Appendices Literature Review

A–D

Art + Science: Broadening Youth Participation in STEM Learning

Exploratorium
Science Gallery, Trinity College Dublin
University of Washington, Institute for Math and Science Learning

STEM

Appendix A
Synthesis of Relevant Literatures

There are a number of relevant literatures that pertain to understanding how art and science integration may expand youth participation in STEM, particularly youth from non-dominant communities. This document contains a brief overview of the research literature in the following domains:

Art and Science Learning

- → Creativity, Imagination, and Epistemologies
- → Youth-Serving Organizations

Broadening Participation in STEM Learning Activities

- → Learning and Identity
- → Culturally Responsive Pedagogy
- → Connected Learning

Art, Science, and Learning

— Creativity, Imagination, and Epistemologies

There is a long history of examining the relationship between art and science, that at times mirrors CP Snow's "two cultures" (1959) model — two worlds apart — and, at others, emphasizes the close intersections. Frank Oppenheimer, founder of the Exploratorium, called artists and scientists the official "noticers" of society (1977; Cole, 2009). Studies have shown that prominent or highly productive scientists are more likely to have trained in the fine and mechanical arts than most scientists or than most of the general public (see Root-Bernstein & Pathak, 2016).

Synthesizing results from a 2011 conference, funded by the National Science Foundation, MacDougall, Bevan, & Semper (2011) named several epistemic qualities of the arts that are critical for learning:

- → Art is a culturally evolved strategy for human cognition related to complex problems.
- → Art frames problems and demands engagement.
- → Art allows new ways in and through scientific material and thought.
- → Art challenges habits and certitude.
- → Art provides opportunities for synthesis and meaning-making.

Maxine Greene (1995) notes that "we can't become what we can't imagine" and has argued for the centrality of arts as a means of "releasing the imagination" in learning. Following Dewey, Greene has argued that a central premise of education is to create critical, generous participants in a democracy. The arts, claims Greene, is key to developing both critical and empathetic analytical tools, as well as means for production and contribution to social life. The links between imagination and creativity, across the disciplines, have also been explored in literature. For example, Sir Ken Robinson states that creativity consists of, "imaginative processes with outcomes in the public world" (Robinson, 2001, p 115).

At Project Zero, the forty-five-year-old research organization at the Harvard University Graduate School of Education, Policastro and Gardner define imagination as an important part of a generative cognitive style, which is involved in what they call "creative talent" (in Sternberg, 1999). Imagination they state is a "...form of playful analogic thinking that draws on previous experiences, but combines them in unusual ways, generating new patterns of meaning" (p. 217). Project Zero seeks to understand how artistic processes are learning processes, and to show how art is a legitimate and vital way of knowing (MacDougall et al, 2011). Project Zero's Steve Seidel, referencing Nelson Goodman's Languages of Art, argues for the ways in which the capacity to use symbols to communicate, represent, and make sense of the world is also the capacity to make art. "What does it mean to develop the vocabulary, syntax, and various means of expression within a language?" Seidel asks.

Gadsen (2008) charts the changing relationship between arts and education through a sociocultural lens that sees the multiplicity of genres in the arts as a resource that contributes to the formation of learner identities. In service of educational contexts where oppression and marginalization are commonplace for learners and communities, the arts (irrespective of its many forms and genres) are reflective of a freedom to imagine new and alternative futures (Gadsen, 2008, p. 25).

In the context of formalized learning, the Arts Education Partnership (2004) focuses on the need to examine the arts in relationship to social and personal development, such as self-identity, persistence, and resilience. The Lincoln Center Institute (Holzer, 2004) developed a set of capacities for imaginative learning in the arts that mirrors in some ways the scientific practices identified by the National Research Council (2012) in Table 1 below.

Lincoln Center Capacities	**NRC Scientific Practices**
Noticing Deeply and Questioning	Asking Questions and Defining Problems
Making Connections and Embodying	Planning and Conducting Investigations
Identifying Patterns	Interpreting Data
Exhibiting Empathy	
Living with Ambiguity	
	Using Mathematics and Designing Solutions
Creating Meaning and Reflecting/Assessing	Arguing from Evidence
Taking Action	Communicating Results

Table 1. *A set of capacities for imaginative learning in the arts compared to scientific practices.*

A potentially relevant framework from research on arts in formal learning settings has focused on the four "studio structures" of demonstration-lectures, students-at-work, critiques, and exhibitions (Hetland et al 2012). Some researchers have emphasized how the arts, as a site for intellectual and social activism (Eisner, 2000; Levine, 2007), are more likely to occur outside of school (Heath, 2001; Hull & Nelson, 2005).

In Made for Each Other (2007), Heath, Paul-Boehncke, and Wolf made the case for the shared practices in the arts and sciences, especially in the ways that "creative ideas move from initial spark to action, invention, or discovery" (p. 16). They reported on the UK initiative, Creative Partnerships Kent, to engage the students, teachers, and staff at Brockhill Park Secondary School in collaboration with professional artists, musicians, and scientists. Project-based work allowed for rich interactions that carried "meaning, risk, and substance" (p. 37). Additionally, framing studios, rehearsals, and laboratories as spaces of performance emphasized the crucial practice of observation that cuts across curricular lines.

In the literature on hybridity, scholars have argued for the importance of designing "hybrid learning environments" in which learners draw from a variety of sources to make sense of the world, which can support learning in a variety of settings (Moje et al., 2004). Hybrid spaces represent a model of supportive learning environments where students draw on their everyday knowledge and experiences in discipline-specific learning (Calabrese Barton & Tan, 2009). These spaces describe the physical and/or social spaces that merge the experiences and knowledge of learners' home communities and networks, which are traditionally marginalized in learning settings, with those of formal, privileged spaces, such as school (Moje et al., 2004). For example, youth might document the practices their family engages in to stay healthy over several days, in order to develop understandings of personal relevance in a science unit about microbes (Bell, at al., 2013).

There are many definitions of hybrid space in research and learning, but it is commonly conceptualized as a navigational strategy, used to negotiate differing communities (Calabrese Barton & Tan, 2009). Hybrid spaces can be those where traditional boundaries of official or academic ways of thinking and doing can be made explicit and expanded, as conflicting knowledge and discourses of different spaces are brought together (Moje et al., 2004).

Hybrid spaces can support learning by supporting and examining the ways that learning settings are socially-constructed and the power relations that afford or constrain participation. Second, they can help us to break down the binaries that limit how we think about what learners offer and take up in various settings in order to create opportunities for deeper engagement in science for all learners. Finally, hybrid spaces offer opportunities for learners to take on authentic authority and authorship as they participate in the activities that cross boundaries, such as conducting water quality research and presenting the outcomes to community stakeholders.

Many scholars see the appropriation of science knowledge as a political process (Lee, 1999, 2005). This view assumes that as students from underrepresented populations gain access to science, they learn to appropriate the language and discourse of science and use it to address local or personal concerns. In this way science (or STEM) becomes a means of taking action in one's own world, often in a very immediate and local manner. Examples may include: community gardens being developed where urban blight once prevailed, or youth organizing financial literacy programs to supplant usurous institutions (e.g., "pay day loan" companies).

A related perspective is that which we deem "cultural anthropological." In this view equity in science learning occurs when individuals from diverse backgrounds participate in science through opportunities that account for and value alternative views and ways of knowing in their everyday worlds (Aikenhead, 1999; Cobern and Aikenhead, 1998; Costa, 1995; Gallard et al., 1998; Maddock, 1981; Pomeroy, 1994). These scholars point to cultural world views while also providing access to science as practiced in the established scientific community. In this perspective educators strive to open up participation in science for students by connecting their home and community cultures to science. Students develop capabilities and practices that are germane to science while retaining their "home" cultural practices. Their achievements are akin to those of bilingualism or biculturalism.

A third perspective is that of individual identity: how learners see themselves in relation to science/STEM learning. Common among these perspectives is an interest in broadening the frame of what is relevant to STEM learning. For groups who have historically been marginalized within STEM, they argue that we must situate learning as much more than "content and skill acquisition." Their personal, political, and communal ties — their trajectories through life — must be integral to how we conceive of and design for their learning. These perspectives also share a view of learner as agentive and STEM as means of taking action within communities, in one's home and everyday life, and to advance one's sense of self.

Previous sociocultural research has established identity as an integral aspect of learning. Wenger (1998) says that "because learning transforms who we are and what we can do, it is an experience of identity" (p. 215). This view of the inextricable nature of identity and learning assumes that learning science can not only change learners' identities, but also how they are in the world at large (e.g. Brickhouse, 2001; Calabrese Barton & Brickhouse, 1996; Calabrese Barton & Tan, 2009; Carlone, 2004). This is because identity is not made up of just individual traits, but is also influenced by the social processes and situated contexts in which learners participate (Wortham, 2004). In other words, identity is constructed and reinforced through what Holland and Lave (2001) refer to as a process of "thickening" in complex social interaction, where individuals bring previous beliefs, histories, and assumptions to assign, take up, reject or embrace prevailing storylines about themselves and others in a given setting (Harré et al., 2009). Nasir and Hand's (2006) definition of *practice-linked identity* that echoes these broader notions: "how individuals acting with agency come to participate in cultural practices in ways that are specific" through the affordances of learning settings (p. 468). In this view, people try to engage in activities they see as part of who they want to be and avoid activities they perceive to be misaligned with who they see themselves as (Calabrese Barton et al., 2008; Nasir & Hand, 2006).

Examining youth engagement in science practices is one way to understand science learning and identity development as embodied activity. Calabrese Barton and her colleagues (2008) situate practices, and thus practice-linked identity, as dynamic contributions between individuals, other members of their communities of practice, the historical context, and other factors, as learners appropriate forms of action or behavior in learning settings. These processes encompass skills, but also actions that are situated in a social context and thus change across physical and social settings (Calabrese Barton et al., 2008, p. 74). The authors argue that science practices can be tools for accounting for both sanctioned and unsanctioned activities that foster identity and social position within and across contexts because practices are used to signal identity or membership in cultural communities.

Building on the work of Holland, Lachicotte, Skinner, and Cain (1998), Carlone and Johnson (2007) argue that science-linked identities are developed through the social performance and recognition of competence in science practices. As in any disciplinary learning setting, learners must negotiate the tension between their everyday ways of being with those in science communities, including deciding what kind of science-oriented person they want to be and engaging in the appropriate practices to move toward that. Because of the social nature of this negotiation, learner identities are affected by the goals, assumptions, and recognition of others.

Many scholars have documented the importance of adult and peer mentors to support engagement in STEM learning (Afterschool Alliance, 2013; National Research Council, 2015). For example, mentors play a key role in keeping minority students engaged in undergraduate science and engineering programs (Summers & Hbrowski, 2006).

Farland-Smith (2011) found that "side by side" interaction of learners with scientists in a camp setting improved or maintained girls' perceptions of science and scientists. By engaging in authentic research and developing relationships with scientists formally and informally, girls were able to understand the appeal of specific disciplinary science work even if they did not identify as the kind of person who might do that work.

While a meta-analysis of apprenticeship studies reported that many studies have validity issues, there is potential for promising outcomes from expert involvement in science apprenticeships (Sadler et al., 2010). This study points to three main factors that seem to influence the outcomes of these experiences: duration of the experience, explicit scaffolds for desired outcomes, and the explicit involvement of learners in all stages of research and critical reflection.

Culturally Expansive Pedagogy

Learning settings can draw on the cultural histories of groups, situating social practices in learners' everyday lives and providing opportunities that extend familiar cultural experiences to new ways of doing things (Gutiérrez & Rogoff, 2003). These settings can facilitate opportunities for learners to take on new roles and strategies by accounting for individuals' "experiences and histories that are influenced rather than dictated by their membership in certain cultural groups" (Gutiérrez & Rogoff, 2003, as cited by Bell et al., 2013, p. 135). The acknowledgement and active co-construction of repertoires of practice by educators and learners can facilitate access to the production of new knowledge and new identities by producing new understandings of what counts as participation. In one example, Gutiérrez's (2008) design experiment examines the socio historical lives of youth from migrant farmworker backgrounds in a university setting. By addressing their relationship to the culture of the historical periods in which they live through literacy projects, learners were able "to reconceive who they are and what they might be able to accomplish academically and beyond" (p. 148). Gutiérrez's study describes how learners were then not only shaped by the social environment, but that examining prevailing narratives about themselves allowed them to develop agency to actively shape the social environment.

Ladson-Billings (1995) reminds us of the need to surface and challenge assumptions about social and psychological forces at work inside and outside the classroom through developing culturally responsive pedagogies that are in dialogue with the home cultures of children and are fundamentally based on the belief that all children can learn, such as in Gutiérrez's (2008) design experiment.

Ladson-Billings (1995) argues for a need to reframe deficit model to assume that all learners are capable and competent; to consider (and help youth consider) the broader social, historical, and cultural contexts they live in, and the ways that they are privileged or marginalized by these consider youth as contributors and include youth culture in learning settings as "authorized or official knowledge" (p. 483); and to give youth opportunities for agency, choice and voice .

Connected Learning

In 2013, Ito et al. formally framed what they call a "connected learning" model "purposeful and selective mediation of spheres of learning in ways that further learning and achievement centered on learning interests, supporting peer relations that are centered on interests, drawing out the academic relevance of interests, and by providing institutional and adult supports for peer engagement. (p. 73). Core properties of connected learning include:

→ shared purpose across age boundaries,
→ opportunities for production, and
→ an openly networked environment that allows for sharing and publicity across settings

Additionally, Boullion & Gomez (2001) found that "a chief reason for low levels of interest in science among students in the United States is that school science often feels disconnected from students' lives outside of school. They argue for a need to form community partnerships that can help make disciplinary and pragmatic connections across settings, so that young people can become aware of how they can shape their communities. They write that ''the failures of students who are female or of color [or in another minority group] can be understood as students' struggles to understand, gain access to, and find relevance in the culture of science as framed by school'' (p. 881). Similarly Basu and Calabrese Barton (2007) found that "when students found education to be empowering and transformative, they were likely to embrace and further investigate what they were learning, instead of being resistant participants" (page 468).

Similarly, Kumpulainen and Sefton Green (2014) propose that a connected learning approach provides a more holistic view of how learning involves crossing social spaces, practices, and time. Work by the HIVENYC research group has oriented towards brokering opportunities for young people across settings through community organization partnerships (Ching, 2015). To these researchers, a connected learning approach puts the onus on educators to support young people's interests and access to meaningful learning experiences (see Ryoo et al., 2015).

These studies build on a *funds of knowledge* approach. Funds of knowledge are broadly conceptualized as the everyday resources learners draw on in communities of practice (Calabrese & Tan, 2009). This includes the social networks and systems in learners' lives, such as peers, families, and other cultural communities, that influence how learners interact with oral and written texts (Moje et al., 2004). Funds of knowledge are social resources that shape learner participation in communities of practice in ways that are crucial to learning (Moje et al., 2004). For example, as students engage in science in their classroom, "they are acquiring certain identities that are related to who they are and who they want to be" (Calabrese Barton & Tan, 2009, p. 51).

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Appendix B
Project Participants

Name	Organisation	Country
Bronwyn Bevan	Exploratorium	USA
Meg Escudé	Exploratorium	USA
Jean Ryoo	Exploratorium	USA
Marina McDougall	Exploratorium	USA
Patricia Ong	Exploratorium	USA
Fan Kong	University of Washington	USA
Shelley Stromholt	University of Washington	USA
Nancy Price	University of Washington	USA
Philip Bell	University of Washington	USA
Lynn Scarff	Science Gallery	IRELAND
Jane Chadwick	Science Gallery	IRELAND
Diane McSweeny	Science Gallery	IRELAND
Michael John Gorm an	Science Gallery International	IRELAND
Jorge Garcia	826 Valencia	USA
Kylie Peppler	Indiana University	USA
Shirley Bryce Heath	Stanford University	USA
Nicole Grueneis	Ars Electronica	AUSTRIA
Julian Sefton Green	London School of Economics	ENGLAND
Sofia Victorino	Whitechapel Gallery	ENGLAND

Name	Organisation	Country
Patricia Thomson	University of Nottingham	ENGLAND
Sara Bragg	University of Brighton	ENGLAND
Robin van Westen	Waag Society	NETHERLANDS
Kevin O Sullivan	Bridge to College	IRELAND
Kathleen O'Toole	Trinity Access Programme	IRELAND

Appendix C
Tentative Research Framework

Engagement with Equity-Focused Art+Science Programs

Construct	*Indicators*
Questions And Problems That Matter	Taking initiative, self-directed learning Engaging in project-based learning
Creative Production	Supporting ideation Incorporating methods for getting and giving feedback
Youth Positioned As Creative Producers	Youth ideas and solutions are explicitly surfaced and shared Opportunities to build and extend ideas are provided
Cross-Disciplinary Epistemic Practices	Observation and Questions Design and Experimentation Modeling and Representations Feedback and Revisions Interpretation Communicating Results

Facilitation of Equity-Oriented Art+Science Programs

Construct	*Indicators*
Recognize and Leverage Skills	Expanded understanding of STEM Identifying funds of knowledge Integrating linguistic and cultural resources
Peer Mentorship and Leadership	Shifting roles Team-work
Brokering of Opportunities	Building awareness of possible futures Arranging for learning across settings Making visible possible trajectories

ISE PD to Support Equity-Oriented Art+Science Programs

Construct	*Indicators*
Culturally Responsive Teaching	Surfacing student interests and experiences Managing inclusive participation Engaging community and families Recognizing cultural resources
Data-Driven Reflection	Adopting strategies to support reflective practice Adopting formative assessment tools
Adapting and Using Formative Assessment Tools	Designing and adapting meaningful measures Iterating and refining tools for different purposes

Appendix D Formative Assessment Tools

Engaging all learners in meaningful investigations is a crucial goal of program experiences working to broaden participation. Engagement is multi-faceted, and programs rarely have ways to measure (without disrupting the flow of activity or the program culture) the engagement of all learners. Building on work from studying engagement within gaming environments (Newman, 2005), Bell and his team experimented with “exit tickets” – quick pulse-taking measures that operate to characterize the degree of learner engagement across a range of dimensions as they engage in project-based experiences and without disrupting the flow of activity or program.

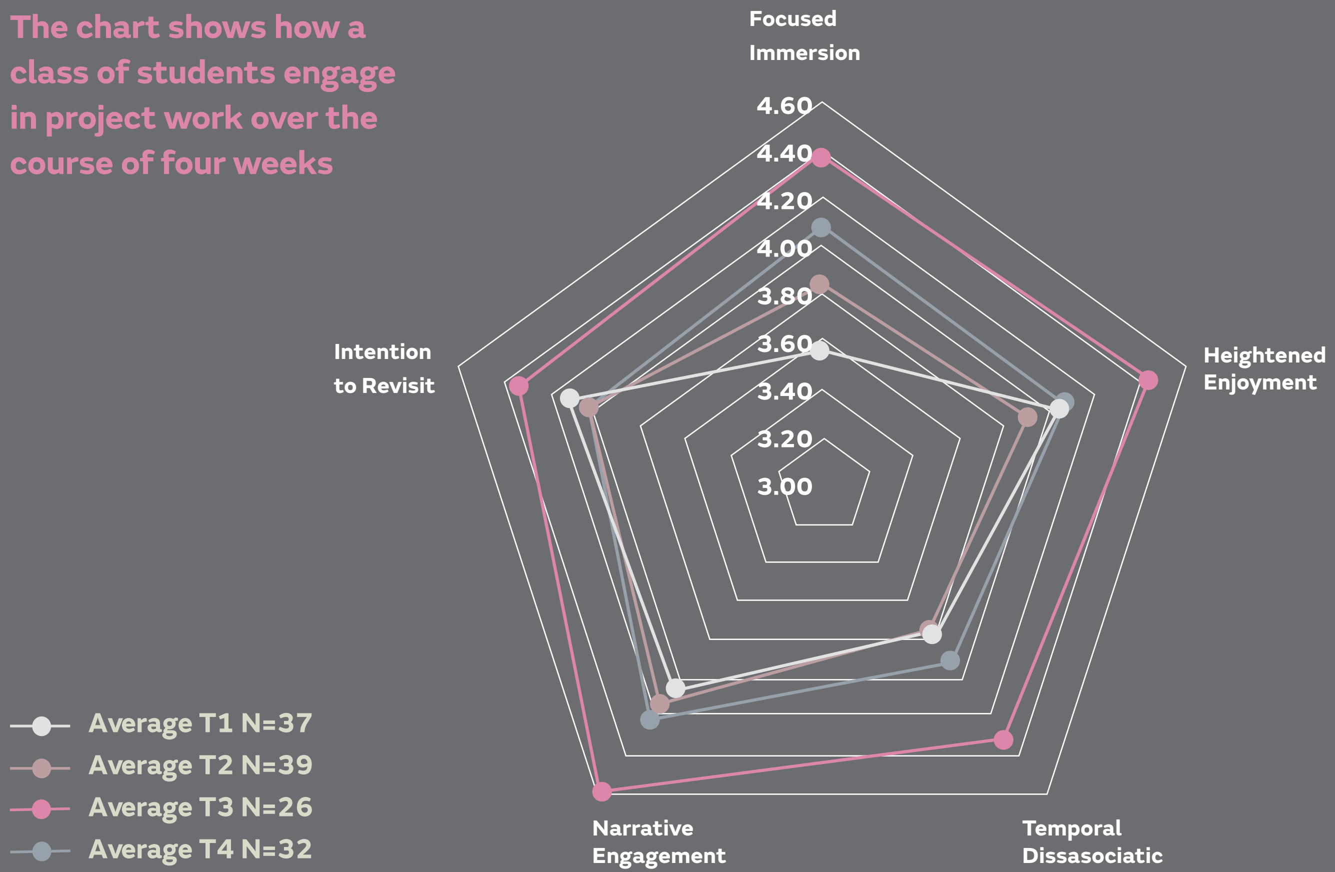
This exit ticket was adapted for use within art + science program environments. Additionally Bell and team experimented with a facilitator reflection tool that was designed to not only take notice of student learning, but to encourage reflection on key dimensions of equity in an art + science context.

Youth Engagement Exit Ticket Overview

— *About*

In this research protocol, youth are quickly polled at different points over time about different dimensions of their engagement in project-based experiences. The information returned is useful to interpret at the individual learner level and at the classroom level. It can also be used to understand how learners are reacting to specific activities in projects and over time over the course of a project to see how engagement is shifting over time. For example, the following chart shows how a class of students engage in project work over the course of four weeks.

The chart shows how a class of students engage in project work over the course of four weeks



Construct

These are the constructs being explored through the exit ticket questions. The constructs and explanations included here have been adapted from Newman (2005)[1]:

- → heightened enjoyment (question 1): This is most closely aligned with "fun."
- → focused immersion (question 2): Related to predisposition both of one's tendency to become focused and one's tendency to be immersed in a particular activity.
- → temporal disassociation (question 3): Time passing quickly implies a high level of engagement in an activity.
- → narrative engagement (question 4): Related to how one joined in or participated, which may be difficult for one to quantify, but strongly correlated with constructs related to fun.
- → intention to revisit (question 5): Related to output indicators, such as learning and socializing skills that arise from an experience.

[1] Newman, K. (2005). Albert in Africa: Online role-playing and lessons from improvisational theatre. *Computers in Entertainment* (CIE), 3(3), 4-4.

1. I have had fun working on the SOLDERING activities this afternoon.

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

2. I was absorbed in what I was doing while I worked on this activity.

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

3. Time seemed to go by very quickly while I was SOLDERING.

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

4. The topic we have been studying is very interesting.

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

2. I would like to learn more about DIY ELECTRONICS.

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

Facilitator Exit Ticket + Protocol

This document includes both the facilitator exit ticket and the protocol for implementation. The exit ticket can be used as a classic exit ticket, as people head out the door, or as a prompt for a discussion at the end of the day.

About

Fan Kong & Meg Escudé developed this exit ticket as a formative assessment tool aimed at supporting reflective teaching among novice facilitators (ages 16-18) in a long-term, out-of-school time youth program organized around the arts, science, and engineering. We are concerned with the opportunities for learning that emerge as people participate in and contribute to cultural activities that they develop. Supporting novice facilitators to collaborate with youth involves ensuring that they learn how to notice youths' ideas, contributions, and shifts in participation. To that end, we focused on cultivating a regular practice of debriefing in order to understanding how and when we see learning, while also sharing pedagogical approaches to respond to students' evolving needs and ideas.

Specifically, we wanted to support the facilitators' recognition of disciplinary practices in the arts, sciences, and engineering (such as those listed in Question #3) in order to strengthen the culturally responsive ways that we make connections to those disciplinary ways of knowing, doing, and being. When collected over the long-term life of a youth program and triangulated with additional data, this questionnaire has the potential to illuminate the various ways that STEM practices/concepts and creative intention can open up (or close off) opportunities for learning.

Construct

These are the constructs being addressed by the debrief questionnaire:

Problems of practice — questions 1, 2, 3
Facilitator Moves — questions 1, 2
Task Design — questions 1, 2
Youth Pursuit of Goals — questions 1, 2
Brokering of Learning — questions 1, 2
Parent Engagement — potentially questions 1, 2
ArtScience Practices —question 3

Facilitator Exit Ticket

Spend ~10 minutes responding to this questionnaire. These questions are aimed at tracking our understanding of the students' creative/productive processes and practices in the arts, sciences, and engineering (things that professional artists, scientists, and engineers do). There are no right or wrong answers. Questions or comments are welcome!

1. Did you have an opportunity today to talk to any students about natural phenomena, scientific concepts, or how things work? Write down their names and 1 or 2 sentences about how you knew what they were investigating.

2. Did you support students to come up with ideas or inspiration for their projects or creations today? Write down their names and 1 or 2 sentences about the idea generation process you noticed or were a part of.

Choose 1 practice and write about an interaction you had around that K,:

Protocol for Facilitator Exit Ticket

— How to use

This questionnaire remains as a draft to be continually adapted and incorporated into existing debriefs activities and collective pedagogical reflection. Because the questions are focused on the connections between the arts, science, and engineering, we have handed out this worksheet on days when program activities and project work were designed with those disciplinary practices in mind. It could be used to kick-start a discussion, or individual questions could be used as a writing prompt. The suggestions that emerge from these discussions can then be drawn upon as resources for in-the-moment pedagogical challenges.

What to look for

Q1

Question #1 is focused on the ways in which STEM concepts and tools become visible or noticeable through social interaction in activities.

Constructs to look for or follow-up questions:

→ What were the specific STEM concepts and tools (ex. density, motion, friction, angle of repose)?

→ How did the concept emerge as a topic of interest to a student, and how could you tell? Was the concept introduced to the whole group? Did a student ask a question or write down an observation in their notebook?

→ How did you engage with them to make sense of what they were noticing?

→ What kinds of questions or suggestions did you offer in order to encourage their curiosity or to go further with their ideas?

→ Did you make connections between the concepts they were interested in and their home/community/academic experiences?

Sample response from pilot study:

Today I talked to Ashwin[2] and Benjamin about gluing their caps onto the tubes. I talked with them about how you know that the seal is good when you don't see air bubbles in the glue. They came up to me to ask about gluing. (Facilitator, age 16)

[2] All names are pseudonyms.

Question #2 is focused on how the facilitators can support students' creative/productive process—specifically around coming up with an idea for their projects or creation.

Constructs to look for and follow-up questions:

- Did a student seem frustrated or "stuck," and how could you tell? Did they ask you for help or did you approach them first?
- What kinds of questions or suggestions did you offer the student?
- Did you share your inspiration for the same project?
- Did you make connections between stories they tell (and their knowledge, interests, and experiences) and the activities they are working on?[3]
- How did you acknowledge the students' goals and dream projects?[†]

Sample response from pilot study:

When I worked with Daniel, I helped him brainstorm what he wanted to do for his final project. He wanted to dye the water and the sand. And I suggested a clear background so he could see the colors better. (Facilitator, age 16)

Question #3 is focused on the various shared disciplinary practices in the arts, sciences, and engineering.

Constructs to look for and follow-up questions:

- Were any terms confusing?
- Which practices were the most relevant?
- Did you make connections between what students were doing and the professional practices of artists, scientists, or engineers?

Sample response from pilot study:

N/A. There was no free response portion in the pilot version of this question.

[3] This question was inspired by Molly Shea's Equity Indicators (unpublished prototype), 2015.

Discussion Guide for Daily Program Debriefs

— About

In this research protocol, facilitators are asked to write in their notebooks around one question and then the group debriefs their reflections as a whole group, thinking about the engagement and learning circumstances of youth, pedagogical moves that were or could be made, and implications that might relate to program design. Please note this discussion guide is separate from the facilitator exit ticket/protocol and probably would not be used on the same day.

Spend ~15 minutes writing in your notebooks. Today's prompt is __________.

General Questions:

→ Did someone surprise you today? How?

→ Did you have a particularly successful or frustrating interaction/moment with a student? What happened?

Sample Discussion Questions by Categories:

Building relationships:

- → How did you make efforts to get to know the students today? How did you relate to them?
- → What did you learn about the students today?

Making personal and cultural connections:

- → What strengths did you notice in the students today? What did the students offer to enhance learning and community in the out-of-school space that you didn't expect?
- → What did you learn about their experiences at school, home, or in their communities?
- → How did you help the students to incorporate their personal interests or communities into their projects?
- → Were there opportunities to show that the students' home language(s) are welcome in this space? How did you show this?

Exploration of ideas:

- → What were the students curious about today? How did you encourage their curiosity or future engagement?
- → What kinds of questions or suggestions did you offer the students in order to encourage them to follow or to go further with their ideas?
- → How did you show that the students' ideas are welcome in this space?
- → Did you notice students making connections to scientific concepts? How did you engage with them to make sense of what they were noticing?

Facilitating process:

- → How did you help the students with techniques or tool use? Did you notice their tool use getting better?
- → How did you start getting to know their ideas before helping them with their project?
- → When did you put your hands on a project and it was helpful?
- → Were you tempted to take over and fix a student's project?
- → Did you notice any students "hanging back"? How did you encourage them to participate or work on their projects?
- → How did you help students who were "stuck"? Did they ask you for help or did you offer?
- → Did any students finish their projects quickly? How did you encourage them to go further or stay active?