

Reflective practice at the intersection of the arts, science, and engineering:

Ethnographic beginnings of a youth program in transition

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**Abstract**

Reflective practice at the intersection of the arts, science, and engineering:

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This study focuses on the reflective pedagogical practice of “debriefs” in a youth program focused on the arts, sciences, and engineering. Building on previous research on out-of-school (OST) and hybrid learning environments and grounded in sociocultural theory and “layers of learning,” this study draws on ethnographic data from one cycle of programming to examine the organizing devices of a distributed teaching and learning workshop setting. Discourse analyses of debrief discussions revealed the ways that OST educators learn to see students’ shifts in participation. Implications for both teacher and OST educator professional development emphasize how an interpretive lens on noticing student learning within the interaction and setting can surface ideological and valued practices.

## Introduction

The historic and persistent under-representation of nondominant youth and communities in the STEM fields is deeply connected to issues of equity and access. The National Research Council's report, "Broadening Access to STEM Learning through Out-of-school Time Learning Environments" pointed out that efforts to broaden participation and access to the STEM fields and in K-12 education reflect the types of the "pedagogical practices long considered canon in OST environments, such as hands-on learning experiences, inquiry-based pedagogy, and contextualized content (Migus, 2014, p. 2). The multidisciplinary nature of the ideas and practices of hybrid arts, science, making, and tinkering settings has recently been taken up as an educative endeavor with the potential to challenge or "de-settle" (Bang et al, 2012) "normative understandings of artistic and scientific ingenuity, particularly with regard to *who* we see as inventors, *what* we see as creativity, and *on whose terms* their ideas and practices are valued" (emphasis in original, Vossoughi et al., 2015, in press, p. 3). Although these types of spaces are potentially generative for students who are often marginalized in schools, I argue for situated understandings of equity through considering the "pedagogical how" of learning environments built on supporting the strengths and cultural practices of young people (Vossoughi et al, 2013). Furthermore, although these types of spaces are uniquely positioned to enrich science learning for youth, the fields of informal science education and youth development struggle with the adequate training, retention, and support of OST educators (Freeman et al, 2009). Within this context, I ask my broad question: *How can we contribute to the ongoing pedagogical training of educators in a multi-disciplinary, out-of-school time (OST) setting?*

When I began this ethnographic study of the *XTech* program at the Exploratorium in the

summer of 2015, the program was in its ninth year of inducting a “beginner cohort” of approximately 40 new students—6<sup>th</sup> and 7<sup>th</sup> graders recruited from the San Francisco Bay Area public schools, local community-based and youth-serving organizations. This free, long-term youth program organized around the arts, science, and engineering consists of over 100 participants (students and facilitators) at any given point. It is the center of the museum’s youth programming, both in terms of its scale (size and duration of program) and commitment to equity-oriented pedagogy.

Within this ethnography—which was primarily funded through the *Science Learning +* program sponsored by the Wellcome Trust UK and National Science Foundation and the San Francisco Department of Children, Youth & their Families—the lead educators and I co-designed and enacted a three-week design-based research study (Phase I) with the goal of contributing to the ongoing training and pedagogical reflection of facilitators, when taking “layers of learning” as foundational to the setting and design. In particular, we were interested in supporting facilitators (who were once *XTech* students) to notice youths’ interests, ideas, and shifts in participation. Thus, we focused on cultivating a debrief ethos aimed at understanding and reflecting on how and when we see learning in this hybrid, multidisciplinary workshop space. The tools and organizing devices we developed included:

- (1) Reflection prompts oriented to the activity system (see Appendix 1);
- (2) Debrief questionnaire on shared practices in the arts, science, and engineering (see Appendix 2); and
- (3) Discussion guide for daily program debriefs (see Appendix 3)

### **Literature Review**

There are many varied attempts to address the STEM “achievement gap.” Recent trends include

the popularity of making and tinkering programs and other similar efforts to integrate the arts and creative endeavors in out-of-school time (OST) environments. As an educative endeavor, these hybrid and multidisciplinary ideas and practices of STEAM (Science, Technology, Engineering, Art, and Math), making, and tinkering settings have the potential to challenge or “de-settle” (Bang et al, 2012) normative understandings of science. However, without investigating the intercultural, epistemic, and sociopolitical values undergirding these initiatives, we risk reproducing disciplinary hierarchies and larger societal inequities within educational settings. Rather than positioning the arts to be in the service of STEM learning (or vice versa), I acknowledge that both domains have the potential to alienate as well as empower learners. By grounding this study in the voices and experiences of participants, I argue for the hybrid and multidisciplinary nature of these programs in order to re-imagine what learning *could be*.

OST program features emphasize designing with the assets, needs, and interests of youth in mind, while promoting the adequate training, retention, and support of OST educators within the landscape of the youth development field (Migus, 2014; Bell et al, 2009). The Coalition for Science Afterschool’s report on supporting the inclusion of high-quality STEM learning opportunities in OST settings highlighted building staff capacity as a critical area for action (Freeman et al, 2009). However, the lack of empirical research in this field leaves open the ideal content and structure of effective staff development, especially within severe time constraints of OST programs.

Relatedly, the literature from hybrid learning spaces articulate a model of culturally expansive learning environments where students draw on their everyday knowledge and experiences in discipline-specific learning (Calabrese Barton & Tan, 2009). These studies highlight how in any learning environment, learners draw from a variety of personal, cultural,

family, and community resources to make sense of the world, which can support learning in a variety of settings (Moje et al., 2004).

While this literature explores the complexities of broadening access and participation in STEM fields, few examine the “pedagogical how” (Vossoughi et al, 2013) of hybrid settings and empirically document the learning ecologies that work toward “mediated praxis” (Gutiérrez & Vossoughi, 2009) – the intentional unification of theory and practice in learning environments as well as the ways in which these environments position all participants (researcher and practitioners, facilitators and students) as learners.

### **Conceptual Framework**

This study is grounded in sociocultural (Rogoff, 2003) and cultural-historical (Vygotsky, 1978; Cole & Engeström, 2007) perspectives on learning. Learning is “a distributed accomplishment where conceptual development is historically situated, socially distributed, and embodied in meaningful everyday activities” (Engeström & Sannino, 2010; Hall & Horn, 2012). I use the framework of situated learning (Lave & Wenger, 1991), which allows us to examine sense-making processes resulting in new and unfolding forms of activity, where the goals and purposes are co-constructed by the participants.

#### *“Layers of learning” in mediated praxis*

Gutiérrez & Vossoughi (2010) posit that mediated praxis involves positioning researchers and educators as learners side-by-side (Erickson, 2006) with the students, with the goal of unifying theory and practice. Within this study, “layers of learning” includes the conceptualization, design, and implementation of out-of-school activities and experiences as embedded in larger contexts—a move from focusing on the immediate learning environment to the larger learning

ecology, with an eye toward power dynamics and inherited power structures (Erickson, 2006; Gutiérrez & Vossoughi, 2010; Mendoza, 2014). In the *XTech* setting, the possibility for mediated praxis dwells within the space of the debrief discussion, where facilitators, lead educators, and the researcher all grapple with new conceptions of teaching and learning. Tensions and alignments, or “stress points” (Engeström, 2011), in the activity system created the occasions for the elaboration of the “pedagogical how” (Vossoughi et al, 2013). Over time, an emerging ethos of debriefs would set the stage for imagining new possibilities of teaching and learning. In other words, debriefs open up the space pedagogically for mediated praxis.

#### *Agency and positional identities in figured worlds*

This study attends to the accomplishment of agency by positional identities in a “figured worlds.” A figured world describes “a socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others” (Holland et al, 1998, p. 51). Holland et al (1998) draw from Vygotsky’s works to highlight the heuristic development of identity and agency, whereby semiotic mediation is one of the tools or the means for agency. This is achieved through two processes: (1) improvisations or moments of resourcefulness (that come from cultural resources, situations in practice, etc.) that (2) in turn get appropriated as a heuristic for the next moment of activity. Attending to participants’ agentic discursive actions during debrief discussions involved the joint creation of new conceptual and pedagogical concepts that arise in-the-moment (Engeström, 2011). These pedagogical resources—dialogically achieved—are the improvisations that become the heuristics for the next moment of facilitation and reflection.

Furthermore, agency cannot be addressed without identities, which are improvised, multiple, and heteroglot, and in relation to larger social structures (Holland et al, p. 7). Within

figured worlds, positional or relational identities laminate over time, through “a set of dispositions toward themselves in relation to where they can enter, what they can say, what emotions they can have, and what they can do in a given situation” (p. 143). These positional identities are a “person’s apprehension of their social position in a lived world,” that is, depending on the others present, of their greater or lesser access to spaces, activities, and discourses, and, through those discourses, develop authoritative voices, or any voice at all (p. 127-128). In Identity and Agency in Cultural Worlds, the authors conceptualize that:

“one’s personal agency is not the creation of a self that is always uniquely one’s own. Rather, agency takes shape in what we call the **space of authoring**. This space is formed, both within us and outside us, by the very multiplicity of persons, who are identifiable positions in networks of social production, and of worlds of inner activity that are also scenes of consciousness...Each act is simultaneously a social dynamic, social work, a set of identifications and negations, **an orchestration or arrangement of voices**.” (Holland et al, p. 111)

Through the lens of agency, positional identities include moments not only when the self is authored, but also how the self is authored by others. Agency, in this sense, helps us to consider the processes of change in positional identities.

## **Methodology**

### *Research Design*

In line with research-practice partnerships and social design experiments, this study was deeply embedded in program design and implementation. In practice, this involved educators serving as contributing members of the research team and researchers participating as co-designers of pedagogy. The process included co-authorship of the research question, co-creation of daily

debrief prompts, and joint data review meetings. Our partnership studied themes emerging through daily collective debrief discussions to understand the pedagogical resources that support facilitators in broadening when and how they saw learning. The broader project was focused on understanding how STEAM programs can support the learning, identity development, and extended learning pathways of adolescents (Bell, et al., 2012). The design team (myself and Meg Escudé, *XTech* Program Director) co-authored these specific research questions to pursue:

- *How can we support facilitators' reflective pedagogical practice within a hybrid arts, science, and engineering out-of-school time setting?*
- *What are the tensions and possibilities of supporting former students to become educators within a shifting curriculum?*

### *Positionality*

Any discussion of ethnography, especially with an attention to equity-oriented pedagogy, must be accompanied by an examination into the researcher's own positionality. My history at the museum and the multiple roles I played in this ethnography had implications on how I positioned myself as a researcher in the space<sup>1</sup>. Attending to the notion of agency is a crucial part of formative interventions, and this includes the agency of the researcher. This research-practice partnership started much earlier than the first day of the summer 2015 session at *XTech*. I worked as a program coordinator, educator, and research assistant at the Exploratorium during the years when museum began their ambitious plans to move from the Palace of Fine Arts in Presidio National Park to Piers 15/17 on the Embarcadero in San Francisco. I witnessed the evolution of the institution's various youth programs, and was involved in other making/tinkering initiatives,

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<sup>1</sup> One of first ethnographers of the *XTech* youth program, Manuel Espinoza, offered this sage advice that served as a meaningful metaphor for me: "Be the first one on the stage." (Personal communication, June

including serving as a facilitator and research assistant on the Afterschool Tinkering Program (a partnership between the Exploratorium and the Boys and Girls Club, lead by Dr. Shirin Vossoughi and Meg Escudé), a keystone of equity-oriented pedagogy in the museum. Due to staff and program cuts, in the summer of 2015, I also served as a facilitator in the “intermediate” and additional “beginner” cohort of *XTech* students before serving as researcher for this study.

### *Context & Participants*

This study took place during a two-week summer session for 20 “beginner cohort” students (incoming 7<sup>th</sup> graders, ages 11 to 12) at the *XTech* program held at the Exploratorium (a museum of art, science, and human perception) in San Francisco. For nearly ten years, this free, long-term youth program has been serving a racially, culturally and linguistically diverse group of participants (over 100 in total). According to its mission statement, “*XTech* encourages students to have a positive sense of their potential, an awareness of their talents, and the self-confidence to pursue STEM learning. The program develops students’ communication skills, creative thinking skills, and both traditional and digital technology skills.” *XTech* is grounded by youth development goals and supports a cohort model whereby returning members (facilitators) teach and assist new members (students). New students are recruited from local public schools, community-based and youth-serving organizations in the San Francisco Bay Area. Each cycle of programming includes an intensive one-week training with facilitators, followed by a two-week session for new “beginner cohort” students during the summer. During the academic year, the program meets twice a month on Saturdays for each cohort (“beginner” and “intermediate” cohorts) of students.

The design team included myself, the *XTech* program director (Meg), and two lead educators (Denny and Tricia), have with a range of seven to ten years working in museum and

youth development settings. The norms and values (brought on by changes in curriculum and staff) of this figured world shifted in the summer of 2015, when the instructional team re-imagined the traditional project-based engineering curriculum to include more open-ended, interest-driven, and making/tinkering) activities. For example, a former “pinewood derby” activity in which students create cars to race down a ramp was modified to become “pinewood jam” activity, inspired by monster truck rallies, in which students designed unique ways for their vehicles to go down a ramp. This change meant that facilitators would be challenged to support a creative process, in which facilitators and students co-construct the goal of an activity—such as creating a car inspired by a marker, a seal, or a parachute, rather than a car with the purpose of going down a ramp in the fastest speed. Furthermore, this transition toward more hybrid, multidisciplinary activities<sup>2</sup> meant that various cohorts of facilitators—high school and undergraduate students who have been a part of the program for four to seven years—also needed to be supported in learning and teaching this new curriculum. This pedagogical shift from facilitating an engineering process to a creative process—one that entailed intellectual risk taking—was a frequent problem of practice posed by the debrief discussions. As Meg has stated, “with new conceptions of learning, we also need new conceptions of teaching.”<sup>3</sup> Thus, debriefs became an important tool for praxis and a space to open up a collective sense of purpose and possibility in this educative endeavor.

Through these collective sense-making sessions, we plant the seeds for expansive learning – where the object of learning is not predetermined from the outset but co-constructed by participants within the activity system.

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<sup>2</sup> One student (part of the second beginner cohort) put it best when he described the program to two strangers (a father and his young daughter) outside the museum during an activity called Sun Prints, “You make things and you get to use your creativity” (~1pm on June 30, 2015).

<sup>3</sup> Personal communication, October 12, 2015, Science Learning + meeting in SF.

The *XTech* “beginner cohort” session consisted of the following participants: the program director and educator (Meg), two lead educators (Denny; Tricia), six teen facilitators (high school students, ages 15-17, all consented), and 20 students (middle school students, ages 11-12, nine consented).

### *Data Collection*

Data sources were drawn from six weeks of ethnographic field work, including jottings, field notes, and analytic memos. I collected photographs of student artifacts, curricular documents, audio and video recordings of small and whole group activities, and debrief questionnaires (16 total). Interviews were conducted with 3 senior facilitators (paid facilitators who were working during other cohorts of *XTech* that summer), as well as with the 6 focal facilitators.

For this study, the data corpus consists of audio recordings of debrief discussions (10 sessions, ~40 minutes per session, ~ 9 hours total) with the three program educators and six elder members of high school-aged facilitators, as well as debrief questionnaires (2 sessions, 16 total) collected during the two-week summer programming for the new cohort of 20 middle school students. I transcribed all 9 hours of collective debrief discussions over the course of 10 sessions (or 2 weeks) of programming, and then used progressive focusing to identify “stress points,” a moment that opens up the possibilities for growth and progress, in the activity system. I then wrote analytic memos to identify “hot spots” for further analysis with the design team.

### *Data Analysis & Coding*

I used progressive focusing to identify moments in the debrief discussions for emergent “problems of practice” (in order to refine the questions for long-term collection) and local pedagogical resources through listening for modalities, such as “should,” “could,” “would,” etc.

Transcripts were coded and analyzed thematically using a grounded theory approach (Glaser & Strauss, 1967). Codes were developed inductively, with reference to the research questions and informed by schemes other researchers have found useful in characterizing changes in educators' professional practice (e.g., Grossman et al, 2001; Rosebery et al, 2015; Sherin, 2003; van Es & Sherin, 2008). I used discourse analysis (Erickson, 2004; Fairclough, 2003) as my primary method.

### **Findings**

The findings for phase of this design research study include describing the organizing devices for supporting facilitators in reflective pedagogical practice. To that end, I report on the development of debrief norms and formative assessment tools at surfacing local problems of practice and pedagogical resources.

Then, I examine one particular moment in debrief when the question of “*What does it mean to slow down?*” emerged as a heuristic tool, or local pedagogical resource, in supporting facilitators in the practice of *cultivating attention*, one of the shared practices in ArtScience<sup>4</sup> settings. This paper's findings include:

- (1) *Reflection prompts oriented to the interaction and the setting have the potential to surface assumptions about learners and the pedagogical values of the space.*
- (2) *When reflective practice is cultivated, productive pedagogical questions can surface assumptions about teaching and learning.*

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<sup>4</sup> M. Bang's presentation.

### *Framing the problem of practice*

Within *XTech*, facilitators have typically drawn from their own experience of the program to inform how they work with new members. Historically, new cohorts were inducted into the program with the completion of an engineering project called the Turbulent Orb, a table-top clear polycarbonate sphere full of colored, flow-visualization fluid containing glycol stearate, a common ingredient in hand soap. The sphere is mounted on top of a pedestal connected to a motor that, when activated, spins the fluid in the sphere to show swirls and waves of internal fluid motions. In the summer of 2015, a new culminating activity of building a tube- or disc-shaped vessel containing liquids and/or sand was introduced. Like the Turbulent Orb activity, these vessels exhibit a kind of natural or scientific phenomenon while allowing for a certain degree of personalization. However, unlike the Turbulent Orb activity (which primarily afforded the choice of different colors), the vessels afforded different ways of displaying the various phenomena of interest. This shift from facilitating an engineering process to a creative process represented just one of the changes in the curriculum.

Prior to the two-week program, senior facilitators (paid staff within *XTech*) who have been a part of the program for at least six years were interviewed regarding how they experienced this change. Two of these facilitators, Roxana (age 21) and Vienna (age 20), exemplified the contrasting pedagogical stances they adopted toward working with youth in these creative projects:

Roxana: "...um, it's a lot more different than what I'm used to cause *XTech* has done the same things and it's been very **structured**...so that way at the end we get the end result of a turbulent orb. Um, these projects, instead of a turbulent orb, we are doing the sand and little vessels, which is more open-ended than what I'm used to...Um, but it's- it's harder for me to find something to talk about with the kids because it's less structured. **So if they have more freedom, it gives me- it makes me feel pushed back from like actually interacting with them cause I don't wanna stifle their creativity**, but at the same time, I feel like I'm

not doing my job as much, but I know that I'm still trying..."

[Interview\_2015.07.31]

Vienna: "I would say...keep an open mind because the curriculum is very, like definitely different from *XTech*, but also when working with students- kind of- realize that **the roles of the teacher and student are more fluid than you think**, that as a facilitator, yes you are in position of authority and a position of more knowledge, but at the same time- kids- these kids are learning- **but you just learn so much from them**...a student might change how you thought of something you would've never thought of earlier." [Interview\_2015.07.31]

In the quote above, Roxana expressed the contradictions and uncertainty she felt with her own role as facilitator of these new activities, which, due to their open-endedness, required a sustained effort on the part of facilitators to take seriously students' interests, agency, and creativity. This was not only because these activities were new to her, but that they also entailed a loss to a collective identity. In the same interview, she stated, "...if you do this [Turbulent Orb activity], you know you're part of it. Like when you're in a show. Once you get your first show done, you're an official thespian. So that's the turning point where you're **an actual *XTech* student**. You know, the end result." In other words, not only did the activities require a different stance toward teaching and learning ("structured" vs. "open-ended"), they also entail a different notion of becoming "an actual *XTech* student."

In contrast, although Vienna noted a marked difference in the types of activities, she expressed confidence in her pedagogical approach in the face of uncertain ends or goals. Importantly, Vienna was able to draw on her experience facilitating in another Exploratorium youth program called Afterschool Tinkering, which also led by Meg: "I think working in Tinkering really helped me...I remember starting with Tinkering and realizing that wow, this is really different from *XTech*, and that doing **so many debriefs with Meg**, developed a style of like- of like **I actually realized what facilitation meant** in the sense that I wasn't the teacher and here's step A, B, and C..." Her interview was replete with the well-attuned sense of a

“troubleshooting mindset,” or “tinkering pedagogy” (Vossoughi et al, 2013; Shea’s AERA conference) made possible by expansive learning—when we learn side-by-side *with students* and position youth generously and with intellectual respect. She highlighted the importance of “so many debriefs with Meg” in helping her understand how to build relationships with youth, leverage their interests and everyday expertise, and help work through youth’s frustrations. In naming debrief as a primary source for Vienna’s development as a facilitator, I identified the design conjecture for this study: *the culture and practice of collective debriefs create the space for facilitators to develop new conceptions of and the fluidity between the social roles of teaching and learning.*

#### *Debrief norms: Building a collective ethos*

As a regular practice of youth programs, debriefs serve to surface immediate problems of practice, track students’ ongoing participation, and collectively come up with solutions in a distributed teaching and learning setting. There are many ways into a debrief discussion, varying in terms of who participates and how participation is structured.

Supporting facilitators to collaborate with youth involves ensuring that they learn how to notice youths’ ideas, contributions, and shifts in participation. We emphasized the development of an *ethos for reflective practice* in order to meaningfully bring facilitators into discussion *with* the teaching team. At the end of each program day at *XTech*, the lead teachers and facilitators gathered to make sense of the day’s events and plan for the next day. After a period of individual writing (usually 10 to 15 minutes) in facilitators’ journals in response to a prompt, everyone was expected to speak and contribute to the discussion based on their immediate reflections and any concerns they choose to bring up. Participants took turns by going around a circle or by nominating the next speaker. The section below further elaborates the suite of tools that were

created to support both the instructional team and the facilitators to sustain a reflective pedagogical practice.

### *Development of Tools*

According to a research synthesis by Penuel, Shephard, & Davidson (2015), improving assessment for learning means being explicit about the type of intervention implemented and its assumptions about how students learn and the ways that the chosen assessment tool(s) support the learning process. For the *XTech* setting, we acknowledged that sociocultural interventions focused on disciplinary ways of knowing, doing, and being can be greatly improved when educators “elicit and make use of interests to inform the course of instruction, particularly at the outset of instruction but also throughout, to help set specific goals for learning” (Penuel, Shephard, & Davidson, 2015, p. 4).

It is a common tendency among novice teachers and facilitators to describe students’ traits or characteristics without contextualizing those descriptions within the activity system. Therefore, we identified the debrief space, as well as discussion scaffolds that prompt facilitators to describe their interactions with students. To that end, tools such as writing prompts and debrief questionnaires were co-constructed with the lead teachers in the space, piloted with the facilitators, and further adapted through the evolving needs of the setting. The three types of tools aimed at surfacing the emic understandings of how and when we see learning remain here as drafts:

- (1) writing prompts that ground the debrief discussion (Appendix 1); and
- (2) debrief questionnaire aimed at capturing the range of shared disciplinary practices (Appendix 2).
- (3) discussion guide of potential reflection questions for debrief discussions (Appendix 3)

The design team developed a debrief questionnaire by the second week of programming to focus on themes such as: how facilitators engaged with students to grapple with STEM concepts and tools; how facilitators can support students during the creative/design/productive process; and the range of shared disciplinary practices afforded by the activities, such as designing, measuring, responding to feedback, etc. In these ways, these tools served both programmatic (understanding students' ongoing participation) and pedagogical (indicating the kinds of valued practices in the setting) functions.

*Reflection prompts oriented to the activity system*

A typical writing prompt would ask facilitators to focus on a particular interaction with a student, followed by follow-up questions expanding on the history of that moment. For example, on the third day of programming, this was the opening prompt:

Tricia: Write about a way that you supported either of the projects today, so sun prints or name plates. Write about **how you interacted, what you did in particular with certain tools with certain people.**

Fan: And, like yesterday, **focus on the interaction** that you had with them.

Tricia: When she says “interaction,” that’s like **two-way. How did they respond to you helping them? How did they approach you, or did you approach them?** That kind of thing.

The quotes above illustrate the co-articulation of debrief prompts – initially between one of the co-teachers and I, and over time shifting to the co-teachers creating their own prompts focusing on the interaction between facilitators and students, or to the activity system. Educators’ moves during the debrief discussion provided additional scaffolds to engage in rich descriptions of unfolding activity, such as specifying ways that assistance was initiated, offered, and taken up or challenged. As one of the lead teachers, Tricia follow-up with additional questions such as, “How did they respond to you helping them? How did they approach you, or did you approach them?” Prior to the start of the summer session, I provided a list of questions (See Appendix 3)

that could potentially open up the space to engage in equity-oriented pedagogy. This emphasis on the interaction between the facilitator and the student points to the importance of the social environment in understanding students' ongoing engagement and participation.

*Transcript excerpt 1: From "he was...dangerous" to "it's dangerous"*

On the second day of program, Denny (co-teacher) introduced the available tools in the workshop – including scroll saw, sander, drill press, hammer, clamps, hand drills, hand saws, etc.— with the goal of creating wooden Name Plates that will hang on the wall in the workshop. Throughout the day, students were sanding, drilling, hammering, sawing, painting, designing, etc., while facilitators supported them with techniques and ideas. As Tricia (co-teacher) introduced this activity: “These are the only projects that you’ll keep here so that this space can truly feel like your own” [FN\_FK\_Week1Day3]. At the end day, the writing prompt during debrief had been:

Denny: They learned a lot of new stuff today. Uh, it’s pretty intense. Would you guys just **describe who you worked with** today?

Meg: The person or the interaction?

Denny: The **interaction**, so you can think about, you know, the actual person, or **what they were trying to do, how you helped them do it, if there was any advice you gave them, if there was any techniques you showed them**. All that can be included.

Transcript excerpt [00:17:03.24] - [00:23:22.11] from file:  
2015.08.05\_W1D2\_0322pm\_Debrief.mp3

Participants<sup>5</sup>:

Researcher = *Fan*

Program Director = *Meg*

Co-teachers = *Denny, Tricia*

Facilitators = *Tammy, Eddie, Amy*

Students mentioned = *Samuel, Steven*

[00:17:03.24]

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<sup>5</sup> All names, except for the lead educators, are pseudonyms.

Tammy: My turn? Um, I was working with almost everybody...Not like, not like everybody literally, but like a few minutes with these people, and a few minutes with other people, or just walking around, like helping other people when they need help, and when I see them doing something not right. Um, I thought that, Samuel? When he came in, the new guy, Samuel...I thought he was very silent and stuff, but then I found out that **he was pretty dangerous**.

Fan & Meg (at the same time): **What do you mean?**

Tammy: He don't clamp things down. He would just hold the board and start drilling like that.

Meg: Was he here for the training?

Tammy: Yeah, he was.

*(Discussion continued with the appropriate type of electric drill to use for different materials.)*

Tricia: Yeah, I was noticing that a couple of **kids were moving really fast**, so I would just **remind them to slow down**, so like asking them to slow down, and clamp--

Tammy: And I figure most people don't clamp very tight. Most of the people, their wood shifts.

Meg: Yeah, learning to use the clamps is like a whole other tool they're learning today, you know.

Tricia: Yeah.

Meg: They're all things that we take for granted cause we know how to do it. They're all like things they're all learning all at once, you know, so it's okay, I mean, you know, it's okay you have to remind them of those things too.

Tricia: Same thing with um Steven (.) he was-

Tammy: -oh yeah, his wood was flying everywhere.

Tricia: Exactly. So that is a point when we can have them stop, you know, because **it's dangerous**, things were flying, and that was not good.

Meg: What happened?

Tricia: Like, he wasn't clamping stuff down.

Meg: Oh, and something actually flew...

*(Discussion continued with other students who also needed help in learning how to clamp.)*

In the excerpt above, through the orientation toward the activity system, we pushed ourselves to co-create generous views of students, when taking the history of a particular “problem of practice” into consideration. Thus, with Tammy’s characteristic of student Samuel as “dangerous,” both the program director and I uttered “What do you mean?” in the same instance. The repair (Schlegoff, 1992), or the mitigation of the deficit frame of the student, that follows after this turn trace the multiple moves that the lead teachers, Meg and Tricia, made in

order to shift the conversation to examine the kinds of support that all students need—not because they were considered “dangerous,” but because “*it* was dangerous [when not clamping].” Tricia then re-framed Samuel as “dangerous” to a description of his and other students’ observable behavior as “kids were moving really fast.” From “moving really fast,” she offered the advice that facilitators tell students to “slow down” in order to address the safety concerns in the setting.

Thus, I arrive at my first finding: *reflection prompts oriented to the interaction and setting have the potential to disrupt adverse positioning of students*. In every youth program and in every classroom, labels such as “dangerous” or “disruptive”<sup>6</sup> coalesce quickly and remain stubbornly, further reifying and constraining youths’ possible futures (Wortham, 2006). Disrupting this adverse framing was important both in the moment and for ongoing practice because these are the words that traverse the powered boundaries of race, class, gender, and ability.

*Transcript excerpt 2: “What does it mean to slow down?”*

This transcript excerpt immediately followed the first excerpt, highlighting how the pedagogical resource of “slowing down” arose out of the need to articulate the ways that facilitators can collectively build a safe and supportive environment, after participants have acknowledged that the setting was “dangerous.”

Tricia: You know, so it's really good, we need to just, we need to **slow down** cause they're gonna get hurt, or they're gonna hurt somebody else.  
Tammy: Like the **sun prints**? Everybody was like that, **moving very fast**.  
Tricia: Yeah

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<sup>6</sup> McDermott talks about how the positioning of a student as “the troublemaker” coalesces along the powered boundaries of race, gender, class, ability, etc.

Meg: Yeah, so what are techniques that help people slow down? What do you guys think works to help people slow down, other than just saying "slow down"? **What does it mean to slow down...**with sun prints, for example, like, what would slowing down look like?

Meg: (.3) question for everyone (h)(h)

Amy: Um, I guess you can, um, tell them to arrange like their pieces more carefully first. cause then I saw like, they kept getting like the sun prints, like the papers, like they went one after another, really fast

Meg: Without thinking a lot about what they're gonna do next. So yeah, what are ways you can help them start thinking about that, like **help them get interested in-** arranging- and stuff

Amy: Um- ask them to look at the shadow more

Meg: -hm-hm

Amy: And see like, um, **so they won't be disappointed** after their piece comes out.

Meg: Totally, yeah. Yeah, sometimes they do- like- with sun prints, **I'll just show them the shadows without the paper, like just have them hold the piece above the ground** and look at the shadow that it makes, and then think about, cause a lot of times they'll place the paper where the shadow isn't, like the shadow is actually over here, **so place the paper underneath and that helps them see, too.** Yeah. I think showing them and getting interested in those details is what will bring them in to start noticing those details, too. Like, if you can **show your own, you know, interest**, of like, pointing things out, is like a way of helping them bring their attention in, you know?

Engeström (2011) pointed out how these “stress points” have the potential to be sources of change and development. Following the conversation turns, we can see how “slowing down” emerged as a rich pedagogical resource co-constructed in-the-moment and with multiple voices. Tricia first mentioned slowing down as a way of attending to student safety (clamping down the wood so people wouldn’t get hurt by wood flying in the workshop). Tammy raised the point that students were also moving very fast during the sun prints activity. Meg suggested that helping students slow down is also a way of noticing student interest. Amy said that it could also be about attending to student affective experience (not being disappointed with the product). Finally, Meg said that slowing down could be a way of cultivating attention to and modeling interest in phenomena (for example, in light and shadow).

Reflection prompts generated within the figured world and about the figured world reveal something ideological. They surface assumptions about learners, about the norms and values of the space itself, and the range of pedagogical affordances of a particular moment and activity. In other words, the heuristic of “slowing down” is also an ideological resource for highlighting the norms and values of the space that all the participants—students and facilitators—are being apprenticed into. Thus I arrive at my second finding: *when reflective practice is cultivated, productive pedagogical questions (such as “What does it mean to slow down?”) can surface assumptions about teaching and learning.*

### **Discussion & Implications**

This project takes up a central concern with equitable pedagogical practices, foregrounding the need to more fully explicate the “pedagogical how” of rich informal environments beyond expanding access to opportunities in STEM learning. Studying educational discourse within youth programs organized around the arts, science, and engineering provides a substantive window into the kinds of pedagogical practices and forms of learning specified in our research questions.

Many researchers have noted that collaborative discourse results in the emergence of new insights and representations, and that once these interactive social constructions have emerged, they both constrain and expand the ongoing collaboration. Similarly, I acknowledge that “knowledge is first collective and external – manifest in conversation – and then becomes internalized” (Sawyer, 2006, p. 191). What initially emerged as a question (“What does it mean to slow down?”) to address to a specific problem of practice (tool use and safety) overtime laminates into a debrief ethos that treats conflicts and tensions as productive resources that elaborate the “pedagogical how” of hybrid and multidisciplinary settings.

When we emphasize the context and the social history of an interaction, we get a different view of agency – one that is collective and mutually constituted by all participants. Samuel’s entrance into the debriefs signaled a shift in the ethos of the debrief discussions: how do we create norms (in other words, “slowing down”) rather than rules (such as “clamp things down”) to guide the community of practitioners? The practice of debriefs can help us understand how facilitators’ decisions in these settings are rooted in personal and ethical considerations: How do I help *this* student in *this* moment? What is the best way to incorporate STEM (or any other practice or expertise) for *this* child?

In a review of research by Zeichner (1994) on reflective practice in teaching and teacher education, the author offered a typology of various traditions in order to add a historical perspective and to clarify the assumptions and commitments underlying particular projects. Zeichner rejected the idea that there are levels of reflection (such as technical, practical, and critical reflection); rather, all are necessary regardless of the experience level of educators (1994, p. 14). “Layers of learning” in reflective practice signals an orientation toward collaborative inquiry by researchers and educators to cultivate a debrief ethos that privileges educators’ learning to notice students’ agentive actions within institutional structures.

The ongoing reflections emerging through this work include: What are effective questions that prompt meaningful reflection about what learning looks like at the intersection of the arts, science and engineering? How can educators cultivate a debrief culture that opens up discussions addressing historical inequities and assumptions about learners? What kinds of questions directly address the inequities that surface within those assumptions?

## **Conclusion**

This project has provoked new questions about the potential of reflective debrief practices in learning environments. The politic of this study is informed by how we can shift adverse framings of students into reframed explorations of pedagogical dimensions of the local learning ecology. Responding to the dearth of research literature on the pedagogies of informal science education environments and pushing back against the commonsense notions of facilitation as student-centered while teaching as didactic (dichotomies of formal and informal learning), the practice of reflective pedagogical creates space for multivocal and dialogic conceptions of teaching and learning. In terms of practice, the development of tools such as writing prompts and discussion questions should be embedded in local debrief practices and attend to the power relations between educators and learners. In terms of policy, this study aims to amplify the productive approaches to youth development and to advocate for the time, space, and resources to engage in reflective practice.

- END -

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## Appendix 1

August 3: Week 1, Day 1

Notebook prompt:

[Meg brings out the fused plastic notebooks and we look at their artifacts. We refer back to the “cheat sheet” as needed.]

Meg: Today, since it’s the **first day**, I thought we could just start by writing, and then after we write, talking about just **how you got to know the kids today**. Like maybe, a couple of the kids that you got to know, things that helped you get to know them, things you might have done to get to know them. Or, of course, **anything else that you feel like that needs to be discussed, questions**.

Trish: Yeah, there were lots of **different settings** – during lunch, during the project, on the floor. Different ways you kind of got to know the kids.

August 4: Week 1, Day 2

Notebook prompt:

Denny: They learned a lot of new stuff today. Uh, it’s pretty intense. Would you guys just **describe who you worked with today?**

Meg: The person or the interaction?

Denny: The **interaction**, so you can think about, you know, the **actual person**, or **what they were trying to do, how you helped them do it, if there was any advice you gave them, if there was any techniques you showed them**. All that can be included.

August 5: Week 1, Day 3

Notebook prompt:

Trish: Write about a way that you supported **either of the projects today, so sun prints or name plates**. Write about how you interacted, what you did in particular with certain tools with certain people.

Fan: And, like yesterday, focus on the **interaction** that you had with them.

Trish: When she says “interaction,” that’s like **two-way. How did they respond to you helping them?** How did they approach you, or did you approach them? That kind of thing.

August 6: Week 1, Day 4

Notebook prompt:

Denny: As they were designing their cars, **what did you notice about their designs?** What feedback did you give them, what kind of revisions did you give them?

Fan: This prompt is about them **moving from their design to their building**, what is it like to facilitate a creative process?

August 7: Week 1, Day 5

Notebook prompt:

Meg: Did any of the kids surprise you today?

August 10: Week 2, Day 1

Notebook prompt:

Trish: I thought we could write about **how you supported collaboration** today...in, I guess, more particularly, in the Marble Machines, but I noticed that folks were collaborating in the t-shirts, too.

Meg: You guys can begin with **where you saw the collaboration**, as well as how you supported it, too.

August 11: Week 2, Day 2

On this day, we replaced the notebook prompt with the *Debrief Questionnaire*.

August 12: Week 2, Day 3

Notebook prompt:

(Denny wrote this on the board) Who did you work with today? **What surprised you?**

August 13: Week 2, Day 4

On this day, we replaced the notebook prompt with the *Debrief Questionnaire*.

August 14: Week 2, Day 5

Since today was the last day of program, we did not put up a notebook prompt, but shared highlights and closing reflections from the day/summer.

Meg: What were your highlights from today?

## Appendix 2

### Debrief Questionnaire

*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.
  
3. Check any or all of these shared practices in the arts, sciences, and engineering that you noticed the students doing today. Choose 1 practice and write about an interaction you had around that practice.
  - asking questions
  - drafting/designing
  - experimenting/trying things out
  - iterating (making adjustments to a project)
  - noticing/observing
  - peer feedback (offering suggestions or incorporating others' ideas)
  - playing with or investigating things unrelated to project
  - reflecting
  - sense-making (gaining new understanding about STEM)
  - writing or drawing in notebooks
  - other: \_\_\_\_\_

## Appendix 3

### Discussion Guide for Daily Program Debriefs

#### **General Questions:**

- Did someone surprise you today?
- Did you have a particularly successful or frustrating interaction/moment with a student?

#### **Discussion Questions by Categories:**

(Questions in red were borrowed/edited from Molly Shea's Facilitation Discussion App)

#### Building relationships:

- 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 XTech space that you didn't expect?**
- **What did you learn about their experiences at school, home, or in their communities?**
- **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?**