investment made in the ITEST program, creating a new body of literature that can guide educators in cultivating STEM workforce development outside of school. The research agenda described in this report, which explores and responds to the needs of the practitioners, will enable the burgeoning afterschool field to play a much greater role in informal science education and STEM workforce development.

As part of the information-gathering effort leading up to the ITEST Afterschool Convening, LRC staff culled research and data from within and beyond the ITEST Program, including a summary of the most relevant findings from the new management information system (MIS) instituted in 2009. The report prepared from this data was shared with convening attendees prior to the event, and LRC staff presented an overview of the report during the convening. Both the report and presentation are available for review on the private convening website at:

http://afterschoolconvening.itestlrc.edc.org/node/18

The MIS is an annual survey completed by every active ITEST project. The goal of the MIS is to provide comprehensive descriptive information about ITEST projects, including participant characteristics, project descriptions, partnerships, dissemination, outcome objectives, and evaluation descriptions. The MIS fills a gap in data-gathering;

previously, while the NSF required every project to submit an annual report, the reports are not standardized and do not always contain the same information. Moreover, they are not always publicly available. The MIS provides an opportunity for projects to provide standardized information that allows a cross-project summary and a broader, deeper understanding of ITEST projects, their goals, and their impacts.

For the purposes of the ITEST Convening on Afterschool, the LRC looked at data on the 62 projects that work with youth in out-of-school settings and completed the MIS, using the lens of the nine different topics framed in the convening white papers: authentic experiences, motivation, computational thinking, effective models, partnerships, professional development, scaling and sustainability, assessment, and longitudinal research. LRC staff pulled information from the MIS that sheds light on six of those topics:

- Authentic experiences. ITEST projects are reaching their target population of under-represented groups, in terms of race/ethnicity, gender, and socioeconomic status. In 2009, the 49 projects that implemented their programs reached a total of 3,696 youth, an average of 75 youth per project.

- Effective models. The projects include specific components to provide STEM workforce experiences, which vary across projects. Seventy percent of projects identify technology-based learning as their primary way of working with youth; other mechanisms include career skills development (58% identify this as their primary way of working with youth), field work (37%), and youth mentoring (23%).

- Partnerships. Projects are working with a wide range of partners, from academia to industry to community-based organizations, and the partners participate in many different ways, including roles in implementation and recruitment. Most projects have more than one partner.

- Scaling and sustainability. In the area of scale-up, the MIS describes what materials the projects develop and how they are shared. The projects produce and disseminate a diversity of products, including curricular materials, implementation models, and software.

- Assessments. Measuring the impact of project participation on youth participants is a key piece of all the ITEST projects. The majority of projects use pre- and post-assessments of interest and knowledge; other methods include observations, web-based data collection, such as blogs, and embedded assessments.

- Longitudinal research. Some projects are laying the groundwork for longitudinal data collection, to track their participants over a longer time period. Two-thirds of projects solicit contact information for post-project follow-up, and many projects obtain permissions for future data collection.

These observations and general points about the work of ITEST projects are more fully explained, and relevant data is supplied, in the report online.

The MIS did not capture information about all the white paper topics; there were no survey questions on professional development experiences of out of school teachers, motivation (except that it is a high priority to measure in project evaluations), or computational thinking. Note that the MIS collects data at the project level rather than at the participant level. More participant-level research is therefore needed to answer many of the questions of greatest interest to out-of-school time researchers and practitioners about the impact of programs on youth participants. Even so, the MIS results provide background information and a useful frame of reference for the development of the research agenda.

Intended Outcomes

Some afterschool programs, like ITEST projects, already connect young people with STEM professionals who engage them in authentic learning experiences. Integrating other key program design elements with the existing strengths of afterschool could yield powerful STEM learning experiences that have an impact on young people's career choices. With this goal in mind, a group of ITEST project leaders, facilitated by EDC's ITEST Learning Resource Center (LRC), met to discuss how to transfer lessons learned in ITEST to the broader afterschool field. Working in partnership with the National Girls Collaborative Project and MPR Associates, Inc., the LRC proposed a 12-month convening project designed to engage practitioner and research groups working in afterschool programs. The project would host a 3-day event comprised of NSF-funded ITEST grantees and other practitioners, researchers in STEM workforce development and informal learning, STEM industry leaders, and philanthropic organizations. Background on the convening organizers is included as *Appendix B*.

The process of the convening and subsequent dissemination efforts will result in the following outcomes:

- Practitioners and researchers will develop new working relationships based on the connections made at the convening.
- Researchers will pursue funding, from NSF and elsewhere, to launch new research efforts addressing the questions and issues of the convening.
- The ITEST community will better understand how to define, validate, and replicate their out-of-school workforce development strategies.
- NSF Program Officers will be better informed for future program directions and priorities.

The agenda identifies data gaps and clarifies central questions regarding workforce development, pedagogy, outreach, and sustainability as well as targeting ways to adopt and replicate specific ITEST strategies. The LRC will work with the ITEST community and researchers thereafter to promote further research that seeks to answer the questions honed in the research agenda, bringing the deep knowledge and experience of ITEST educators and other experts to bear.

Convening Planning & Activities

A planning committee of STEM researchers, national experts on afterschool, and ITEST principal investigators helped guide the planning, organization, and convening follow-up. Advisors met monthly via conference calls and collaborated online via a Web portal and blog, to review and extend the work of the project team. They worked directly with the project team on the solicitation of white papers, the selection of attendees, the creation of the convening agenda, and the review of all results and publications.

The planning process for the project included culling relevant information from a survey of the ITEST community to help describe current practices, as well as a review of the research on STEM workforce, informal science education, and afterschool practices to help establish an understanding of existing research efforts. A collection of the literature referenced appears in *Appendix C*. The survey included the ITEST community's assessment of accomplishments and current needs as well as results they feel are validated by their evaluation efforts, data gaps, and research challenges to date. This information gathering effort also documented how projects have attempted to share their techniques and resources with others in the afterschool field and how successful those efforts have been.

The project also involved the solicitation and production of nine white papers on topics such as program design, professional development, partnerships, cultural implications, and sustainability, to spark conversation before, during, and after the convening. In advance of the gathering, the white papers were circulated to all invitees, along with guiding questions to help attendees prepare for the event. White paper topics, titles, and authors included:

- **Assessment:** *Broadening Assessments in the Afterschool* **-** Larry Gallagher, Vera Michalchik & Britte Cheng, SRI International

- **Authentic Experiences:** *Voice, Choice, and Participation: A comparative look at youth STEM experiences in and out of school* **-** AnnMarie D. Baines, Shelley Stromholt, Déana Scipio, Philip Bell, and Andrew Shouse, University of Washington

- **Computational Thinking:** *Examples of Computational Thinking in the K-12 Experience* - Irene Lee, Santa Fe Institute and Joyce Malyn-Smith, ITEST Learning Resource Center at EDC

- **Effective Models :** *Imhotep Academy: Photonics Pre-college Program Model (3PM)* **-** Joyce Hilliard-Clark & Pamela Gilchrist, North Carolina State University

- **Longitudinal Research:** *The continuum of participation in meaningful, purposeful out of school experiences mediating identity development as STEM learners, consumers and producers* **-** Jennifer Adams, Brooklyn College & Preeti Gupta, New York Hall of Science

- **Motivation:** *Motivated by Challenge or Challenged by Motivation? Insights on Engaging Youth in STEM Learning Experiences* **-** Irene Porro, MIT Kavli Institute for Astrophysics and Space Research

- **Partnerships:** *Role Models Matter: Promoting Career Exploration in After-school Programs Or If it's Worth Doing, It's Worth Doing Right* - Linda Kekelis & Jennifer Wei, Techbridge

- **Professional Development:** *STEM RAYS: Researching the Role that Strong Teacher Preparation and Authentic Science Research Play in OST Program Effectiveness* **-** Marie Silver, STEM RAYS

- **Scaling & Sustainability:** *Planning for Scaling and Sustaining Afterschool STEM Programs* **-** Melissa Koch & William R. Penuel, SRI International

White paper abstracts are included in the final section of this report.

The project team and advisors worked together to identify a representational group of 75 attendees, using a selection criteria that took into consideration their prior work and the contribution that they could make to the proceedings, at the same time ensuring a broad representation of stakeholder communities. Attendees were drawn from both within and beyond the ITEST community. A full list of attendees is included as *Appendix D*.

An attendee website was also created to house all convening materials prior to the gathering, including copies of the white papers, background on all attendees, goals, and intended outcomes for the convening and other logistical information. Participants had the opportunity to make comments and engage in discussion prior to and after the event via the site.

The convening took place over two and a half days in June of 2010 at the Science Museum of Minnesota. The project team endeavored to create a relaxed, working environment where participants could step away from the day-to-day management of their respective projects and work together toward common interests. The team loosely based the structure of the event on the Wingspread conference model developed by the Johnson Foundation (http://www.johnsonfdn.org), bringing together a "diverse group of individuals to define a problem clearly, create plans for its solution, and build collaborations for effective action." A detailed agenda for the convening is included below as *Appendix E*.

Participants were asked to attend the proceedings for the entire duration, as each invitee was given a role to play. Authors of white papers shared their key points while others were asked to function as respondents from common or opposing perspectives. ITEST project principal investigators shared observations from their work as well as key findings from their project evaluations. Representatives from afterschool intermediaries reported on the state of STEM programming and the overall capacity of the field,

especially with regard to professional development. Participants from industry spoke to their capacity to support these kinds of informal learning experiences and the skills they need to see fostered in future STEM workers. Researchers were asked to synthesize these varying perspectives with their own understanding of current research efforts to propose real strategies to better measure and document effective program models.

Another framing element for the convening was the use of reflection teams. The reflection teams were designed to provide opportunities for participants to meet in small groups and share with colleagues their perspectives on the topics being addressed throughout the convening. The intent was to give every attendee the opportunity to influence the content of the research agenda. Small groups of 7-9 participants met three times over the course of the convening. A team leader for each group was assigned to guide the reflection process, to encourage everyone on the team to share thoughts and ideas, and to aid the team in collectively sharing recommendations for the overall research agenda. In the end, each team was asked to create a "poster" that highlighted their conversations and best ideas, and conceptualized an approach to advance research around STEM workforce development in afterschool.

As it is central to the goals of the ITEST program and the work of NSF, a special emphasis was placed throughout on the impact this kind of work can have on underrepresented groups in the STEM workforce – women, minorities, and persons with disabilities. Most, if not all, attendees are in some way working to advance STEM workforce development or afterschool learning for underserved populations, and planners encouraged discussions to explore the needs of these populations. To further support discussions of diversity and equity, we selectively used discussants or respondents throughout the various sessions who could speak directly to the needs of underserved groups. The goal is the formulation of a research agenda that not only charts a way to promote STEM workforce development in afterschool but also ensures that resulting discoveries and strategies truly address underserved and underrepresented groups.

During the months following the convening, project staff reviewed, analyzed, and synthesized the discussion topics, central research themes and questions, and recommended methodologies to create the research agenda presented at the beginning of this report. Artifacts from the convening are available online at:

http://itestlrc.edc.org/afterschool-convening

Evaluation & Dissemination

An evaluation is being conducted to determine the impact of the white papers, research agenda, and other products on the afterschool and STEM education fields. Working with our evaluator, the project team intends to capture and assess our effectiveness in each of these areas, using observations at the gathering, content and discourse analysis, and follow-up data collection methods including phone interviews and online surveys to track perceptions of the effectiveness of the research agenda and resulting

research proposals and funded projects. These findings will be shared via the LRC and serve to promote the advancement of research and practice related to STEM workforce development in afterschool.

The convening planners believe that a well crafted research agenda – one created collaboratively between practitioners in the afterschool field and researchers dedicated to defining STEM workforce development – includes compelling questions for exploration, existing knowledge to inform strategies, effective methodologies used in similar efforts, and ultimately, the buy-in of all stakeholders. More than just "getting the word out" about the gathering, we expect each attendee to move the research agenda forward in some fashion through their own work and/or in collaboration with other attendees.

For our part, we intend to advance the research agenda in our work through the LRC. This will likely involve integrating recommendations into the LRC MIS currently under development, informing the future direction of the ITEST Afterschool working group, re-convening attendees at the future ITEST Summits to share resulting work, underscoring the research agenda in LRC publications, and conducting additional surveys of gathering participants one or two years out to measure the extent to which they are following through on their promises.

Key Themes, Issues & Questions from Convening Discussion

The convening sessions (see *Appendix E* for full agenda) were designed to provoke in-depth thinking around issues related to STEM workforce development in afterschool, with participating researchers, practitioners, and others in attendance serving as presenters and respondents throughout the gathering in order to facilitate ongoing exchange and cross-pollination of ideas. Key themes and points of inquiry emerged and recurred in the course of the discussions, such as the central role of identity in youth outcomes and the high degree to which parents, family, and community influence students' career aspirations.

The research agenda converts these various points and questions into a set of recommendations for the field regarding future studies on STEM workforce development experiences in afterschool. Comments and questions captured during the convening coalesce into the three main recommendations detailed in the research agenda, and a summary of the discussion and key points underpinning each recommendation follows. The organizers appreciate the individual contributions of attendees, which are reported collectively in this section.

1. Future studies should describe STEM workforce development experiences in afterschool.

Workforce Development

Attendees sought greater clarity on what the STEM workforce actually is – i.e., how the STEM professions are defined, what skills are needed, and what changes as technology changes. They have a number of questions about skills and content:

- Is technology such a major skill that we need to help people learn differently for workforce development?
- How do we integrate math into programming?
- Does computational thinking need to be taught, or is it happening already? How can we achieve it without expensive programs?
- Should social skills be explicitly taught in STEM workforce programming?

As a group, attendees pondered what it means to be intentional about workforce and what that workforce piece might look like, especially in the early grades. They asked: What are the precursors for workforce development with regard to young students? What are the outcomes that indicate students have the necessary skills and knowledge to go into a STEM field if they choose? It was argued that the message to youth has to be 'these are the skills you need to keep your options open later on.' One member of the group formulated this question as a possible point of inquiry: "How do we strengthen workforce development so that kids are more intentional with their decision-making and make choices tied to careers?"

As companies increasingly see the value in diversifying the workforce and workforce development efforts, one suggestion was to bring to the table others who benefit. For

example, ask employers, what are you looking for from your workers? Attendees advocated that, when afterschool programs and STEM professionals connect, program staff should be seen as making a valuable contribution to this overall effort – not just needing scientists to fill a hole in their programming.

A lingering question involved appraising practice: How do we evaluate workforce development efforts? In particular, what does success look like? To be scientifically active as a citizen can be a measure of success, some attendees noted. But what is the right balance of youth development and STEM content to build a science-literate society? What is the recommended dosage and exposure? Or, if the intent is strictly focused on building the STEM workforce, what's the dosage and exposure for that? Determining how to strike this balance between STEM content and youth development within the context of NSF's funding initiative animated discussion among the researchers, practitioners, and other stakeholders in attendance.

Positive Youth Development

Promoting research that comes from a positive youth development point of view was held as a prerogative of the group – as a way to present a positive picture of STEM OST and to help the field improve. However, tension around the ultimate goal of this OST STEM initiative persisted throughout the convening. This is one way it was framed: Is the goal to expose young people to STEM and STEM careers, so that their choices aren't limited? Or is it that adolescence is an important time for positive youth development, which gives youth the foundation to make informed decisions?

That debate aside, other questions were raised about how to share and integrate best practices in youth development, and what types of positive youth development measures can be used. In addition, attendees discussed how programs could negotiate the barriers associated with a culture that often discourages innovation and youth voice. Asked about the connection between youth voice/choice and agency, one presenter responded that they look at it in terms of an individual's relationship to context and people around them and whether they have the right to act, are positioned to act, and are invited to participate, i.e., Do I have individual power to act? Empowering youth so that they feel this sense of agency takes various program supports, which led attendees to query what types of partnerships and bridges can be built between institutions in order to boost students throughout their lives. You have to look at the lives of students, one member of the group declared.

Connection to School Day

There were different perspectives on how afterschool could be connected to the formal school day – or whether it should be. NSF Program Officer Sylvia James noted that ITEST projects link to standards and that the Center for AYS has data on how afterschool programs improve outcomes in school. The group discussed how OST strategies might translate into the formal day, and various ways that the formal and informal spheres can inform and support one another. Service learning was cited as a

model for this connection; service becomes a text for the learning. Attendees held that partnerships between informal and formal teachers give teachers more strategies and enable them to learn different ways of recognizing intelligence. It was argued that this creates different sociocultural values and more equitable learning environments.

While supportive of relationship-building and connection between schools and afterschool programs, one attendee submitted that, ideally, in a new world, there'd be a meeting in the middle – an effort to give kids what they need when they need it. Recent research around learning ecology dovetails with that concept, as researchers seek to record free choice learning (whether in school, OST, online) to show how a student learns throughout their days. Clearly, at this point in time, some attendees are against explicitly tying afterschool to the school day. A couple of their pointed questions include: How can school catch up with the informal learning setting? Why can't school prove to us that they should be connected?

Unique opportunity for STEM in OST

The opportunity to define what expanded learning time should look like, to re-envision the day, was compelling to the attendees. They demonstrated a general commitment to the idea that OST is and should be different than in-school. For example, on their poster, one group recorded a set of underlying assumptions - that STEM OST programs:

- Can provide access to experiences that are not commonly available through formal education.
- Allow students to succeed in areas that they do not commonly succeed in formal education.
- Can provide opportunities for building interest, motivation, and scientific identity that formal education does not normally afford.
- Provide opportunities for building social capital.

In addition, attendees value out-of-school time as a special place to engage youth in real world STEM experiences.

A presenter shared research that shows youth keep coming back to OST programs when their experiences in them are meaningful, integrated, and support personal development. Attendees noted that OST learning isn't bound to standards – more about habits of mind – and a few in the group wondered whether it makes sense to set a learning progression, create new standards. One of the key questions that arose was, how do time, freedom, and choice – hallmarks of afterschool – contribute to this thinking/learning? Some aspects of OST STEM lead to other (non-career) outcomes, and the group considered what other outcomes should be pursued (i.e., lifelong interests, citizenry, other jobs such as teaching). The capacity of afterschool was also a focus, and attendees mulled questions like these: How will technology play a role in extending what we do in OST? How much can out-of-school time really take on?

Engaging Partners

The various dimensions of involving stakeholders cropped up repeatedly in the course of discussion. One attendee shared these suggestions for deliberative, constructive planning in program design: Think about what you want your innovation to be, but also about the community and where you are. Step back; figure out who are the right partners. Sit down early with program people as well as local officials. Make ownership not just the program but the whole process.

The group discussed key roles that partners play and what makes for effective partnerships. They noted it's important that program partners have leadership who buys in so that role models are supported in taking the time to volunteer. A focus of discussion was how to assess partnerships, including the impact of partner activities on youth and, conversely, the impact on businesses and professional organizations that are serving as partners. Attendees talked of striking a balance between supporting partners, corporate volunteers, etc., and letting them bring their own passion. A couple of the questions that resonated, that gave attendees food for thought, were: How do we be good partners so others want to partner with us? How can relationships be sustained over time?

Staff/Mentor Development

Getting a complete picture of what youth development staff are already doing was important to the group. This would help clarify the core issue – that is, what are the essential competencies for OST staff working in STEM programs? Attendees were interested in learning what to invest in, i.e., the cost-benefit of staff experience vs. expense. One of the presenters acknowledged it's expensive to pay their teachers (school day staff), but it's the relationships students have with the teachers that keep them in the program. It's all about creating a STEM professional that knows how to motivate and facilitate, said an attendee. But the motivation has to be there for staff to want build these skills, to want to be developed. This might take institutional change.

Creating an education workforce around STEM and/or a youth development workforce around STEM can happen in different ways. One attendee envisions a new kind professional – someone whose credential would be youth development as the content area. She referred to a pedagogue, a credential in the Scandinavian model; they learn youth development. This person occupies a different role from teachers. Professionalizing the field is happening, she notes. Attendees support applied research, a study of various models for professional development to gauge which models work for whom and how. One possible question being, what's the model that allows for a full-time OST professional?

A lot of the same questions might be directed at mentors who participate in programs. What motivates mentors? How in a large system can you train volunteers about working with youth? As one case in point, Techbridge helps define goals for the role model. Techbridge's training and support is crucial; they take feedback from students to

guide the work that the role models/mentors do. As with other collaborations, attendees talked about the need to build in time for reflection for youth and role models, in part to tease out valuable elements that would inform the model for training and support.

Performing Assessments & Measuring Impact

Attendees agreed that assessment really forces the conversation about what's going on with the learner. Talk turned to what, then, the field must do to move forward in assessing student learning. To answer their questions – i.e., how do we get to more valid measures? How do I elicit the learning that's important to the students/program, and portray it to funders? – attendees underscored the need to identify and put resources into efficient assessments that "we all think matter," that have credibility with funders, etc.

Evidence-centered assessment design was presented with the explanation that there's a sweet spot wherein an activity used for assessment is minimally disturbing, efficient, and participant-centered. Beyond consulting outside evaluators for assessment, participants in a community of practice can be tapped for peer knowledge. Participants often know who can do what, and attend to the knowledge/skills relevant to the situation at hand. Following naturalistic assessment practice, presenters advocated finding ways to document students using their skills, building relationships with other youth and adults, and exhibiting the qualities that the program is designed to promote. It was urged that students help define what success is, and help design their assessments. A new idea gaining traction is that youth own and have control over a portfolio, which shows their progress in school and OST activities as well as family experiences.

We frame too much of our work in school learning language, one of the researchers in attendance admonished. She advised that we need to develop language to capture the wide array of things we know are important (i.e., tinkering). Attendees exchanged strategies and ideas for how they convince people with a hard science background of the validity of participatory research.

To identify evaluation and assessment models that have worked in afterschool settings, the group thought a synthesis or meta-analysis would be valuable. They envisioned converting consistent, generalizable findings (i.e., ITEST elements of success) into guiding principles that could drive assessment and help measure impact. Whether addressed in a review of the existing research or in new investigations, these emerged as a couple of the essential questions for the research agenda: What is the impact of a learner's culture or environment? How do we track students over Pre-20?

2. Future studies should investigate the role of the participants' culture and context.

Serving Underrepresented Groups

Engaging more youth from groups traditionally underrepresented in the STEM workforce is fundamental to NSF's ITEST Program. Attendees at this convening sought data to answer the basic questions about who is targeted, recruited, and served in OST STEM programming. "How can we get to a body of evidence," they asked, "that's both broad and deep in terms of who we're reaching and how?" Further discussion explored why youth stay or leave programming, and what works to motivate different types of students (i.e., self-selected vs. unengaged).

Key questions about engaging youth arose throughout the convening, including: How do youth perceive programs? What types of experiences do we need to make more pervasive so that there's an equal playing field? How do we foster that kind of community that leads to a particular experience? Attendees recommended looking at culturally relevant strategies for motivating youth and weighing essential ingredients, such as a safe, supportive environment for learning, youth development approaches, and scaffolding.

The ability to visualize oneself in the STEM field was identified as a clear challenge – an equity issue – for minorities and women who don't see STEM professionals like themselves. Attendees spoke to the importance of setting up nurturing relationships and pathways so that there are multiple entry points to allow for youth who fall off the path. The pathways model was supported as being effective for underserved populations.

Identity

The issue of identity surfaced many times, in different contexts, throughout the gathering. They proffered questions for study: How do you ask about identity? How did the specific set of experiences in afterschool help develop student identity? What parts of these authentic contexts are working to help students form their identities? Ascertaining the impact of various factors in an afterschool program begged the question, how can we record the changes in identity as a result of programming? They calculated that understanding the learning ecology of the whole student would inform such an inquiry. In addition, they wondered whether a student's learning ecology impacted his/her entry into the workforce as a critical thinker or as a scientist.

Beyond exploring how identity formed, some convening attendees were interested in discovering how to shape it, i.e., How can I help a child identify themselves as a critical thinker, actualized problem-solver in whatever realm they're in? Independent of whether or not program participants eventually become scientists, they were concerned that youth know these possibilities and identities are out there. A member of the group asserted students should have permission to shift identities, i.e., school identity vs. job identity. The broader question, a research question, followed: How can we maximize the variety of identities that can be developed – and not exclude?

A key topic in the presentation on Authentic Experiences, the concept of "learning identity" was established not as something to be achieved, but ever shifting. A moving

target, such as it is, attendees asked, when does learning identity happen, where, and how does one come to it? What factors shape it? One presenter suggested what tenets could guide an inquiry into STEM learning identity[1]:

- Culture of science
- Successful interactions with science could build positive science-related identities
- Identity in practice recognizes that identity development is shaped in activity and in relation to others
- Learning and identity development is an embodied practice of being and learning in a particular environment or context
- Learning how different science-related identities develop and are enacted in different contexts

Role of Parents/Families

The important role played by parents and families in OST STEM efforts was a recurring theme in the sessions – and not entirely expected. Attendees emphasized that the career development process begins at home, is nurtured over time in school and in the community, and, at some point, individuals translate skills and abilities into a job. Parents that are encouraging and excited about science, regardless of content expertise, greatly impacts whether or not their child goes into STEM field. For example, research was cited that found the expectations and exposure provided by her family and school represent the number one factor of whether a girl will pursue STEM. In rural communities and reservations, parents can see their children getting careers and that encourages them to motivate their children.

To determine how to involve parents most effectively and what interventions are successful with families, the group looks to the current research. They're interested in what families may already know about good STEM education, and what strategies can be employed to engage parents in children's STEM activities. Making a program attractive to both students and parents can be pivotal. A number of questions emerged in the discussions: How do we involve parents/families in the recruitment and learning process? Should families be reached out to as first step? Who – student or parent – has to get motivated first? And, what long-term supports do families need?

3. Future studies should follow impact over time.

Longitudinal Research

Determining what it takes to interest, engage, and sustain youth participation in STEM over a long period of time; building youth capacity through their long-term engagement; and designing scaffolded programs were offered up as critical areas to investigate as part of the research agenda. Because some programs focus on more immediate impact (i.e., providing a good youth development experience) as compared to the longer term goal of workforce development, it is complicated to identify the salient questions and

[1] This material was presented by Jennifer Adams from Brooklyn College, drawn from the white paper she co-authored with Preeti Gupta of the New York Hall of Science.

points of inquiry. One attendee advised that a theory of action is essential, and posed these questions:

- What's the desired impact (i.e., youth becoming a science major)?
- What evidence supports the theory of change?
- What's the best tool to collect this? How are we accounting for what is happening at school, home?

It was noted that the ISE Request for Proposals asks applicants to think across the learning infrastructure in planning their programs and interventions. Attendees debated how best to devise research questions – and a comprehensive research agenda – that taps into these interconnections, this learning infrastructure. There was a call for both basic and applied research questions, and, especially, longitudinal studies. Attendees agreed there should be a series of longitudinal studies, very purposefully conducted in different communities and designed so that there are common measures and approaches to facilitate comparisons. The group discussed the need to develop realistic goals, intermediate outcomes, transition points, and scaffolding. Among the challenges in this type of research effort, attendees cited issues such as: How do you reconcile self-selected participants with the wider population? Does being studied impact future decisions? What constitutes failure at the end of a longitudinal study?

Addressing these questions, and the host of other issues associated with this broad-based initiative, was a vital function of the convening, and attendees engaged in problem-solving throughout. For instance, one person articulated the need for coherence from the practitioner field as well as the evaluation and research fields – that is, an agreement on a shared goal and some similar ways to get there. Another attendee advised contextualizing the successes and failures of OST, and contrasting them with another youth experience. It was suggested that we should consider a larger research effort (i.e., looking at not just afterschool or museum settings, but all informal spaces). However, the demands of these efforts in terms of costs, human resources, and logistics were frequently acknowledged. Funders have the tools and infrastructure to do longitudinal studies, attendees noted, so, they asked, How do we make the case for why it is important to fund longitudinal research?

Sustaining & Scaling Programs

Think about sustainability and scaling from the beginning of the program design a presenter told the group. The framing of the program needs to change as time goes on, to allow it to evolve. Attendees observed that working on sustainability in different contexts (i.e., rural, tribal communities vs. urban centers) posed different challenges. A model developed by researcher Claudia Weisburd, a convening attendee, was put forward as a useful theory/framework to approach scaling and sustainability.

Attendees shared other recommendations, insights, and admonitions throughout discussion of these issues. It was advised that a program should start at the appropriate scale, aligning the intervention with organizational capacity, and then

expand organizational capacity going forward if warranted. That is, scale what works. And, how do we know it works? How do we expand it? The following were offered as the important questions:

- What is being scaled?
- What is the objective?
- What are the long-term outcomes you are seeking?
- Who is driving the scaling?
- Who is responsible for scaling? Do they have the capacity to do it?

A couple of the key issues under discussion involved ascertaining the scalability of STEM curriculum and models, and determining how best to integrate STEM into existing programs. Scale-up is a change process model, argued one member of the group, not a replication model. Organizations should ask, how could this be enhanced to elicit creativity in adaptation of a program model? Finally, attendees wondered how do you evaluate scale-up? What are the challenges?

Making the Case for OST STEM Workforce Development

The group perceives a gap between what they know and think, and what policymakers are hearing. They questioned the implications of this gap, and what needs to be shared with policymakers to redress it. There was consensus around targeting policymakers and scientists as audiences for the work. Moreover, attendees advocated addressing the youth themselves as an audience. That is, communicate why we want them to be engaged in STEM in the first place – especially if they're going to be research subjects. Further, it's important to know why this is valuable, why this outreach is important. A few key points to consider include:

- How do you communicate what you do in your program so that it's adaptable/replicable somewhere else?
- Outreach effort has to do with parents, but it's about the environment too, targeting
    - Parent, teacher, community
    - Also, cultural context
- A comprehensive outreach effort makes for a more successful program.
- Attendees highlighted national conferences that bring people together, talking across the states.
- Is anyone working on sustainability at state policy level? What we need to sustain is the notion of afterschool STEM. How do we do that as a collective community?

Attendees concurred there is a need to challenge the perception that federal STEM workforce programs are redundant. They discussed how to illustrate and prove these programs are not redundant, i.e., identify the minimum publishable units – as a microbiologist in attendance suggested.

- Publish/disseminate to communicate why variation is not the same as redundancy. Variation of programs is important to a rich educational ecology.

- We're publishing what works - how do we communicate what doesn't?

To successfully make the case for and implement OST STEM workforce development programs, the group pressed for answers to key questions, including: How do we know *who* the right stakeholders are? How do we work with policymakers to achieve goals? How do we get stakeholders at all levels to understand each other's goals?

White Paper Abstracts

This section includes abstracts of each of the nine white papers presented at the convening. The full set of essays will be published collectively in a forthcoming journal.

Authentic Experiences: *Voice, Choice, and Participation: A comparative look at youth STEM experiences in and out of school*
Authors: AnnMarie D. Baines, Shelley Stromholt, Déana Scipio, Philip Bell, and Andrew Shouse, University of Washington

Abstract: This white paper leverages data from two ethnographic studies supported as part of University of Washington's Learning in Informal and Formal Environments (LIFE) Center to inform research and development of informal science learning environments for groups underrepresented in STEM. Although one study focuses on high school youth in an informal science apprenticeship and the other on high school youth with disabilities across everyday settings, they both examine how students develop identities around STEM disciplines in settings outside of school. Students are interviewed and observed across a variety of contexts to determine how these different experiences either support or discourage interest and motivation in STEM-related subjects.

Motivation: *Motivated by Challenge or Challenged by Motivation? Insights on Engaging Youth in STEM Learning Experiences*
Author: Irene Porro, MIT Kavli Institute for Astrophysics and Space Research

Abstract: The task presented to us is to identify what factors support young people engagement in STEM learning and pursuit of STEM career pathways. To this end I present a summary of relevant information - statistical data, results from research and experience derived from an actual STEM program - and personal considerations to be used as discussion starters. A focus on older youth populations underrepresented in STEM seems especially important and it may well provide insights for how to promote STEM learning experiences among the whole population. Ultimately this paper aims to foster a conversation that is not only inter- and cross-disciplinary but also trans-disciplinary in order to critically examine and ultimately discuss the causes of both a shortage in the nation's STEM workforce and a lack of diversity among its people.

Computational Thinking: *Examples of Computational Thinking in the K-12 Experience - Adapted from the ITEST Working Group CT White Paper (authors in alphabetical order: Walt Allan, Foundation for Blood Research; Bob Coulter, Missouri Botanical Garden; Jill Denner, ETR Associates; Jeri Erickson, Foundation for Blood Research; Irene Lee, Santa Fe Institute; Joyce Malyn-Smith, ITEST LRC at EDC; Fred Martin, University of Massachusetts Lowell)*
Authors: Irene Lee, Santa Fe Institute and Joyce Malyn-Smith, ITEST Learning Resource Center at EDC

Abstract: Several years ago a working group of ITEST Principal Investigators posed the question: What do ITEST youth know and what do they do with technology? We found that ITEST youth were using a wide variety of technology tools and systems, from simple to highly sophisticated; and many to high degrees of skill. As we dug deeper we began to explore the impact this use of technology had on youths' patterns of thinking, processing information and problem solving. We began to discuss some of the commonalities we were observing among the ways youth approached problems and used computational tools/systems to develop various solutions. We talked about this as a type of technologically enabled and enhanced thinking. About the same time Jeannette Wing's article on Computational Thinking was published in Communications of the ACM (Wing, 2008). We found the concept of Computational Thinking (CT) closely aligned to what we were observing in the behavior of participants in our projects, and began to discuss our observations in light of the CT framework. Over the past 18 months the working group (renamed CT Working Group) of ITEST Principal Investigators and others explored youth's computational thinking within ITEST and other NSF EHR programs. This article summarizes the group's findings including a framework that identifies youth's computational thinking trajectory, and shares examples of what CT looks like in action in EHR projects.

Effective Models : *Imhotep Academy: Photonics Pre-college Program Model (3PM)*
Authors: Joyce Hillard-Clark & Pamela Gilchrist, North Carolina State University

Abstract: Imhotep Academy is a science learning and career exploration pre-college program at The Science House-North Carolina State University for middle and high school students from groups underrepresented in the sciences and engineering. Our goal is to prepare students to take advanced mathematics and science courses throughout high school and to mentor students throughout their secondary and postsecondary experiences. To achieve this goal, the program model integrates practical and theoretical strategies to prepare students for the global workforce and college enrollment. The Photonics Pre-college Program Model (3PM) guiding principles and program outcomes are presented in this white paper to justify using a participatory approach to equip students and to empower teachers, STEM professionals and parents to address the demands of our technologically driven society.

Partnerships: *Role Models Matter: Promoting Career Exploration in After-school Programs Or If it's Worth Doing, It's Worth Doing Right*
Authors: Linda Kekelis & Jennifer Wei, Techbridge

Abstract: Role models can play a critical role in helping inspire students in science, technology, engineering, and mathematics (STEM), expanding their options for the future, and providing guidance on how to successfully prepare for a professional career. After-school programs are an ideal venue for introducing role models who can transform excitement from a hands-on project into a career interest in STEM. In this white paper we will share the resources and best practices from the Techbridge program on

partnering with industry and academia on outreach. We will also share lessons learned and challenges involved in outreach and raise questions about next steps needed for promoting workforce development in after-school programming.

Professional Development: *STEM RAYS: Researching the Role that Strong Teacher Preparation and Authentic Science Research Play in OST Program Effectiveness*
Author: Marie Silver, STEM RAYS

Abstract: Can authentic research-based science in an after-school setting lead to students and teachers who think of themselves as scientists and as someone who knows about and contributes to science? Answering this question is the goal of STEM RAYS (Science, Technology, Engineering and Mathematics Research Academies for Young Scientists.) and has guided the University of Massachusetts and its partners in their research as they worked with over 25 classroom teachers and 800 students in the Connecticut River Valley region of Massachusetts. STEM RAYS challenges teachers to work alongside college science research faculty and engage a group of after school students in ongoing research at their school during the academic year. STEM RAYS can be an instructive model for OST science at school sites using experienced classroom teachers leading groups of students in science research clubs. Understanding and leading authentic science research is the keystone of our teacher professional development and a major strength of the STEM RAYS model. Each club has up to 12 elementary or middle school students in grades 4-8 working with one classroom teacher. Prior to the program start, teachers are trained by college faculty in their area of science research. Time is spent in these training sessions learning the basic science and in the lab learning necessary techniques. No set curriculum is provided, except for example activities to teach basic concepts. Teachers lead their clubs for one year in a science research question (or questions) connected to research of the mentoring faculty. Some have science backgrounds and most have a history of supportive and engaged relationships with students. College faculty train and mentor the teacher leaders, meet with them monthly and keep in email contact, visit the clubs several times throughout the year, host campus visits for the clubs and serve as role models for both students and teachers.

The results of our research and evaluation indicate that STEM RAYS can be an effective model for achieving both student and teacher development as scientists. Surveys asked teachers to rate their research skills, identification as scientists and understanding of the nature of science at the beginning of their involvement in STEM RAYS and again at the end of the academic year; the results showed significant gains in almost all areas. Parent studies indicate that students increased their understanding of the nature of science and the particular topics studied, increased their interest in science careers and their identification as scientists.

Issues that remain to be addressed include (1) the cost/benefit of using higher paid teachers in OST science programs, (2) long-term impacts on student and teacher interest in science and student interest in science as a career, (3) the sustainability of a

college faculty driven model of authentic science research and (4) the role of student self-selection in the success of this model. It would also be interesting to compare and contrast the model of year-long, teacher–led authentic science research to kit-based or curriculum-based programs using staff with less science and classroom experience.

Scaling & Sustainability: *Planning for Scaling and Sustaining Afterschool STEM Programs*
Authors: Melissa Koch & William R. Penuel, SRI International

Abstract: This paper develops a sustainability framework for afterschool STEM programs. The framework draws primarily from research on supports needed to scale and sustain innovative programs in schools. It also addresses challenges to and strategies for promoting sustainability unique to the afterschool context. The framework highlights that, to achieve implementation depth and program evolution, programs must be designed with usability in mind. Designers must consider up front the capacity of the organizations that will be implementing the program. We present illustrations of five successful strategies afterschool STEM programs have used to achieve scale and sustain themselves: (1) achieving depth through co-design; (2) achieving spread through partnerships; (3) developing ownership from the beginning rather than transferring ownership; (4) sustaining programs through professional development infrastructure; and (5) developing and aligning frames to allow programs to evolve. This paper concludes with a call for developing credible plans for sustainability in program proposals and for more research on scaling and sustaining afterschool programs.

Assessment: *Broadening Assessments in the Afterschool*
Authors: Larry Gallagher, Vera Michalchik & Britte Cheng, SRI International

Abstract: This white paper discusses some of the key difficulties in assessing learning in the out-of-school time settings, focusing on afterschool programming designed to engage students with STEM concepts and practices. The paper notes the importance of assessing learning in afterschool environments in ways that can meet the criteria for informal STEM assessment set forth in the recent NRC volume on informal science learning. The authors outline a three-part typology of assessment types for consideration in relation to afterschool STEM and describe an approach through which *naturalistic assessment* practices—participants' own on-going judgments of who can do what—can be leveraged to serve the learning, programmatic, and documentation goals of afterschool programs. The authors also posit that the development of an afterschool research agenda with serious implication for STEM workforce development has to take into account the importance of STEM learning practices and outcomes that extend beyond traditional notions to target interest, identity, and the symbolic and experiential potency of being a legitimated participant in STEM-related activities. Overall, we offer that the appropriate assessment approach for the afterschool should function naturalistically as part of the learning practices that advance participants along trajectories towards outcomes that serve personal and social needs and simultaneously

should allow for documentation sufficient to capture the strengths and successes as well as the points of improvement needed to improve programs and better support their participants.

Longitudinal Research: *The continuum of participation in meaningful, purposeful out of school experiences mediating identity development as STEM learners, consumers and producers*
Authors: Jennifer Adams, Brooklyn College & Preeti Gupta, New York Hall of Science

Abstract: This white paper presents a case for a research agenda around the continuum of youth participation in out-of-school programs in an informal science institution and its implications for STEM workforce development. Applying a theoretical framework of identity development in collaborative practices, we argue for a research agenda that examines how youth participate in science-related out-of-school activities during a span of their K-12 years and how this shapes identity in and motivation to pursue science related activities and careers. The following questions frame our discussion: how does long-term participation in out-of-school programs at an informal science institution shape science-related identities? How does youth participation in out-of-school change over time (with changing identities, interests and level of engagement)? What keeps youth participating in these science-related out-of-school activities and how could this contribute to increasing the numbers of immigrant/underrepresented people in the STEM pipeline? Using the New York Hall of Science (NYSCI) as a context, we examine the participation of youth (elementary, middle and high school students) beginning with the Afterschool Science Club and continuing into the nationally replicated Explainer program for high school and college students. We end our whitepaper with a discussion of implications for research and funding policy.

Appendix A: ITEST Program Snapshot

A new generation of innovations depends on a new generation of innovators.[1]

For America to continue to lead the world in science and technology innovation, it must have the most knowledgeable and skilled workers in the world.[2]

The most powerful computing systems in the world are in the United States, but America lacks sufficient numbers of computational scientists to fully realize its leadership position.[3]

The Innovative* Technology Experiences for Students and Teachers (ITEST) program was established in 2003 by the National Science Foundation to address the looming shortage of technology workers in the United States.

The ITEST experience—including 161 projects across 39 states—helps young people and teachers build the skills and knowledge needed to succeed in a technologically rich society.

ITEST impacts more than:

- **189,800 K–12 students**
- **6,800 educators**
- **2,000 parents and caregivers**

ITEST participants become scientists, engineers, and technologists exploring the frontiers of knowledge using the same innovative technology as STEM professionals:

- Using **GIS technologies and scientific modeling in an IT-rich engineering environment**, 70 students, 20 parents, and community leaders in Lansing, Michigan, engage in field experiences to investigate the need for and design of **green energy technologies that matter to cities**. Using **digital media tools**, they communicate community-relevant outcomes they developed together.
- In the Pacific Northwest, 125 high school teachers and their 3,750 students, along with 90 scientists and 15 career counselors, use **DNA sequence alignment tools, molecular visualization software**, and **gene expression analysis tools** to learn about bioinformatics careers and **to conduct research**.
- In North Carolina, 70 math and science teachers and 70 students work in teams with business partners using **critical and analytic thinking, information technology skills,** and **mathematical principles** to solve challenging real-world business problems.

Untapped potential . . .

A diverse pipeline will increase our ability to discover, create, innovate, and adapt.

Women and minorities remain underrepresented in science, technology, engineering, and math (STEM) occupations:

Women constitute just 26% of the STEM workforce, compared to 47% of the overall workforce. African Americans make up only 6% (compared to 11% of the overall workforce), and Hispanics account for a little more than 5% (less than half their share of the overall workforce).[4]

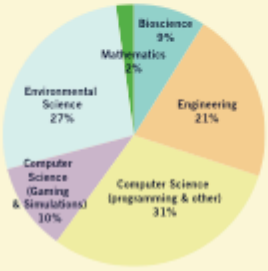
"I Am a Scientist"

Young people ages 5–18 use sophisticated technology to explore their environment, conduct research, build programmable machines, and create media in community settings after school and during the summer. Across all ITEST projects, youth are using the same technologies, tools, and methods that scientists use on the job.

Authentic Learning

Teachers work together with students to pursue research questions and deepen their scientific and technological expertise—and learn strategies for integrating IT concepts, skills, and applications into their classrooms. Teachers are learning the strengths of combining formal and informal learning environments together to create authentic learning experiences for their students.

Primary Focus of Projects



ITEST Projects Increase STEM Learning and Career Exploration

Now in its seventh year, the ITEST program funds a variety of innovative projects. **Strategies** projects design, implement, and evaluate models that engage youth, educators, and often other community members in STEM-rich, contextual learning experiences. **Scale-Up** projects take proven practices and expand them to engage larger populations of learners. **Research** projects enrich our understanding of how to enlarge the country's STEM workforce. **Conferences and workshops** contribute to the development of a research agenda on K–12 STEM workforce preparation and development issues, workforce participation, and cyberlearning.

1) Obama, B. (2009). *Remarks by the president on innovation and sustainable growth.* Speech delivered at Hudson Valley Community College, Troy, NY. Retrieved September 27, 2009, from http://www.whitehouse.gov/the_press_office/Remarks-by-the-President-on-Innovation-and-Sustainable-Growth-at-Hudson-Valley-Community-College/.
2) National Economic Council. (2009, September 20). *A strategy for American innovation: Driving towards sustainable growth and quality jobs.* White paper). Washington DC: Office of Science and Technology Policy. Retrieved from http://www.whitehouse.gov/assets/documents/SEPT_20__Innovation_Whitepaper_FINAL.pdf.
3) Council on Competitiveness. (2008, April). *Thrive: The skills imperative.* Washington, DC: Author.
4) National Science Foundation. (2010, January). *Science and Engineering Indicators 2010* (NSB 10-01). Arlington, VA: National Science Board.

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itestlrc.edc.org

Appendix B: Background on the Convening Organizers

The ITEST Learning Resource Center at EDC (http://edc2.org/itestlrc/) uses technical assistance (TA) opportunities to connect ITEST projects to each other and the field and to leverage lessons learned into new knowledge that can be shared nationally. The LRC's efforts tighten the research/practice cycle, promote data-based decision-making, and build the capacity of the projects to use technology as a tool for learning and working. The staff of the LRC has extensive experience working at the intersection of formal and informal learning and looking at the developmental process of lifelong learning. EDC is the ideal home for the LRC. With a 45-year history of collaborative projects in both formal and informal education, EDC has both the internal expertise and the relationships with key stakeholders that are needed to guide the project. Founded in 1958, EDC is a publicly supported nonprofit research and development organization dedicated to improving the quality, effectiveness, and equity of education throughout the world. It is recognized globally for its innovative and inclusive use of technology in learning.

The National Girls Collaborative Project (http://www.ngcproject.org) supports fourteen regional collaboratives and serves over 1500 girl-serving STEM programs. The strength of the NGCP model lies in the strategic methods and activities for engaging participants. NGCP facilitates collaboration by creating and sustaining an online and in-person community for those doing this work, and provides professional development and incentives for collaboration both regionally and nationally. NGCP has extensive experience in convening and managing events that encourage collaboration and action.

MPR Associates, Inc. (http://www.mprinc.com/) is a research firm with more than 25 years of experience designing and conducting studies of the implementation of education reforms, curricula, and professional development initiatives. MPR researchers are experts in using a combination of qualitative and quantitative methods, particularly in case study approaches, school or classroom observations, and teacher surveys and interviews to evaluate the degree of implementation of educational programs. MPR has experience with projects involving science literacy, civic engagement, and media usage. For example, they are currently the external evaluators for the NSF project, ITEST LRC. MPR has also recently completed an evaluation of the *We the People* civic education curriculum for the Center for Civic Education. Finally, with funding from NSF, MPR has developed *WorkWise,* a series of multimedia case studies designed to immerse students in the world of work by engaging them in authentic projects that join the strongest aspects of academic and vocational-technical education. In addition to offering this content experience, MPR has also collaborated successfully with EDC in the past, using formative evaluations in a participatory manner to improve program quality.

Appendix C: Selected Research & Resources

The ITEST Learning Resource Center (LRC) reviewed a wide variety of publications addressing issues in the STEM and afterschool fields in the course of preparing for the ITEST Convening Event: Defining an Afterschool Research Agenda. From this scan of the literature, the LRC compiled a bibliography of materials for reference leading up to and after the convening. This collection of research and resources has since been supplemented with references from the nine white papers, written to illuminate the following topics in relation to afterschool STEM workforce development: authentic experiences, motivation, computational thinking, effective models, partnerships, professional development, scaling and sustainability, assessment, and longitudinal research.

Beyond the general topic of the integration of STEM workforce development in afterschool, the LRC sorted literature into five additional areas of focus:

• Integration of STEM Workforce Development in Afterschool
• Effective Program Models & Core Elements
• Professional Development of Staff
• Engaging Under-Represented Groups in STEM
• Partnerships with Industry & Academia
• Sustainability Strategies

The intent of this collection was to reference background materials that provide rich context for an examination of STEM workforce development, informal learning, and afterschool programs, as well as to identify topical research and other resources that would inform the effort to define an afterschool research agenda.

To be included, resources had to address issues (listed above) that the conveners regarded as fundamental to this inquiry into STEM learning afterschool. It was also important to find complementary resources that covered various dimensions of an issue (i.e., research related to different groups in the subtopic on engaging under-represented groups). Further, the LRC sought to include National Science Foundation-funded research and publications by ITEST Program principal investigators. And, finally, research and articles of importance referenced by the authors in their white papers merited inclusion.

In all, the selected resources include articles in peer-reviewed journals, evaluation reports, research summaries, government-issued reports, books, commissioned white papers, issue briefs, best practices guides, position papers, and various online publications.

The vast majority of resources in this collection were culled from a few key sources:

- ITEST Afterschool Convening White Papers
- *Preparing Tomorrow's STEM Workforce through Innovative Technology Experiences for Students and Teachers*, a publication of the ITEST LRC (2009)
- The bibliography compiled by the ITEST afterschool interest group, with an emphasis on publications authored by ITEST Program principal investigators.
- *Learning Science in Informal Environments: People, Places, and Pursuits* by the National Research Council (2009)
- A Literature Review compiled by the Coalition for Science Afterschool, the leading advocacy organization for science in afterschool
- Afterschool Matters, a national peer-reviewed journal published by the National Institute on Out-of-School Time

- New Directions for Youth Development: Theory, Practice, and Research, a quarterly publication focusing on contemporary issues challenging the field of youth development

Other resources were identified via Google web search, using “STEM” and “afterschool” for search terms, plus key words associated with the subtopics, such as “program design,” “professional development,” and “sustain.”

Please note that resources have been categorized in the subtopic most closely related to their content, though they may also pertain to other subtopics.

Appendix D: Attendees

Jennifer Adams
Brooklyn College

Soledad Alfaro
Foundations, Inc.

Andres Alvear
After School Matters

AnnMarie Baines
University of Washington

James Bell
UPCLOSE/LRDC

Bronwyn Bevan
Exploratorium

Siobhan Bredin
ITEST Learning Resource Center, Education Development Center, Inc.

Jeff Buehler
Missouri AfterSchool Network

Robby Callahan Schreiber
Kitty Andersen Youth Science Center, Science Museum of Minnesota

Becky Carroll
Inverness Research, Inc.

Felicia Chong
Michigan Technological University

Aaron Cortes
Northeastern Illinois University

Lynn Dierking
Oregon State University

Rachelle DiStefano
Alameda County Office of Education

Jessica Donner
Collaborative for Building After-School Systems (CBASS), TASC

Kirsten Ellenbogen
Science Museum of Minnesota

Camille Ferguson
Center for Children and Technology, Education Development Center, Inc.

Jason Freeman
Learn Science Everywhere

Larry Gallagher
SRI International

Ellen Gannett
National Institute on Out-of-School Time

Pam Garza
National 4-H Council

Rachel Gates
Science Museum of Minnesota

Simone Gbolo-Thompson
Institute of Technology, University of Minnesota Twin Cities

Pamela Gilchrist
The Science House, North Carolina State University

Kate Goddard
Education Development Center, Inc.

Lyn Gomes
Carollo Engineers

Amy Grack Nelson
Science Museum of Minnesota

Lowana Greensky
St. Louis County School District

Dean Grosshandler
University of Illinois at Chicago

Carol Hanley
Tracy Farmer Institute, University of Kentucky

Joyce Hilliard-Clark
Imhotep Academy

Anne-Marie Hoxie
The Center for After-School Excellence at TASC

Richard Hudson
TPT Twin Cities Public Television

Holly Hughes
Sam Noble Museum

Charlie Hutchison
Science and Math Programs, Education Development Center, Inc.

Margaret Jacobs
The American Museum of Natural History

Jameela Jafri
Project Exploration

Sylvia James
National Science Foundation

Julie Johnson
Science Museum of Minnesota

Ilene Kantrov
Education Development Center, Inc.

Linda Kekelis
Techbridge

Cheryl Kessler
IDEA Evaluator

Melissa Koch
SRI International

Michelle Kolar
Illinois Mathematics and Science Academy (IMSA)

Suzanne Le Menestrel
4-H National Headquarters

Irene Lee
Santa Fe Institute

K. Virginia Lehmkuhl-Dakhwe
Department of Science and Mathematics, Columbia College Chicago

Rebekah Lin
The After-School Institute (TASI)

Carrie Liston
Evaluation & Research Associates

Jennifer Long
University of California, Department of Education

Joyce Malyn-Smith
ITEST Learning Resource Center, Education Development Center, Inc.

Karen Michaelson
Tincan

Diane Miller
St Louis Science Center

Carrie Parker
ITEST Learning Resource Center, Education Development Center, Inc.

Beverly Parsons
InSites

Karen Peterson
National Girls Collaborative Project

Irene Porro
MIT Kavli Institute for Astrophysics and Space Research

Karyl Resnick
MA Dept. of Elementary & Secondary Education

Wendy Rivenburgh
Education Development Center, Inc.

Beth Robelia
Kitchen Table Learning

Ivan Rudnicki
Machine Science Inc.

Nisha Sachdev
DC Children and Youth Investment Trust Corporation

Marie Silver
STEM Education Institute, University of Massachusetts

Laurel Sipes
MPR Associates, Inc.

Joanna Skluzacek
University of Wisconsin Extension

Cary Sneider
Noyce Foundation

Maryann Stimmer
Educational Equity Center @ AED

Tony Streit
ITEST Learning Resource Center, Education Development Center, Inc.

Shelley Stromholt
University of Washington

Gina Navoa Svarovsky
Science Museum of Minnesota

Heather Thiry
University of Colorado, Boulder

Gretchen Walker
Lawrence Hall of Science

Anika Ward
Science Museum of Minnesota

Claudia Weisburd
Foundations, Inc.

Appendix E: Convening Agenda

NSF ITEST CONVENING: DEFINING AN AFTERSCHOOL RESEARCH AGENDA
Location: Science Museum of Minnesota, 120 Kellogg Blvd W, St. Paul, Minnesota

Wednesday, June 9, 2010

4:00-4:30 Intro & Welcome

Facilitators:
Karen Peterson & Tony Streit, ITEST Afterschool Convening Co-PI's

Remarks:
Julie Johnson, Science Museum of Minnesota, & Sylvia James, NSF

4:30-5:30 Youth Immersion

Activity: SMM youth participants guide attendees through a hands-on demonstration of the IDEA program

Facilitator: Rachel Gates, PI, IDEA

5:30-6:30 Dinner & Reflection Team Meetings

Facilitator: Siobhan Bredin, EDC

Team Leaders:
Red – Suzanne Le Menestrel, National 4-H
Orange – Amy Grack Nelson, SMM
Yellow – Felicia Chong, Michigan Technological University
Green – Camille Ferguson, EDC
Blue – Carol Hanley, University of Kentucky
Indigo – Dean Grosshandler, UIC
Violet – Jameela Jafri, Project Exploration
Black – Ivan Rudnicki, Machine Science, Inc.
White – Carrie Liston, Evaluation & Research Associates

6:30-7:00 Guided Discussion

Prompt: *What elements made the Youth Immersion a powerful STEM workforce development experience?*
Respondents: IDEA youth participant, Pam Garza, National 4-H
& Lynn Dierking, OSU
Facilitator: Joyce Malyn-Smith, PI, ITEST LRC

7:00-7:30 Dessert & Reflection Team Meetings

Facilitator: Siobhan Bredin, EDC

Thursday, June 10, 2010

8:30-9:30 Breakfast & Charge for the Day

Facilitators: Tony Streit & Carrie Parker, EDC

9:30-10:30 Plenary #1 – *Program Design & Delivery*

Topics/White Paper Authors:
Authentic Experiences – AnnMarie Baines
& Shelley Stromholt, University of Washington
Motivation – Irene Porro, MIT
Computational Thinking – Irene Lee, Santa Fe Institute

Facilitator: Karen Peterson, NGCP

10:30-11:00 Break

11:00-12:00 Breakout Sessions

Authentic Experiences: *How can STEM workforce development experiences be truly responsive to the needs of underrepresented groups?*

Facilitator: Jason Freeman, Learn Science Everywhere
Respondents: Diane Miller, St. Louis Science Center

Motivation: *How can young people be truly be inspired to pursue STEM careers?*

Facilitator: Pam Garza, 4-H
Respondent: Mary Ann Stimmer, AED & Andres Alvear, Afterschool Matters

Computational Thinking: *What ways of thinking about and applying IT best support STEM workforce development?*

Facilitator: Lynn Dierking, OSU
Respondents: Jamie Bell, UPCLOSE & Karen Michaelson, Tincan

12:00-1:00 Lunch & Homogeneous Discussions

1:00-2:00 Plenary #2 – *Transforming the Field*

Topics/White Paper Authors:
Effective Models – Joyce Hilliard-Clark, North Carolina State University
Partnerships – Linda Kekelis, Techbridge
Professional Development – Marie Silver, STEMRAYS

Facilitator: Ilene Kantrov, EDC

2:00-3:00 Breakout Sessions

Effective Models: *What are the essential ingredients of a STEM workforce development experience in afterschool?*

Facilitator: Bronwyn Bevan, Exploratorium
Respondent: Cary Sneider, Noyce Foundation & Jennifer Long, SeaTech

Partnerships: *What are the ideal industry & academic partnerships to advance these programs?*

Facilitator: Karen Peterson, NGCP

Respondents: Jeff Buehler, Missouri Afterschool Network & Gretchen Walker, Lawrence Hall of Science

Professional Development: *How should staff be prepared to facilitate quality programs?*

Facilitator: Jason Freeman, Learn Science Everywhere
Respondents: Ellen Gannet, NIOST & Holly Hughes, Sam Noble Museum

3:00-3:30 Break

3:30-4:30 Reflection Team Meeting #2

Facilitator: Wendy Rivenburgh, EDC

4:30-5:00 Report-Out & Closing Discussion

Facilitator: Tony Streit, EDC

5:30-7:30 Reception – Twin Cities Public Television

Hosts: Rich Hudson, TPT & Luther Luedtke, EDC

7:30-9:00 Birds of a Feather Dinners (optional)

Friday, June 11, 2010

8:30-9:00 Breakfast & Charge for the Day

Facilitator: Karen Peterson, NGCP

9:00-10:00 Plenary #3 – *Advancing the Research Agenda*

Topics/White Paper Authors:
Scaling & Sustainability – Melissa Koch, Build IT
Assessments – Larry Gallagher, SRI
Longitudinal Research – Jennifer Adams, New York Hall of Science

Facilitator: Siobhan Bredin, EDC

10:00-10:30 Break

10:30-11:30 Breakout Sessions

Scaling & Sustainability: *How can afterschool STEM workforce development experiences be sustained & brought to scale?*

Facilitator: Pam Garza, 4-H
Respondents: Jessica Donner, TASC & Claudia Weisburd, Foundations Inc.

Assessments: *How do you measure quality & success in a STEM workforce development context?*

Facilitator: Bronwyn Bevan, Exploratorium
Respondents: Becky Carroll, Inverness Research & Kristen Ellenbogen, Science Museum of Minnesota

Longitudinal Research: *What can be done to track long-term impact on youth?*

Facilitator: Lynn Dierking, OSU
Respondents: Beverly Parsons, InSites & Margaret Jacobs, American Museum of Natural History

11:30-1:00 Lunch & Reflection Team Meeting #3

Facilitator: Kate Goddard, EDC

1:00-2:00 Synthesis Session

Activity: Posters and discussion of Reflection Team discoveries and recommendations

Facilitator: Carrie Parker, EDC

Synthesizers:
Bronwyn Bevan, Exploratorium
Julie Johnson, Science Museum of Minnesota
Karyl Resnick, MA DOE 21st CCLC

2:00-2:30 Defining The Research Agenda: Next Steps

Facilitators: Karen Peterson & Tony Streit