“Deep Hanging”: Mentors Learning and Teaching in Practice

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Abstract: This paper is a comparative case study focused on the experiences of mentors in a chemical oceanography afterschool program. The study explores “deep hanging”—the term mentors used to describe their experiences learning about the culture of science, scientific research processes, as well as learning they could be- and become- scientists. “Deep hanging” entails authentic tasks in rich contexts, providing access, capitalizing on opportunity, and building interpersonal relationships. Data include reconstructive history interviews with mentors and video of their interactions with youth in the afterschool program. The conceptual framework for this paper explores the ways that constellations of situated events lead to changes in sociomaterial practices overtime. Findings suggest that surfacing and exploring mentors’ self-position with respect to STEM is crucial to understanding how they will position youth. These findings have implications for the design of learning environments that seek to broaden participation for non-dominant groups in the sciences.

Major Issues Addressed

Bringing educators and experts together to create rich disciplinary focused learning environments for youth has the potential to broaden youths’ pictures of the types of people who can do science (Barab & Hay, 2001; Hsu et al., 2009; Polman & Miller, 2010). These programs operationalize learning in practice by making ways of knowing and doing in the sciences visible to youth and engaging them in contemporary scientific practices. Youth from non-dominant communities face barriers to Science, Technology, Engineering, and Mathematics (STEM) learning based upon the ways that they are typically positioned with respect to the domain of science. Postionality with respect to science domains and practices interacts with race, Socio-Economic Status (SES), gender, English language learning, epistemological commitments, family expectations, and cultural repertoires of practice (Bell et al., 2009; Calabrese Barton, Tan, & Rivet, 2008; Czujko, Ivie & Stith, 2008; Hanson, 2007; Lee, C., 2007; 2008; Lee, O. & Buxton, 2008; Nasir et al., 2006).

This paper is a comparative case study focused on the experiences of mentors in a chemical oceanography afterschool program. This study explores “deep hanging”—the term mentors used to describe their experiences learning about the culture of science, scientific research processes, as well as learning they could be-and become- scientists.

Potential Significance of the Work

One approach to building broadening participation programming for youth from non-dominant groups entails bringing scientists and youth together. Broadening STEM participation is more than teaching youth about STEM practices, it also entails making the mores, expectations, values, and ways of being (Herrenkohl & Mertl, 2011) visible to youth. Delpit (1995) would refer to these hidden ways of being as codes of power. One way that designers of learning environments seek to make these codes of power visible is by leveraging experts in STEM fields to serve as mentors for youth. Mentors serve as models to make the practices of sciences visible and accessible to youth from groups traditionally underrepresented in the sciences. Scientists from non-dominant communities who have successfully navigated the societal and disciplinary barriers to participation are in a unique position to help youth understand what else it takes to be and become a scientist. The experiences of mentors from non-dominant groups have the potential to serve as resources for youth from similar backgrounds entering into the sciences. The rationale is that scientists who have personal experiences with complex scientific practices are well positioned to make ways of knowing and doing STEM visible to youth.

Unfortunately, there is a metaphorical black box around the social and cultural contexts that influence the developmental trajectories of scientists from non-dominant groups. From the point of view of novices to STEM fields, this black box obscures disciplinary practices and cultural expectations about STEM domains. For youth from non-dominant groups it can make pursing a career in science seem impossible. From the point of view of scientists from non-dominant groups it can obscure their connections to community. Our lack of knowledge about the processes that helped mentors come to participate in STEM means that designers of learning environments are ill equipped to design learning environments that leverage all aspects of mentors’ expertise to broaden participation for youth. Understanding what is happening for mentors in spaces where youth have access to identity building experiences has implications for the design of informal learning environments. As the learning sciences field strives to design “spaces” for youth to gain expertise in the sciences, a focus on knowing & doing is essential but fails to capture all aspects of learning. Studying the ways that learning environments foster the development of the kinds of people who can do science is integral to understanding the ways that they can help youth become the kinds of people who can *be* scientists.

This paper seeks to add to the growing literature on learning as identity development and deepening participation (Azevedo, 2013; Baron, 2006; Bricker & Bell, 2014; Herrenkohl & Mertl, 2011; Lee, 2007; Nasir, 2002; Nasir & Hand, 2006) to explore natural scientist mentors' experiences learning they could be and become scientists. Further, this paper seeks to establish a link between mentor's personal experiences and the ways they then want to introduce youth to the complex practices of STEM by focusing on identity development for youth in informal settings. Finally, there are implications for the ways designers, educators and researchers prepare mentors to work in informal environments designed to broaden STEM participation for youth.

Design Principles

The Chemical Oceanography Outside the Lab (COOL) Program is an ongoing collaboration between a Parks and Recreation afterschool space, an oceanography lab, and a Learning Sciences program. COOL is a design-based research initiative to introduce young women of color to practices of the geosciences through engagement with a six month long chemical oceanography afterschool program. The COOL program echoes design principles advanced by The Institute for Science and Math Education (http://sciencemathpartnerships.org/).

Designers positioned youth as developing experts and sought to build bridges from youth's everyday knowledge of science and technology to discipline specific modes of inquiry and participation. Designed learning spaces brought youth and experts into collaboration to accomplish projects that had personal, community and disciplinary relevance. We believed a learning ecology built around these commitments would place youth and adults into a robust and productive learning environment likely to enable shifts in youth identification with the domains of science. The theoretical framework used in this paper explores the types of places, actions, and positions that lead to long-term changes in youths' sociomaterial practices.

Sociomaterial practices are social arrangements and material resources that together support particular lines of practice. In the COOL program, we created constellations of social arrangements that included people, materials, and activities to make complex science content. We took a peer reviewed paper about fish feminization in the Pacific Northwest (Johnson et al., 2008) and created a mapping activity that would allow youth to collaboratively create a representation of the locations and numbers of feminized dish. Then we overlaid maps that showed population density and wastewater treatment overflows. Once students participated in building this representation they came to the same conclusions that the scientists did in the discussion section of their paper. This sociomaterial arrangement of materials, people and activities allowed youth to participate in data analysis and think in ways that scientists did about their data.

Theoretical and Methodological Framework

Theoretical Framework

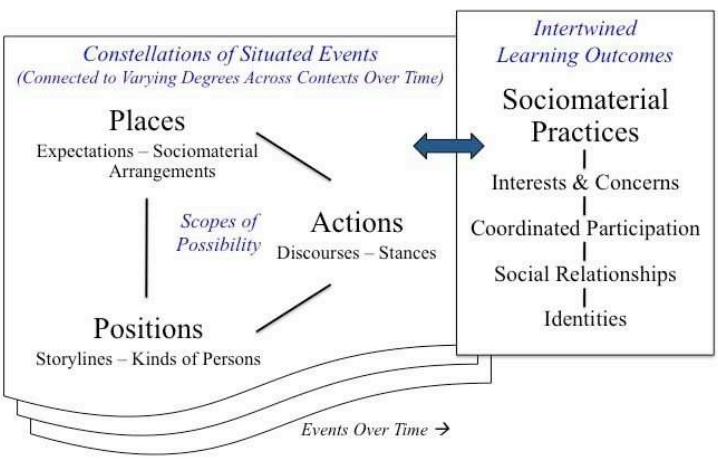

Figure 1. Cultural Learning Pathways Framework (Bell, Tzou, Bricker, & Baines, 2012).

Youth centered learning environments that leverage experts as mentors can offer youth opportunities to think like scientists, engage in authentic practices, negotiate identities, answer personally relevant questions, and learn about disciplinary specific cultural tools (Calabrese Barton, Tan, & Rivet, 2008; Cornelius & Herrenkohl, 2004; Tabak & Baumgartner, 2010; Cornelius & Herrenkohl, 2004; Polman & Miller, 2010). Harré et al. (2009)

defined positioning as a triangle of speech acts, storylines, and stances taken together these constructs shape the ways individuals develop within structures of social practice (Dreier, 2009). Positioning theory frames the ways that constellations of interpersonal interactions and social learning facilitate shifts in sociomaterial practices over time (Bell, et al.,2012). The conceptual framework for this paper focuses on the constellations of situated events on the right hand side of figure 1 below (Bell et al., 2012). As youth and mentors interact in a learning environment designed to allow for co-constructed moments of coordinated participation in chemical oceanography practices, we can observe the ways that mentors and youth access to places, positions, and discourse shape their scopes of possibility. Specifically we can observe ways that mentors' moves grant youth access or constrain opportunities for youth to participate in chemical oceanography practices.

Participants

Three professional scientists participated in the program as mentors to youth. These mentors were all women from groups traditionally underrepresented in the sciences (one German Latina, one Bolivian American, and one Diné). They were in the process of or had already attained graduate degrees in the sciences. There were fourteen female participants from sixth and eighth grades in the afterschool program (eight African-American, two White, one Filipina, one Asian-American, two Latina).

Table 1: Mentor Participants

Mentor	Ethnic Affiliations	Educational Background	Current Position
Eva	German & Latina	MS in Aquatic and Fisheries Sciences	Student and enrollment services director at local university, Director of a STEM enrichment program
Jessee	Diné, Hopi & Ute	MS in Molecular & Cellular Biology-Developmental Biology; MIT Secondary Education	Upward bound student services educator for local community college
Angelica	Bolivian American	MS in Botany; MA Museology	Research Analyst at Museum Consulting firm

The description of participants would not be complete without a description of my own positionality with respect to this project. As an Afro-Caribbean woman, I had many things in common with the largely African-American eighth grade COOL participants, as we were all members of the African Diaspora. Yet, as an Afro-Caribbean woman and an adult I was not a full community member able to leverage in-group language, references, or certain shared repertoires of practice with the youth participants. Within the COOL program, I was a full participant observer. I co-taught and co-designed the curriculum. During COOL sessions, I often took on the role of lead instructor. With the mentors in the program my role was that of pedagogical mentor and guide into the world of science education. Eva, Jessee, Angelica and I spent many hours debriefing the program sessions. We would talk about individual youth's developmental learning trajectories, flow of lessons, youth development, and pedagogical moves. Eva and Jessee have both gone onto teaching roles in the local community and I have continued my role as pedagogical mentor. This largely entails fielding questions about problems of teaching practice, approaches to teaching STEM content, and youth development work.

Outside of COOL sessions, I coordinated the program, liaised with mentors, school administrators, teachers, parents, and family members. I organized field trips, managed supplies, made calls to collaborators, and facilitated the successful completion of the COOL program from end to end. These positions gave me a unique perspective on the program activities and an intimate relationship with youth and mentors that had a positive impact on the interviews, my perspective on COOL sessions, and my analysis of program data.

Methods

The data used in this analysis were collected during the second year of the COOL program. Data sources for the analysis in this paper included field notes of mentor and student interactions, and 1.5 hours of interviews with youth and adult mentors. The entire data corpus includes over 33 hours of video, field notes for each program session, mentor and youth written reflections, and 6 hours of interviews. The interviews chosen for this analysis were the reconstructive history interviews with mentors conducted at the beginning of the COOL program in fall 2010. All interviews were transcribed and analyzed using a hybrid of emergent coding and codes built using the cultural learning pathway framework (Bell et al., 2012). This analysis surfaced a mentor generated analytical construct that will be explained in greater detail in the next section.

“Deep Hanging” became an analytical construct for understanding the ways that professional scientist mentors positioned both themselves and the COOL program participants with respect to science: as an enterprise and as a set of practices. Once a Deep Hanging profile had been built for each mentor, I returned to the video of mentor and youth interactions from the afterschool program sites and coded for ways that mentors positioned youth through stances, sociomaterial arrangements, actions. I also leveraged possible future selves (Markus & Nurius,1986) as a way of linking mentors’ past experiences with ways that they envisioned themselves working with youth and the ways they were able to see themselves as people who could be and become scientists through their Deep Hanging experiences. We surfaced places, actions, youth, and mentor positions related to STEM practices.

Major Findings, Conclusions and Implications

Deep Hanging

“Deep Hanging” (DH) was Eva’s term. She used it to describe her learning experiences and the ways that she was brought into science and recognizing that she could be- and -become a scientist. She referred to the research cycle—i.e. the things that scientists do to complete a research project—in her description of her learning process. Eva maintained that while your advisor should facilitate this process it is actually through the interaction with peers and “just being part of it” that people learn complex scientific practices. Eva described a process of learning in practice. The question of where you can learn to fit into the culture of science was a recurring theme in interviews with other mentors and related directly to the ways they positioned themselves with respect to science. The following quote is Eva’s response to a question about how people learn complex science practices.

> I think part of it is the “deep hanging” that you do. Ideally, it should be through the mentorship of your advisor…Your peers are going through the process, you’re discussing things…So being able to understand where you fit within that cycle, I think comes from just being part of it. I think a lot of it is the socialization that happens (Eva, 2011).

Eva described a socialization process that does not happen through direct instruction from a more competent other- from your advisor but it actually comes from “just being a part of it.” Learning to be and become a scientist happens in practice. As a research scientist, Eva participated in the culture of science within her lab and used science to make sense of the world.

She acknowledged that the professional definition of science that was not made accessible to everyone. “When we say science it has the Western academy picture behind it but that is not the only way of knowing or doing that helps us make sense of the world” (Eva, 2011). Eva believed that being able to see yourself as the type of person who can do science was key to the actual practice of doing science, and she is not alone; Herrenkohl & Mertl (2011) also described learning as a process that entailed knowing, doing, and being. Eva’s words challenge us to recognize that knowing and doing are not the only important aspects of becoming a scientist. DH recombines all three components- knowing through doing facilitated by being in relationship with others.

Deep Hanging as Eva described it was a process that helped change her sense of who she could be and become. This construct has four interconnected characteristics as Eva described them: Deep Hanging entails 1) authentic tasks in rich contexts, 2) direct access and engagement with novel practices, 3) leveraging interpersonal relationships to facilitate participation, and 4) interpersonal relationships that encourage shifts in identity and deepening identification with the discipline. I will use DH going forward to explore the STEM induction experiences of mentors in the 2011 COOL cohort.

Lave & Wenger’s (1991) Legitimate peripheral participation (LPP) might seem like an explanatory framework that could encompass Deep Hanging. Similar to LPP, DH entails having a purposeful activity within an ongoing complex practice. Eva was a technician in a local research laboratory and this role meant that she was engaged in purposeful activity during her interactions in the lab. However, there are a few key differences between LPP and DH. LPP has a definite telos- novices join the community of practice with the intention of becoming central participants i.e. moving ever closer to the center of practice. The LPP model when applied to mentoring in STEM presupposes that the goal of STEM education is to produce new STEM practitioners- specifically bench scientists. The “Pipeline” metaphor is an often used to describe the desired outcomes for broadening participation programs. Blickenstaff’s 2005 literature review describes the reasons that the pipeline intended to carry people from an interest in STEM through high school, college, and into a STEM career disproportionately leaks women at multiple points. Given this framing, interventions would aim to plug the “Pipeline” in such as way as to allow women to stay in the pipeline all the way into careers in STEM disciplines. This framing suggests that people who leave bench science to pursue other STEM related career paths (education, communication, or policy) have fallen out of the “leaky” pipeline. By this metric, none of the mentors who participated in the 2011 COOL Cohort would have been qualified to mentor youth because they did not reach the center of STEM practice. I reject this framing of the COOL mentors because they were each negotiating new spaces for continued and broadened participation in STEM fields.

The mentors in the COOL program were not passive drips falling out of the STEM pipeline. They were agentive decision makers who chose to step away from the bench to bring youth into the practices of STEM by sharing their professional and disciplinary expertise. Their goals were to make visible and accessible to youth from groups traditionally underrepresented in the sciences the complex practices of science. By sharing their own journeys into science careers along with lessons learned along the way the COOL mentors shared more than the master novice relationship with youth in the program. The COOL mentors were pushing for the youth to have had enough experience with STEM practices and identities to make an informed decision about what they wanted out of their own interactions with STEM. Their stance echoes a more expansive version of STEM literacy advanced by Noah Feinstein (2009, 2010) and Joseph Polman et al., (2012) who suggest that STEM literacy needs to be functional in the lives of students as community members and individuals making decisions that have impacts on their health, communities, and career trajectories.

Both Angelica and Eva had mentors who provided direct access to novel practices. They both choose to engage in those practices with their mentors. Angelica spent time reading articles with her mentor in a context where she felt comfortable and encouraged to ask questions and develop new skills. Eva was invited to participate in lab meetings and join the full practice that was taking place in her research lab above and beyond her role as a scientist. Deep hanging also hinges upon interpersonal relationships in a nuanced way. Relationships with experts who serve as mentors helped Eva, Angelica, and Jessee deepen their participation in STEM pursuits. Jessee found her mentor in middle school. Her mentor spoke with Jessee's parents about letting her join a summer science program for girls. While their mentors provided access, it was up to Jessee, Eva, and Angelica to decide take up these practices. The other aspect of relationships translates directly into the COOL space. For Eva, Jessee and Angelica, relationships with scientists helped to shape their ideas of who they could be- and become. Eva got to know the scientist in her lab while they were working together on purposeful project; "there was that interpersonal space being brought into your professional setting. I really got to know them and to understand why they were in graduate school" (Eva, 2011).

Within Project COOL, findings from analyses of the impact of mentor Deep Hanging with youth show youths' broadening understanding of what it meant to participate in STEM, growing sense of identity as participants in the work of the chemical oceanography laboratory, and more generally an identification with the discipline. Findings on mentor learning indicate that mentors made shifts in their pedagogical and sociomaterial practices throughout the course of their involvement. In alignment with the cultural learning pathways framework (Bell et al., 2012) we saw changes in the interests and concerns of mentors, as well as the ways in which they coordinated participation in activities and deepened social relationships. This in turn allowed for mentors to reflect on how their identities as scientists, mentors, and educators changed through their participation in the hybrid learning environment.

What Deep Hanging Means for Mentors Positioning Themselves

The mentors in our program had their own complicated relationships with science. Mentors described the effects of the black box on their self-positioning with respect to science and the sense of responsibility they felt to their communities. Eva described science as a selfish proposition and one that caused culture clash "often in academic science, it's a very selfish endeavor that really goes against the grain…that's not the values we were raised with so you know there's lots of culture clash when you to get to academia" (Eva, 2010). Here Eva was discussing the ways that she found it difficult to reconcile her identities as an agent of change for her community and as a bench scientist.

COOL connected with Jessee, Eva, and Angelica, as they were each choosing to veer off of the traditional STEM career pipeline. Jessee came to our program after deciding to change her career path from a PhD in bench science to leaving with a Masters in science to join the Masters in Teaching (MIT) program at the same university. She used her hours in COOL to count towards the mandatory student contact hours necessary to enter the MIT program. Eva has just finished a Masters degree in fisheries science and was transitioning into a position in a laboratory as outreach and education manager. Angelica was finishing a Masters degree in biology and transitioning into a Masters in museology. These transitions away from exclusively pursuing bench science were connected to changing positioning for all three women (see Table 1 above).

Eva was the most directly aware of the impact of privileging the Western definition of science when working with youth from communities traditionally underrepresented in STEM.

> There are people within the western academy who want to hold on to the profession, to the definition of science. I've seen that play out in a couple of different ways. What I think is so important for the girls' identity building is to see that they *can* do science, that there is an option, and that the practices they engage in are like science- in this way. When we say

> science it has the western academy picture behind it but that is not the only way of knowing or doing that helps us make sense of the world (Eva, 2011).

In the above quote Eva positioned herself as someone who pays attention to privileged ways of knowing within the Western academy's definition of science but goes beyond to incorporate other ways of STEM sense making. This was a storyline for Eva, where she saw herself as a type of person who challenged what it meant to engage in science and inherently as the kind of person who facilitates a broader sense of learning for the youth she works with. Part of this came from Eva's position as a woman of color whose role as community builder was a central part of her identity, part of this stance came from her journey of learning a disciplinary specific set of scientific practices, and all of these things came into play as she took up her role in the COOL program.

Deep Hanging played a role in the lives of other mentors as well. Angelica came to the COOL program seeking to learn more about teaching science. She was finishing up her work in a biology lab with a Masters degree although she also came into the program seeking a PhD. Angelica was applying to a museology program at the same university. Angelica described a similar process of finding a mentor who helped her see herself as the kind of person who could be and become a scientist. However Angelica's learning in practice did not happen at the lab bench. Angelica foregrounded the sense of encouragement and comfort level she felt having conversations with her ecology professor about scientific papers. When she met with her mentor they would read and discuss articles together. Angelica described this time as pivotal to her development as a scientist because this helped her to feel confident as a consumer of scientific research. This comfort led her to envision a role for herself in creating scientific research.

These Deep Hanging experiences played out in the ways that mentors worked with youth in COOL. For Eva this meant that she valued the downtime, always came early to spend time with youth before the program started, and excelled at pulling in these of things into the COOL activities. Once the young women were talking about curling their hair and later in the day Eva used curlers as an analogy to describe the internal make-up of the Gas Chromatography machine. Angelica's DH experience meant that she was attuned to seeking and creating a sense of comfort paid most attention to the quietest participants and made sure that all students felt comfortable participating in games and scientific discussions. Angelica leveraged her language expertise and spoke Spanish with youth to make it more comfortable for them to participate in activities and encouraged them to share their ideas with the group.

What Deep Hanging Means for the Ways that Mentors Position Youth

The mentors all came to the COOL program at a time when they were questioning their own position with respect to STEM careers. Angelica and Jessee were particularly disillusioned as a result of negative interactions with their academic advisors- who were also running the labs they were participating in. They were in essence flirting with stepping outside of the black box. This tension made these mentors particularly aware of the ways that COOL as a broadening participation effort positioned youth. Broadening participation efforts can be built upon assimilationist metaphors, and focus on making sure that youth from non-dominant groups gain access to dominant ways of learning in practice. The COOL mentors viewed broadening participation in more expansive ways. Their vision included broadening the concept of what it meant to participate in STEM, suggesting that the ways that mentors position themselves with respect to science is crucial to understanding how they will go on to position youth.

All of the mentors in the program talked about the ways that they wanted the youth to see themselves as capable of becoming scientists. Youth from non-dominant groups may look at the black box of STEM from afar and make a decision without any knowledge of what kinds of possibilities it might hold. In essence mentors wanted to make sure that youth could make choices about participating in STEM careers with knowledge of what was inside the black box. In response to a question about the role she wanted to play Angelica said she wanted to:

> Just to be the kind of person that would excite students about a subject and then make them feel that you know they could do it to and feel that they could really go on and be successful or even just think that they could be a masters student or a doctoral student. Kind of like a guide, that's how I saw myself (Angelica, 2010).

Another mentor, Jessee put it this way:

> "Or even for them to realize, hey I don't really like science, I can do science. But it's not something I want to …to be able to actually comprehend the long term interest in science would be amazing, for me to see that, and to actually see that that's actually possible" (Jessee, 2010).

Neither mentor discussed the pipeline as a goal nor STEM careers as the endpoint for youth STEM participation. They wanted youth to leave the program with a new storyline about themselves as science participants who could go on to learn and do more science. Mentors' picture of broadening STEM participation for the youth in our program connected more deeply to the concept of "possible future selves" (Markus & Nurius, 1986).

Positioning youth as people capable of doing science and becoming scientists as opposed to future scientists within existing STEM paradigms balances the need to honor student agency while creating authentic access points to discipline-linked STEM participation. The mentors in our program were uniquely positioned to manage this tension. Here mentors' own experiences with learning scientific practices and managing tensions between assimilationist models and making their own meaning comes out. Jessee's comments highlight this tension, " hey, I don't really like science, I can do science" demonstrates this nuanced picture of what she wants for the students she mentors. Mentors in COOL pushed youth to find science personally relevant without letting go of the scientific rigor and this led to youth participants making comments like "scientists do what we did," when we asked them to describe a scientist in follow up interviews.

Implications

The above findings- specifically the role of Deep Hanging in shaping mentors' motivations can help us better understand what mentors are trying to do when they work with youth. By engaging mentors in reconstructive history interviews about their STEM induction experiences we can gain insight into the ways that they will work with young people. As a design strategy we have turned mentors into reflective practitioners with the ability to think about their own experiences of learning in practice. With programs like COOL, our design goal is to get youth into the black box, or at a vantage point to the black box for long enough to make informed decisions about their continued STEM participation. To achieve these ends, we want scientists with expansive attitudes to broadening participation and what it means to participate in STEM. Within the world of teacher education the apprenticeship of observation (Grossman, 1991) is the term used to describe the link between an individual's histories of learning which in turn prepare them to work with learners in particular ways. This study intimates that this holds true for disciplinary mentors. They learned they could be and become scientists through Deep Hanging and used this construct to position and work with youth in the afterschool program.

Warren, Ogonowski, and Pothier (2003) explained that researchers and teachers in their work with young people from non-dominant communities in the sciences, "had to work at learning to see and hear the intellectual substance" (p. 143) in their students' contributions. This reframing from "student as deficit" to placing the onus on teachers and researchers to remediate their visions of science learning and participation is a valuable change. It requires adults working with youth to make changes rather than expecting youth to do this alone. Thus creating another hybrid space where youth and disciplinary expert perceptions and participation are honored. The findings of this study go a step further to encourage the design of environments where mentors can position themselves as bridge builders not gatekeepers. Broadening participation in COOL means more than just teaching youth to do the things mentors or scientists do. It also means broadening the picture of what it means to participate in STEM.

Asking questions about disciplinary expert meaning making in programs intended to broaden participation is one way to begin this work. Future work could chart the ways that disciplinary experts are prepared to leverage youths' cultural and out of school identities into STEM learning contexts by exploring their past STEM learning experiences. Additionally, we can work to understand how experts and youth position one another with respect to STEM disciplines. Finally, we can look into the ways experts view the STEM practices of youth in relation to their own disciplinary practices.

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