





Disruptive moments as opportunities towards justice-oriented pedagogical practice in Informal Science Learning

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Abstract

Despite the promise of Informal Science Learning settings (ISLs) in supporting youth science engagement in ways that value their experiences and communities, in practice, such opportunities are limited. While some ISLs promote more culturally relevant approaches to science engagement, many still reflect White supremacist and patriarchal worldviews in discourse and practice. In Research Practice Partnerships, we engaged eight ISL educators from two partner sites—a community center and science center, and youth from across their six programs. Using participatory ethnography we explore how educators' pedagogical practices supported youth in codeveloping more justice-oriented ISL experiences—experiences which disrupt these dominant and oppressive norms. Our analysis pays attention, in particular, to those fraught moments when youth, in interaction with peers and educators, sought to disrupt their ISL experience in ways that centered and amplified their lives, hopes, and desires for being and learning in ISL and humanized the ISL learning community. Two kinds of pedagogical response patterns emerged that we report on

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in our findings: (1) *collaborative critique* and (2) *critically being with each other towards new relationalities*. We discuss how these two practices centered political and ethical dimensions of teaching and learning, fundamentally shifting power and relationalities towards new ISL possibilities. We also discuss how these practices involved leveraging specific moments to resee youths' activities in new ways, making visible how an ISL space limited opportunities for youth visibility of presence in science—a kind of pausing for justice.

KEYWORDS

equity, Informal Science Learning, justice, pedagogies

When I'm here [at science club] I feel like I can be me. Like, it's not judgmental here. We get to learn and do things and experiments and make things that are real, and they help people... When people see [my light-up dog leash] and they use it, they'll say I did a good job, and I stood up for myself. They'll say I worked hard, and I'm really good at science, and like caring for dogs and people. It's weird because I didn't even like science, but it felt different here to make something for dogs. Mandana, age 11, Arab-American

1 | INTRODUCTION

Mandana's comments offer insight into how and why engaging in Informal Science Learning environments, or ISLs, can benefit youth, providing crucial and powerful access to science opportunities. Her quote, which shows how she feels accomplished and recognized for her efforts to help dogs in a place where she can be herself, speaks to her developing sense of self in science, and her positive feelings about her after school science club. It also highlights how she used science to stand up for herself. Of additional note is how this quote stands in contrast to how she described her experiences at school. Mandana held low views of herself in sixth grade school science class, and said she often felt "invisible."

We begin with Mandana's quote because her experiences are not unique. For many Youth of Color, like Mandana, for whom school science has been marginalizing, ISLs have fostered meaningful opportunities for engaging in science (Deschenes & Malone, 2010). Many youth, like Mandana, want to be welcomed, and seen as whole people, with valuable knowledge, practices and experiences that matter in science. ISLs, like Mandana's after school club, have been held up as spaces that promote greater equity in science learning opportunities. Many of these programs are built around youths' interests, and reach youth during pivotal times in their academic trajectories, such as the middle grades (Bevan & Dillon, 2010; Bricker & Bell, 2014).

However, despite the promise of ISLs in supporting youth in engaging in science in ways that value their lives and communities, in practice such opportunities are limited (Feinstein, 2017). While some ISLs work to promote more culturally relevant approaches to engaging in science, many still reflect White supremacist and hetero-patriarchal views of the world through the discourses and practices legitimized there. Oftentimes, when educators enact these discourses and practices they are not meaning to intentionally exclude or oppress youth—even though they do—it is likely that they are not aware of how entrenched these dominant norms may be.

Using critical ethnography within the context of participatory design with informal educators and youth, we explore how educators' pedagogical practices supported youth in codeveloping more justice-oriented ISL experiences—experiences which disrupt these dominant and oppressive norms. Our analysis pays attention in particular to those fraught moments when youth, in interaction with peers and educators, sought to disrupt their ISL experience in ways that centered and amplified their lives, hopes, and desires for being and learning in ISL and humanized the ISL learning community. We refer to these moments as fraught because they often exposed, disrupted, and sought to transform such dominant norms—the discourse, practices, physical and social representations, and power relationalities normalized by the White, heteropatriarchal narratives and practices which dominate ISL spaces.

We ask:

- What pedagogical practices do ISL educators take up in their efforts to notice and respond to youths' disruptions?
- How do these pedagogical practices shape youths' opportunities to engage meaningfully in ISL?

Few studies have examined the role of pedagogies in ISL. Our work is grounded in a 4-year study, where, working in research + practice partnerships (RPPs), we collaborated with middle school aged youth and ISL educators in two different ISL settings—a community center and a science center—in a mid-sized midwestern city in the United States. Involving both youth and educators in our RPPs is central to our efforts as studies of pedagogy in ISL have not centered the voices and perspectives of youth or educators as integral to knowledge formation for the field (Penuel, 2017). Taking an historicized yet future-oriented proleptic and participatory approach (Gutiérrez et al., 2017), we hold the stance that educators and youth are colearners, codisruptors, and cocreators of a more just world with and through ISL.

2 | CENTERING JUSTICE IN ISL

2.1 | Beyond inclusion: Working towards a rightful presence in ISL

A focus on equity in ISL has gained increasing attention over the past decade (Feinstein & Meshoulam, 2014). The vast majority of ISL equity efforts focus on inclusion, or supporting increased access and opportunities to participate in a wide range of ISL experiences. However, recent studies have shown that *how* youth are included in ISL makes a difference in whether or not youth are welcomed as fully legitimate members of their ISL communities (Shea & Sandoval, 2020).

Many youth do not feel like their *whole person* is invited into ISL. Their feelings, experiences, histories, hopes, and fears are often not integral to what happens in ISL. When people are denied their whole selves in learning, their lives and histories can be partially or completely erased from science (Bang et al., 2012; Herrenkohl & Bevan, 2017). This erasure can result from ISL experiences which center or reinforce dominant cultural norms in science (Bevan et al., 2019). These norms limit possibilities for seeing youth for who they are and want to be in ISL. They can position youth as outsiders, diminish opportunities to learn and become, and limit collective growth and transformation. Youth of Color, youth from low-income communities, youth who are undocumented, and youth who speak languages that institutional power holders do not, can face dehumanization in ISL on a daily basis due to its colonizing and racist histories (McGee & Stovall, 2021). Consider Dawson's (2014) illustration of how staff in science museums/centers “reinforced” a “preexisting sense” of alienation by scolding younger visitors for how they engaged the exhibits, and by assuming visitor background knowledge (p. 981). These kinds of studies help researchers better understand *how* ISL may oppress through how power-mediated norms of being/interacting take shape in local practice.

We thus question how youth may be more fully welcomed in ISL as *rightfully present* (Calabrese Barton & Tan, 2020). We see rightfulness as claimed through youths' fully legitimized presence, in the sense that power relations shift so that youths' lives—their ways of knowing, doing, acting, talking, and being—become integral to



learning. The outcomes of learning would also shift, attending not only to individual gains but also to the kinds of social transformations that allow for presence to thrive (Calabrese Barton & Tan, 2019). This justice-oriented framework, while acknowledging the importance of access and opportunity, thus challenges the underlying power relationalities that shape what learning, engagement, and participation look like.

Working towards recognizing rightful presence thus requires a commitment to allied political struggle—the work of educators and youth collaboratively seeking and securing more equitable power redistribution to dismantle asymmetries and to critique unjust systems that uphold them. This means educator-and-youth, as accomplices, work to make visible and present the whole of youths' lives. Often in our work, we see this initiated by youth critique of an injustice experienced in a learning space, or by a disruptive act that effectively pauses a group learning interaction. As educators, we know how such moments can present themselves as uncomfortable or inconvenient challenges just as easily/often as delightful surprises. We also know that even when committed to justice, pedagogical practice is imperfect, and power is not always shared in humanizing ways despite any individual's best efforts. As researchers and educators, we know how our responses to such moments can play into discriminatory patterns of discipline that reproduce injustices. We argue that where adult educators take up such moments as a youth-initiated call to action and/or reflection, disruption can become collective and transformative within the learning community towards justice-oriented outcomes.

We are thus deeply concerned with the ways in which youth seek to make their rightful presence visible in ISL. In this manuscript we have sought to make sense of those moments where youth actively disrupt dominant norms in ISL experiences, how such moments may be noticed and productively responded to by their educators, and how these moments impact not only those youth who initiated these moments, but the broader learning community itself. We are not suggesting that it is the responsibility of youth to foster the kinds of social transformation in ISLs needed to bring about justice. But, to not recognize or work to support what youth are seeking to make present would be to erase or minimize their lives and/or desires. We focus on these moments and educators' pedagogical responses to them because even though the educators we worked with are committed to equitable practice, focusing on these fraught moments offers insight into how educators may learn to further develop their pedagogical practice through them.

2.2 | Response-ability: Conceptually framing justice-centered pedagogies

How educators pedagogically notice and respond to youth involves a kind of “response-ability”—that is, “to witness beyond recognition” and “to enable response-ability from others” (Villenas, 2019, p. 156). There is a small but rich body of work in science education that offers insights into justice-centered pedagogies in ISL. Much of this study has offered important insights at the intersection of epistemic and sociocultural aspects of teaching and learning. For example, studies highlight the importance of assets-based and participatory pedagogies, which seek to respect and value youth and community knowledge and resources in their science learning and engagement. To illustrate this point, in a study that examined the interpretations and perceptions of Black girls who participated in a community-based science programming, King and Pringle (2019) show that Black girls thrive in their science learning when legitimacy and counterspaces are fostered for Black girls to make connections, critique, and build new understandings about the informal and formal learning environments within the context of their everyday lives. Other studies have focused on the importance of reorganizing the hierarchical binaries of what/whose knowledge, experiences and voices matter in science while supporting youth's learning, engagement and agency (Calabrese Barton & Tan, 2010; Rahm, 2014). These studies open up new ways for understanding how educators can stand with youth from nondominant communities, including Youth of Color, youth from low-income communities, youth who are undocumented, and youth who speak languages that institutional power-holders do not. They point to how the equity agenda in ISL has to move beyond inclusion to a reconstruction of ISL itself, acknowledging that youth already contribute powerfully to its coconstruction.

However, there is limited work in science education that focuses on how these epistemic and sociocultural dimensions of teaching and learning interact with the ethical and political. Just because youth seek to disrupt and transform their ISL learning experiences, does not always mean that it is taken up in productive ways by those in power. Consider Shea and Sandoval's (2020) argument that it is important for ISL educators to develop understandings of political and historical injustice and to make these understandings central to pedagogies that support young people in taking back science within their communities. Using the work of nine informal educators, they show how equitable pedagogical strategies are grounded in the understandings of the specific political and historical injustices that the working class Latinx youth they served faced. They illustrate how educators created a space of "affirmation" and "care" that, when combined with "macro-level political critiques," supported youths' deep engagement in science along with new opportunities for "dignity" and "belonging" in their ISL program (p. 45).

Our focus on the political and ethical in *pedagogical practice* is grounded in conceptual frameworks of consequential learning precisely because of its focus on power in relation to learning and social transformation (Calabrese Barton & Tan, 2019; Gutiérrez, 2012; Jurow & Shea, 2015). Consequential learning calls attention to how people engage science towards affecting people's lives, social relations and possibilities (Vakil, 2018). It focuses on how people author meaningful forms of engagement, rooted in both community knowledge, practice and wisdom, and deepening disciplinary engagement (Birmingham et al., 2017). Such practice challenges and changes sanctioned modes of participation for individuals and collectives across scales of activity. Contentious power-mediated tensions arise as people, ideas, and histories come into contact, along with the critical awareness and reorganization of power relations that can sometimes result.

We thus consider youth as coconstructors of their worlds in their everyday lives and efforts to learn about and take action in relation to their worlds with and through science. In politically and ethically engaging with youth pedagogically, possibilities begin to exist for normative routines to be disrupted and transformed. This study involves educators and youth working together to challenge and transform what participation in science can be, or what meaningful representations of learning look like, in ways that humanize participation and value youths as whole people. These disruptions and transformations can change whose knowledge, practices, and experiences matter. Educators play a crucial role, not only as representatives of powered domains, but also as people who can give witness to youths' efforts to be more fully and legitimately present in ISL.

We focus on pedagogies because they are front-facing structures that shape young people's opportunities to learn and become in ISL. We are further concerned with pedagogies that youth help to coconstruct because this is a vastly understudied area in the field of ISL. We seek to make sense of pedagogies that center the importance of having one's lived life—including fraught histories and collective community wisdom—as integral to learning and engagement in ISL.

3 | METHODS

Our study was carried out as a critical ethnography situated within a participatory design approach. Critical ethnography is a justice-oriented methodology, with an explicit focus on participatory critique and social transformation (Trueba, 1999). Critical ethnography foregrounds power dynamics in a given community and the multi-layered factors affecting power dynamics, including actors (e.g., youth, educators, and administrators), institutional norms and practices, and culture and history of the institution and actors. Our work is also situated within participatory design as we seek to include multiple voices at the research and design table, including youth and community educators (Tzou et al., 2018; Vakil et al., 2016). Using participatory forms of critical ethnography, we sought to empirically examine inequalities from multiple perspectives and collectively work toward transforming these inequalities. This approach was important as we attempted to make sense of how ISL educators engaged with youth who are positioned in particular ways due to race, gender, and class.



We approached this study, knowing that our positionalities lead us to have only partial understandings of the knowledge, practice, wisdom and experiences of partners. We are a group of diverse women, in terms of our age, race and ethnicity, country of origin, home language, professional experiences, and locations. Four of us are White, two of us are Black, another Latina, and another Korean. All but one of us have taught science in the past, some of us in formal schools, some of us in ISL, and some in both spaces. We represent both university researchers and ISL educators.

We grounded our work in politicized trust and a shared vision of creating more equitable and just ISL spaces. By politicized trust, we refer to “actively acknowledging the racialized tensions and power dynamics inherent in design partnerships” (Vakil et al., 2016, p. 199). The concept of politicized trust was crucial as we sought to acknowledge and disrupt traditional power asymmetries existing between participants due to different positions in research and institutions, which would intersect with our racial differences. We sought to center our differences as a way to make visible new ways of understanding justice in ISL broadly as well as in our data generation and analysis (Cammarota & Fine, 2010).

For example, as we attempted to make sense of how ISL educators engaged with youth, most of whom are Black or biracial, and from low-income communities, our participatory critical ethnographic approach was important in helping us to identify and unpack our own assumptions, forms of privilege, and ignorance about youth experiences and perspectives. Central to our efforts were our long-time memberships in the local community, and time spent with youth and families in different contexts beyond the ISL programs studied. We have been able to learn with and from community elders, as they have mentored us for more than a decade in how learning happens with and in the informal networks and epistemologies which sustain community members. As we have worked to critically navigate intersectional power mediated boundaries, we have been offered opportunities to recognize and disrupt our unintended complicity in them. We also foregrounded *tensions in practice*, focusing on disruptive and transformative power embedded in the tensions toward realizing youth's rightful presence. We engaged in critical reflective dialog with one another and with youths and their parents to challenge and transform dominant normative experiences/assumptions underlying ISL discourse and practices.

3.1 | Context

Our work was conducted in a RPP with a regional science center and a community center, both located in a US midwestern city. We worked closely with eight educators and two directors of the respective institutions. The RPP structures facilitated the coinvestigation and enactment of pedagogical practices centering justice, or positioning justice at the core. Researchers observed, assisted, and codeveloped the informal science programs the educators implemented. Educators participated in generating, analyzing, and interpreting data to construct a set of pedagogical practices in support of youths' rightful presence. Directors offered institutional support for researchers and educators across institutions to engage in collective reflection on their practices and design and implement programs based on this collaboration. Youth were also integrally involved in planning sessions, as well as in data cogeneration and coanalysis.

In this manuscript, we focus on six science programs taking place in the two partner sites—a community center and a science center—during the years of 2017–2019 (see Table 1 program summaries and youth demographics). In these programs serving youth (age: 10–16), including programs serving predominantly Black youth and programs with fairly equal numbers of White youth and Youth of Color, youth engaged in different ISL opportunities with eight educators, some of whom participated in multiple programs. See Table 2 educator participants.

3.2 | Data generation

We cogenerated three sets of data with educators and youth participants in the six ISL programs: reflective conversations, educator portfolios, and researchers' ethnographic documentation.

TABLE 1 Partner programs

Partner institution	Program	Youth participants	Educator participants	Key features
Community Center	STEM Club	18 Youth, 15 Black, 2 Biracial, and 1 White youth, ages: 11–15	Maria, Starr, Taylor, June	<ul style="list-style-type: none"> • Meets twice a week after school, October–May • Weeklong Summer camps (during vacation) • Project-based
	Coders Hangout	10 Youth, 8 Black and Black-Biracial, and 1 White youth, ages: 9–11	Starr	<ul style="list-style-type: none"> • Meets once a week after school • Coding in multiple languages + app and website building
Community Center + Science Center Collaboration	STEM Mash-up	12 Youth, all Black & Black-Biracial, ages: 10–12	Addison, Starr	<ul style="list-style-type: none"> • Held at community club, taught by science center educator • Once a week after school • Inquiry-based
Science Center	YAC	20 Youth, 11 Black, 7 White, 2 Latinx, ages: 10–16	Olga Chris Addison	<ul style="list-style-type: none"> • Saturdays once a month, on-going • Youth codesign of science center experiences
	Forensics	50 Youth, multiple races, about 50% White, 50% Black, Biracial, Latinx, Asian, specific racial (information not available), ages: 11–12	Abe Addison Chris	<ul style="list-style-type: none"> • Once a week • Forensic science inquiry based
	Summer Camps	60 Youth, about 60% White, 40% Black, Biracial, Latinx, Asian, specific racial (information not available), ages: 11–14	Chris Addison	<ul style="list-style-type: none"> • Weeklong all day experiences • Inquiry & project based

Abbreviation: YAC, Youth Action Council.

TABLE 2 Educator participants

Educator participants ^a	Demographics (ISL teaching years)	Programs involved (institution)
Maria	White female (20+)	STEM Club (Community Center)
Starr	White female (10+)	STEM Club, Coder's hang out (Community Center)
Taylor	Black female (3)	STEM Club (Community Center)
June	Korean Asian female (2)	STEM Club (Community Center)
Olga	Latina female (20+)	YAC (Science Center)
Addison	Indian American female (6)	YAC, Forensics, Summer Camps (Science Center); STEM Mash-up (Community Center + Science Center collaboration)
Abe	White male (5)	YAC, Forensics, Summer Camps (Science Center)
Chris	White male (3)	Forensics (Science Center)

Abbreviations: ISC, Informal Science Learning; YAC, Youth Action Council.

^aParticipants' names are self-selected pseudonyms.

Reflective conversations. Reflective conversations helped us initially identify and come to a shared understanding of the moments in which youth moments manifested and educators recognized, supported, and amplified what youth sought to disrupt. Different forms of reflective conversations took place: (a) *Group conversations* included youth and educators, during program sessions, 15–20 min, video-recorded, (b) *end-of-day individual conversations* conducted by researchers with educators and youth, immediately after programs, 15–30 min, audio-recorded, and (c) *biweekly RPP meetings* of researchers and educators across institutions (and additionally at least twice during portfolio cogeneration per each program).

Educator portfolios. Each educator cogenerated an educator portfolio. The portfolio included planning documents, annotations about how their program sessions went, educator- and researcher-selected videos/photos of program implementation, youth-generated artifacts, and youth exit surveys. These data were used to enrich and complicate our understanding of educators' daily pedagogical practices and how they played out in the identified moments.

Ethnographic documentation. Researchers developed ethnographic data composed of their daily field notes (in either written or audio form) focused on educator–youth interactions, youth engagement, and educator actions. We also kept information on attendance, the norms and routines of programs, and materials.

3.3 | Data analysis

3.3.1 | Identifying moments

We attended to the importance of critical moments as an entry point to the insights regarding what they sought to notice, address, and transform in teaching practices (Luna, 2018). By moments, we refer to bounded actions and interactions that shifted the momentum of activity. While reflecting on actions and interactions—in our case, by having reflective conversations among researchers, educators, and youth, we identified those particular instances where youths' and educators' actions and/or interactions reflected a kind of political struggle which contested how legitimacy is manifested and which sought to make youths' lived lives visible and integral in their ISL. We simply called these instances “moments,” and they ranged in length from 30 s to 5 min.

The process of cogenerating moments involved youth, educators, and researchers. Youth from both the STEM Club (Community Center) and the Youth Action Council or YAC (Science Center) participated in the analysis through periodic reflective conversations on data and data analysis. For example, educators and/or researchers sat down with youth from these two programs, both individually and in groups, to discuss their experiences in ISL programs, and to support youth in identifying moments they felt were critical to their engagement (or disengagement). Any moment a youth, educator, or researcher identified as salient due to such disruptive and transformative messages was considered. For example, across reflective conversations with educators and youth, we utilized a set of questions that would help us identify moments. We described moments as instances that stood out to any of participants, youth, educators, or researchers because they seemed to make youth's lives and presence visible and integral (or not) to youth's ISL experiences (e.g., are there any "moments" in particular that you want to highlight? Why do those moments stand out to you?). If researchers identified moments that seemed meaningful, they would share that with educators and youth. Researchers and educators also later identified additional moments through biweekly meetings for data analysis of reflective conversation transcripts and educator portfolios.

Researchers and lead practitioners then held weekly analytic meetings. Different versions of analytic tables were developed in a sortable google spreadsheet. We organized moments by program, educator, and time/place with vignettes of the moments. This helped us document and codify youth actions/interactions that manifested as moments, educator practices in support of youth actions and interactions, impact on youth and educators (including tensions that emerged), and contextual features of moments. All other generated data (e.g., transcribed reflective conversations, educator portfolios, field notes) were also analyzed to surface additional insights on identified moments. Differences in analytic views were debated until new meanings were generated. A detailed list of emergent codes was kept with analytic memos which we then brought to bear on all identified moments. We identified 173 moments illustrating youth seeking a rightful presence in ISL spaces and educators' engagement with these youth efforts.

In identifying these fraught moments, two organic categories emerged: Moments in which educators' practices contributed to "opening up" (156 moments) or "shutting down" (17 moments) opportunities in response to youth disruptions. Greater emphasis was placed on opening up moments as we wished to make sense of the practices educators engaged in to support equitable and transformative engagement in ISL. However, we purposefully sought to identify shutting down moments to ensure we had comparative points.

3.3.2 | Identifying patterns of practices manifest in the moments

Zooming into the identified 157 opening-up moments, we narrowed the set to 60 for deeper analysis in relation to pedagogies. This winnowing process involved examining these moments from both youth and educator perspectives. For example, we selected those moments that youth described in reflective interviews as a highly influential moment, and/or that educators described as impactful in terms of soliciting a response or shift or sticking in a youth or adult's mind. Specifically, educators identified these moments as some of the "most challenging" and/or "most disruptive" moments of their teaching experiences during this study, and/or the most impactful in disrupting their teaching positionings/assumptions in-the-moment. We then developed these 60 moments into vignettes, further annotated by the key actions/interactions that occurred, the pedagogical practices educators used, and the impacts on the individual, the learning communities, and/or the program/institutional context as relevant to the analytic vignette. Over a series of meetings, we shared these vignettes with youth and educators to collaboratively further code educator practices across the moments. In doing so, we added codes that described how educator practices shaped youth learning and were shaped by youth actions. For example, eight major parent codes included: Sharing authority, recognizing, reclaiming, shifting narratives, reseeing, collective critique, critically being with, and humanizing. Within and across these parent categories, we sought to identify patterns that emerged in this phase included forms of practices that responded to disruptions (e.g., what educators did in relation to these themes, e.g., talk moves, disruption, transformative or reconstruction of structures, spatial configurations, etc.) to support youth



experiences (e.g., expanding participation, expanding social networks, supporting youth action taking) and disrupt power (e.g., knowledge hierarchies, participation, otherization, etc). Cross-category patterns led to the two patterns in pedagogies described in the findings.

4 | FINDINGS

Two kinds of pedagogical response patterns emerged that we report on in our findings: (1) *Collaborative critique* and (2) *Critically being with each other towards new relationalities*. Below we describe each pattern, including how these patterns made visible the political and ethical dimensions of teaching and learning ISL, using brief examples across our data set. Following each pattern description, we offer an in-depth analytic ethnographic vignette to explore how youth efforts are taken up and responded to in the moment, and how this shaped opportunities to learn for the involved youth as well as for the larger learning community. Cutting across these patterns we show how these pedagogical responses are directed towards shifting power—who has the power to name and legitimize what and who matters in ISL, how and why. We follow these descriptions with a cross-case discussion of how educators' pedagogical responses support youth efforts to disrupt and/or get recognized in learning interactions towards transformative possibilities for learning spaces and relationships.

4.1 | Collaborative critique

Across sites, we noticed that many partner educators engaged in a sustained practice of working to make sense of why youth sometimes seemed to resist or challenge activities and experiences in their programs. Educators took time to collaboratively make sense with the youth about what they were challenging and why (collaborative critique), and then to engage the youth in reorganizing participation forms and structures in response to those critiques.

By engaging youth in critiquing participation forms and structures, educators positioned youth as agentic people in ISL. Educators bore witness to that which was limiting or erasing youth presence in ISL, working with youth to remediate those limiting structures. As one educator, Maria, explained when reflecting on a particular moment with a William, a youth in the after-school science program she facilitated:

William threw down his bookmark during [our e-textile unit] declaring “this is STUPID! I want to make a fanny pack!” At first I thought he was just frustrated with how his circuit kept shorting. Using conductive thread is not easy. It frays and you can short circuit without even knowing it. He had been *so proud* that his grandma taught him to sew, and I didn't want to lose that connection. All eyes were on him as his peers stopped what they were doing and looked on.

In this comment Maria worried about how the challenges of constructing e-textiles might be frustrating for William. She wondered about all of the technical ways his e-textile project could go wrong. She describes how, in her uncertainty, she tried to make space to learn from William:

I just wanted to give him some space in that moment to express his frustration, but I also didn't want him to just give up. So, I just decided to take him at his word and ask, “What should we do? What do you need?”

Maria further explained that William said he wanted to make a fanny pack because it was “something real, something he was gonna actually use” to keep his prized possessions safe. Maria explained how his peers joined in, offering different ideas for why a fanny pack was a good idea:

After that, a whole group was making fanny packs, using William's pattern. While they were making, they started talking about an incident in the lunch room that day. One of the girls said a friend's purse got stolen at the lunch room, and another girl said, "You mean her *money* got stolen." That's when William declared "and that's why you gotta have a fanny pack." It was a powerful moment. I had not realized how much that meant.

Making a fanny pack did not change the technical challenges presented by e-textiles that William encountered with the bookmark. However, William viewed the fanny pack as a worthwhile space to engage with the technical and social dimension of the project he named. Also, layered into his new engagement were the potentials for the "afterlife" of his project—how his fanny pack might be used. Opportunities for this engagement expanded how William's cultural knowledge/practice (e.g., sewing, knowledge of his peers' needs) became legitimized in and hybridized as a part of his maker project, reshaping whose cultural knowledge had capital.

Maria's comment further reflected the stance held by educator partners who viewed youths' oppositional action not as a form of misbehavior, but rather as an effort to make visible what was unfair or inequitable in their learning spaces. Supporting William meant supporting a collective critique where William and his peers reimaged the task into one that made visible the ways in which e-textile making carried salience in their lives in that moment.

Partner educators noted that they did not always successfully respond immediately to youth, especially when a moment raised critical and multilayered questions around race, sexuality, power, and oppression in ISL that educators had not received explicit training around. For example, during a forensics unit one youth, Amir, called out, "Unless you're Black. If you're Black, you'll be convicted," during an activity focused on the fair use of forensics evidence in criminal investigations. Mr. A, the educator, told us that this moment hit him "really quick[ly], because it's a very powerful thing to say. But, at the same time, it's a challenging topic to talk about in front of a whole group of students, when all these students come from different backgrounds. I gave him a smile. I didn't want him to think that what he said was necessarily wrong." He went on to explain that in the moment, he did not consider ISL class "a place to bring up politics... a place to bring up that type of conversation."

Educators also described how they felt uncertain, and sometimes challenged, by those moments when youth seemed to reject their planned activities. Olga noted that "It's not that we think our activities are perfect, but when a youth resists you have to wonder, what is going on? What are they wanting or needing that I, or we as a whole group, are not providing?" These educators explained that when they recognized youth action as a call for educators to listen, they were able to reframe a wider range of youth actions as agentic modes of participation and meaning-making in ISL. In this way, disruptive action could be considered productive if it opened up possibilities for engagement that supported youth in ISL.

As educators noted, youths' actions called into question how the traditional discourses and practices in ISL marginalized their lived lives and their communities. We thus view collaborative critique as a powerful way of opening up new discourses and practices that push back against the dominant norms that shape experience in ISL. This practice positioned youth with the agency to be "partners and active designers of their own learning experiences," where their intellectual and cultural resources were leveraged and legitimized as "positive meaning making practices" (Wright, 2019, p. 1341).

4.1.1 | Exploring collaborative critique through Chris' practice

Below we explore how collaborative critique played out during a Saturday youth STEM club session at a science center, and how this shaped youths' opportunities to engage in the club. One youth, Ivy, publicly challenged an activity that educator Chris had designed because it "felt like school." As we show below, what Ivy meant by this statement was that the activity limited her ability to draw upon her strengths to engage in ways that were humanizing and that allowed her to see herself in science. School was a place where she felt like "no one listened" or



“cared.” We illustrate how Chris, the adult educator, worked to reorient his practice in direct engagement with Ivy’s concerns, extending to how he used Ivy’s insights to collaboratively remake the activity for the whole group of youth. In this vignette, Ivy’s moment became a public resource for supporting a collective transformation of what it meant to participate and to see oneself in their maker club.

Ivy’s Critique. First we explore how Chris acknowledged Ivy’s critique to his planned activity and redirected it to the whole group for collective engagement. This is important because it shows how he responded to Ivy’s critique as a moment to reorganize the learning environment.

Chris had designed an activity to support youth in showcasing their interests and talents in science and making. He explained they would make posters that showcased their projects, and that these would be displayed in the makerspace. He wanted to “center their accomplishments” in an “enjoyable” way.

At the start of the session, Chris showed the youth a set of prompts he had written on the white board that they could use as a guide for their poster:

I’m most proud about...

What I make with...

Why I make...

In the future I will...

I want the world to know...

He also shared a poster he made that illustrated his work with materials and power tools, and his love of inventing. He explained how he brainstormed ideas using the questions on the white board, and filtered them before designing his poster. He told the youth they could “put anything you want on your posters,” and reminded them that there were many ways they could accomplish the task.

While most of the youth seemed excited about the activity, Ivy sat back with her arms crossed, and declared to her peers sitting at her table, “It feels like school work. I don’t want to do this.” One of those peers nodded to her in agreement with a knowing side-eye look. Ivy saw this, and in response, she turned towards Chris and more loudly repeated her declaration with a small word change: “We don’t wanna do this!” Then she turned to her mom who had been invited to join the session that day, and complained more quietly: “Mom, this feels like schoolwork!”

At that moment, Chris noticed several sources of tension layering Ivy’s statements. In her calls to adults in the room, she was calling for help and support. This was a moment, Chris realized, to reflect on what she needed support to confront, navigate, and question. He noticed that there was a vocal urgency in both her whispers and her louder call outs. Later, Chris explained that he experienced a “quick-thinking moment” with thoughts racing through what sources of frustration Ivy might be dealing with in an activity Chris considered to be low-stakes, creative, fun, and youth friendly. He considered that the participation expectations he had shared could have triggered her frustrations with school norms, parental expectations, Ivy’s previously unshared desires for participating, and Chris’ own ISL program goals:

Her mom gave her this look like well, it’s—you’re gonna do it. I’m sure that’s the look that she’s used to giving her when she says, “I don’t wanna do my homework.” I felt the history in that moment. And then [her mom] turned around and looked at me apologetically, and I’m like, “It’s a fair criticism.”

Chris heard Ivy’s remark to the group and her mother. He turned to the whole group and said, “You know what? That’s a really fair criticism because this is a very schoolwork-type assignment.”

Chris' pedagogical move engaged Ivy's challenge as a legitimate form of critique. Ivy told the small group at her table, "Painting is how I express myself. Painting can show what making means to me in a different way." In this moment Ivy indicated to the group that she could paint her feelings about STEM-rich making rather than brainstorm a list of maker projects she made during her time in the program. Ivy later said in an interview:

It just felt like school. "This is me" assignment (air quotes). You write all this stuff, *and in the end it doesn't really matter*. No one reads it. But then when I could paint my ideas, not write words about myself, and that could be an example, that felt different... *like being me was good enough*.

For Ivy, this was not just about how youth could share their accomplishments in making, but also the method by which they could recollect, curate, and name their accomplishments to be communicated with others.

How Chris incorporated youth critique into the activity. Chris used his power as the educator to share this critique with the whole youth group. This move was important because as Chris invited the whole group into dialog on what this project could and should be, the youth layered many additional perspectives alongside Ivy's, related to both the purpose and goals of the proposed activity, and the approaches they took to engage with it. This shift from individual to collective critique invited a much richer and more nuanced view of what it meant to accomplish something in their science club.

For example, one of the youths exclaimed he wanted to make a three-dimensional light-up collage on wood, with different images and words using chalk art and animations that showcased how he was a storyteller and loved to give speeches, and that these qualities mattered in what he did with his science work. He wanted a picture of himself giving a speech about racial justice with a quote from Dr. Martin Luther King saying, "I have a dream." Another youth wanted to create a "keep calm and code on" poster that lit up. For this youth, being a Black girl coding expert, was integral to her identity. Another youth wanted to make a picture of his dad in the form of an action figure hero, with images of the places where his dad works because his dad inspires his maker efforts.

Chris' pedagogical actions involved a "slowing down" of the process to engage with Ivy's moment, and to invite other youth into giving greater texture to that process. He paused the planned activity to create space for the youth to think more about how they wanted to express themselves, and why their ideas for doing so mattered to them. This move felt challenging to Chris. He told us after this session that he had been "really nervous" to "completely open up the activity." He told us that he could tell his supervisor Olga, who was in the room at that moment, was thinking "We don't have time for that!" However, Chris made the decision to do so anyway because to not respond, he noted, would dismiss Ivy's critique as not important. As he encouraged the youth to share their ideas, he noticed that Ivy, who had previously paused engagement, was then active in the conversation.

Chris' move to slow down the process and invite the youth to corevise the activity with him was important because it showed how Chris viewed the object of this collaborative critique as the particular activity structures themselves as well as the underpinning relations of power which traditionally facilitate, frame and give particular meaning to ISL activities and structures. The youths' ideas transformed the activity in how it expanded not only what youth represented about themselves in science through the activity, but also the forms of making that went into those representations.

Following the conversation, Chris further supported Ivy and the other youth by working with them to find the tools and materials they needed in their makerspace and in various storage rooms in the building. He brought out the painting supplies, and other building and crafting materials youth asked for.

Chris reflected later in an interview how this "ended up being this cool moment of—'cause she's good with these materials.'" As Chris reflected, he had noticed Ivy "just wasn't into what we were doing, anything through the day" and there was "definitely a palpable tension there of her expectation." While he was initially worried that Ivy would "check out and we're just gonna lose her for the day" and would fall behind everyone, when he saw what she was producing, he noted how she had a "cool place to start for the next time."



When the next session started, Chris used Ivy's painting with the group and discussed the symbolism in the artwork she created. He encouraged the youth to continue to think broadly about how they might use the wider variety of materials in the room to further express themselves in creative ways in their projects. Chris viewed this moment as a chance to extend beyond showcasing the youths' making practices, to one where youth actively reorganized what it meant to be a science and maker expert.

Shaping youths' engagement in ISL. This moment impacted both Ivy and her peers' engagement in their maker program. For Ivy, this reorganization meant authoring an opportunity to represent herself in making in ways that showcased her strengths and that also felt authentic to her. Collectively, this reorganization also allowed the whole group new opportunities to reimagine what expertize in making looked like, and what it meant to represent oneself as an expert. As the other youth commented positively on Ivy's painting, they drew inspiration from it, and their projects underwent substantive changes during the next few sessions. For example, fellow member Jazmyn adopted Ivy's push for symbolism and painted an Egyptian goddess representing her strengths as a young, Black, female leader. Her little brother also took up symbolism, asking peers to help him trace anime hero characters and search online for additional symbols of formative experiences throughout his life.

4.1.2 | How collaborative critique disrupts

Youth experience oppressions in ISL in the moment, usually through the structures, routines and practices that are so routine, they have been inscribed by dominant culture as normal. We see the youths' critiques as not just about finding an activity *dis*-engaging, but also as critiques of the *structures which limit their being and becoming in science and making*. For example, feeling like school, for Ivy, meant feeling like it didn't matter; that she didn't matter. Calling out "If you're Black, you'll be convicted" was Amir's call for not only his life experience, but the history of being Black in structures that frame both life and science practice, to be integral to learning forensics.

When educators paused activity to support and make publicly visible youth critiques, they made possible new ways of knowing and being for the youth, allowing their lives and forms of expertize to be more visible. For example, Chris offered an activity that he felt was inclusive, welcoming, and included a multitude of youth interests. He had support from powerful others in doing so (his supervisor, and others, including Ivy's mom). The youth in the program went along with the plan, and Ivy's dissent disrupted the shared but implicit flow of participation. In this case we see the critique of "felt just like school" as a powerful proxy for how youths' interests, passions and joy are erased through routine activity, which can compound over time.

Youth-led and educator-supported disruptions of preplanned learning activities catalyzed important changes in programming in-the-moment and moving forward. Disruptions reverberated into new participation forms, leading to new possibilities for youth engagement and adult educator practice. Further, when youth had opportunities to collaboratively critique and codesign *from* positions of strength—that is, when their experiential and historicized knowledge was treated as powerful/legitimate/necessary—new opportunities for justice-oriented learning opened up for both youth and educators.

4.2 | Critically being with each other towards new relationalities

Another way we witnessed educators responding supportively to youth disruptions was by critically being with each other towards new relationships. By "critically being with," we refer to an educator's choice to more fully exist alongside and in solidarity with youth. This calls for a critical humanizing stance that involves giving witness to historical and systemic sources of inequity underlying educator–learner relationships. This can look like ending initial movement towards predefined goals and repositioning practice to realign it in step with explicit direction from youth goals, needs, and visions. It can require deeper engagement with youth narratives of their lives and

positionings (Haig-Brown, 2003), especially when educators do not share the same identity and positioning as youth (e.g., racial, national, gender, etc). It necessitates a commitment to allowing youth to be and act as fully themselves, including allowing youth to have emotions and express them in learning spaces.

For example, as was typical during YAC sessions, educator Addison had music playing in the background for youth to enjoy. Youth often sang along as they worked. On this particular day, frustrations were mounting as several youth experienced technical challenges with the maker activity of the day. When the song from Frozen, “Let It Go” began to play, several youths immediately sprang out of their chairs to the carpeted area of the room and began to sing *Let It Go* with gusto, while dancing along. Within a matter of seconds, everyone, Addison and other educators included, began singing and dancing too. People were laughing, moving with the song together, making eye contact, and enjoying the moment. When the song ended, one of the youths stated that she had not wanted that moment to end because it captured how they were feeling. They all needed that moment of emotional release to let their in-the-moment project frustrations go before they could move on with their projects of the day.

Critically being with is a deliberate choice, a relational and ethical practice foregrounding the always, already, and imagined present in how and why people relate to each other (Villenas, 2019). It implies that youth are continually calling on adults to be and move with them in tighter solidarity. Noticing and responding to such calls moves pedagogy towards imagining new possibilities for youth and adults being together in learning (Delgado-Bernal et al., 2012).

In another example, as one STEM Club session was ending, new youth member Lionel approached the group with a last-minute challenge to “Take my Kahoot!,” an online quiz he made using a website platform that displays answers immediately. Several peers had just shared their long-term STEM Club project updates, and Lionel, while new, wanted to share something too. Educator Logan publicly supported this challenge and framed it to the group as a chance to learn more about creating dynamic quizzes. All members and adults turned their attention towards Lionel, with many answering questions on their own devices and some watching on the side. It quickly became obvious that there was no possible way to get any of the questions correct, however. This was a quiz with questions about Lionel, with answers only he knew. His older sister exclaimed loudly, “Even I don’t know this one, Lionel! Nobody knows this but you!” Questions included “Which one of these is the best song?” Youth laughed together with Lionel as they tried to guess answers and as they kept getting items wrong. Logan realized that this quiz was Lionel creating a bigger and more solid presence for himself in the program and with people in it. This was an attempt to share himself in a deeper way, as both a fully human person with interests even his sister did not know, and a quiz-design expert. Instead of marginally entertaining this sharing as cute and endearing, Logan announced that this was a great way to get to know Lionel better, while also learning a form of educational game design. Logan asked Lionel if he could teach him how to make quizzes like his, and Lionel shared that maybe he would incorporate a Kahoot quiz as part of his larger Science Club project, to educate others about public health.

As indicated in the brief examples above, this kind of space making is without conditions, making for an often unpredictable and messy—or not easily managed or planned for—way forward. One of the educators, Starr, spoke about this practice as “an inconvenient love,” referencing how being with did not always fit into the time frame or structure of ISL, often disrupting plans, yet opening up new directions for youth learning she “could not have dreamed alone.” Villenas (2019) refers to this as something that can feel like “difficult solidarity,” in that imagining such new possibilities implicates the educator in the coproduction of the historical and political relations of power that give rise to such difference (p. 162). Critically being with involves moving forward with a depth of commitment as well as realization or acknowledgment of these inherent uncertainties.

While we have thus described “critically being with” as a human relational practice, educators and youth are always interacting in relation to existing structures of learning, shaped by where, how and why programs take place. In this sense, “critically being with” requires an engagement with structures to make visible how structures play powerful roles in reproducing and disrupting dominant norms, routines, discourses and practices. Many of the moments of critically being with that we documented involved educators giving witness to youths’ efforts to raise concerns about different forms of injustice as salient to their experiences in science and/or ISL. In other moments,



educators noticed and responded to youth encounters with and expressions of what Starr defined as “deeper-than-just-momentary frustration, everything-is-stopping-until-we-talk-this-through kind of pivot points.”

4.2.1 | Exploring critically being with towards new relationalities through Starr's practice

In what follows we explore how educator Starr engaged with Lulu through critically being with her, opening new opportunities for Lulu and her peers to engage more fully in their local neighborhood community center's science club.

Lulu's shifting relationalities. In an example of this practice, community center STEM Club educator Starr noticed that youth member Lulu was disengaging in club activities. Lulu had, at different points across several sessions, physically removed herself from the larger group to engage in unrelated activities in a corner of the room (sometimes even sitting on the floor behind a table to avoid attracting attention from peers or adults). At other points, she had invited a peer to work with her, only to forcefully take over the activity while saying they had done something incorrectly and she could do it better, ultimately driving that peer away to another group.

Starr knew from previous parent chats that Lulu was going through big life changes at home, as her parents were divorcing and her mom had recently switched her to a predominantly White school, where, as a Black student, she was now in the minority. She wondered if Lulu may be detaching from the larger group to seek or enact a sense of control and/or emotional self-care during STEM club. Starr was struggling to support Lulu during this time while also teaching other youth and seeking to maintain a collaborative culture in the room. She had wondered, “What should we do about Lulu?” in an RPP meeting after one session, putting the question to other educators. She added:

We keep coming up with compromises to get through one day at a time with her, but it's not sticking. As soon as one small thing doesn't go her way, she's back under the table. I can't keep having this same conversation with her every session. It's taking time away from others, and I don't even think it's helping.

The other educators in the meeting shared concerns that any solution to Lulu's needs and actions must also take other youths' needs into account, as Lulu had often abandoned group members mid-session, delaying peer progress. She had also locked herself inside the club's digital studio side room during one session, prioritizing her own need for control and/or self-care over her peers' needs to use the shared digital production equipment located in that room.

How Starr sought to critically be with Lulu. In recognizing Lulu's vulnerability, Starr sought direct communication with Lulu. Before STEM Club one afternoon, she pulled Lulu aside to costrategize a different type of solution together, asking: “How can we make STEM Club work better for you?” Later, Starr explained:

I wanted to meet her halfway, but I know Lulu. She needs to be in the driver's seat. Especially now. It's just not going to last unless it's Lulu's plan. Lulu's still seeking to engage in science activity, just in a different way that did not match with program norms or expectations.”

This quote shows how Starr recognized Lulu's actions as efforts to authentically engage in ways that were more responsive to her needs. When Starr paused to directly ask Lulu how she could help her efforts, Lulu shared that she was feeling irritable and could benefit from engaging for a while in a “solo project.” Starr shared that idea with other educators at a later planning meeting. They agreed to endorse and work to sustainably support Lulu's solo efforts, a deviation from their program's central norm of peers working collaboratively.

In viewing Lulu's arguments for recognition of independent activity as a valid form of ISL engagement, we see an effort to claim a rightful presence in STEM Club, born from frustration with available forms of being across

multiple spaces. Lulu was seeking to create and protect a space of independent-but-supported engagement in ISL. Further, she explicitly called for adult sanctioning and resourcing of this effort.

Over the next few sessions, Starr engaged Lulu's efforts by spending time helping Lulu to *reorganize the space*. She assisted Lulu in clearing away scattered soldering equipment and moving a wall of heavy robotics containers to create a new corner in the makerspace with a table and a few chairs. Lulu moved a broken sewing machine to her table, announcing an intent to repair it. She also made a "Lulu's Sewing Center" multimedia sign featuring smiling-and-waving clay figures of different shades, which Lulu explained represented a racially diverse STEM Club membership. She successfully fixed the machine's bobbin tension issues within only two sessions, explaining that her grandmother had taught her some skills and that looking closely at machine parts helped her to understand their functions/interactions. Then she began creating fabric bags for peers to help organize their project materials in the makerspace.

Starr also created *new participation structures* with Lulu to legitimize her activity in the makerspace: Lulu would join the opening discussion circle and then when group time began, she would move to the corner table alone. After a couple sessions of this, Lulu began to occasionally invite one or two peers to join her during group time, depending on the day. She also invited peers to visit and learn how to sew when they explained to her that those skills were necessary for their own projects.

Lulu was experiencing life changes and the power structures worked to limit Lulu's control over those updates. Critically being with included recognizing Lulu's actions in the makerspace as reasonable given such changes. This helped Starr to see Lulu as a fellow reasoner instead of a problem-causer.

Shaping youths' engagement in ISL. Once able to more fully witness Lulu's efforts, frustrations, and responses, Starr could take steps towards building new understandings, expectations, and practice plans with Lulu that allowed Lulu expanded ways of being in the makerspace. When educators supported her efforts by seeking new ways to honor where she was in-the-moment and what she needed to succeed, new forms of legitimate activity opened up for her, deepening her connections to science and enhancing their abilities to make meaning in her making. These new forms of legitimate activity gave Lulu the space to explore new projects without taking on the extra burdens of peer socializing and navigating group-work power dynamics. Lulu's after school hours could then serve a more emotionally restful and restorative purpose while still keeping her connected to engagement in her maker program. Lulu, in dragging a table over to a corner of the room, created a subspace in the room that could honor her need to feel present in a way that she controlled directly and completely. But within that subspace she had created, she was deeply involved in pursuits that held meaning for her as a central part of her science repertoires, skill building, and identity development.

This moment impacted both Lulu and her peers' opportunities for a more rightful presence in ISL. For example, during an open house event later that year, Lulu made her presence as a sewing machine expert more public. Her sewing corner poster was now more prominently hung on a wall with a visitor sign-in sheet on her work table. She invited visiting parents and relatives to try out different stitches on scrap fabric as she shared feedback on their techniques. Lulu also took responsibility for introducing the entire open house to adult visitors. At the beginning of the event, Starr stood next to Lulu and two other youth to announce:

Thank you for being here this evening. We have a couple things to tell you, but I'm going to hand it off to the STEM Club representatives that we have here presenting tonight. I'd proudly like to introduce Lulu, Louise and Tyon... Lulu's going to get us started and kind of give an overview of what this program is.

Starr said she "deliberately did not say another word," and instead gave facial and body language clues to the youth to encourage them when it was their time to speak. She also physically stepped back about a foot, positioning Lulu, Louise, and Tyon as the main speakers and hosts, and positioning herself as the support staff for the evening.

Lulu began by introducing what the Club's name stood for and what activities the youth engage with in the program. Louise, who was standing alongside Lulu during this introduction, followed Lulu's introduction with the following impromptu speech:



I'm going to explain what STEM Club is to me, and I've heard comments like this. *STEM Club is a place where I can be me*, where I can build things, sometimes to help with anger issues. It's just a place where I call home, besides my actual house. A place where I can go to hang out with my friends, talk a little, enjoy life, be young, even though I'm about to be a teenager soon.

As Louise spoke, she looked down and around as she formed the words. Lulu looked straight forward, with perfect posture, hands clasped together in front of her. When Louise said the word “home” referring to the Club, Lulu's face turned from stoic to broad grin, and she turned her face as if sharing her smile across all people in the crowd. As Tyon continued introductions, explaining STEM Club as a place “where um, I can, be myself,” Lulu and Louise both turned towards him encouraging him to continue, before both turning back to face the crowd with continued large smiles. Following the speeches to the crowd, Lulu invited adults to visit what she had created in her corner of the room, “a sewing club” within the club's larger “STEM Club.”

4.2.2 | How “Critically Being With” disrupts

Critically being with each other towards new relationalities supports justice by meeting youth where they are, which first requires making the time and energy investment to learn about “where” youth are and where they want to go next. Youth experience historical and systemic injustices, such as racism, on a daily basis (including inequality in ISL). When educators responded to how these experiences play out in the moment, they centered these experiences as mattering in ISL and important to how and why the youth engage in ISL. For example, Starr used available participation structures to create times for more personal chats with youth, to learn more about their lives and worries. She integrated short, relationship-building chats with Lulu's mom and accessed general updates on how Lulu was doing outside of the makerspace, contextual information that became a vital resource for helping Starr understand where and how she needed to pivot her own educational practices and assumptions to “meet Lulu where she was” in the makerspace.

Critically being with requires meeting youth where they are and recognizing and welcoming youth as they are, as whole people. This involves slowing down and asking why youth are participating in a particular way, what might better support their meaningful engagement, and what youth need beyond simple access in ISL. To be with youth in critical ways involves recognizing and working with the messy interactions of developing selves: The making expert, the daughter of parents going through divorce, the Black student now navigating a mostly White space at school, the friend who likes chatting and sharing skills with peers. Critically being with requires educators to slow down and recognize that youths are unique individuals navigating multiple life experiences. Compartmentalizing to only look at one form or source of science engagement as valid closes down possibility. Disrupting such inherently inequitable norms to welcome youth as whole people allows youth to participate in ISL as fully themselves.

For Lulu and for other youth in our identified moments of this study, adults critically being with youth allowed youth and adults to codesign new engagement structures when previous structures failed to meet their specific in-the-moment needs. When Starr gave witness to the efforts Lulu was already making to engage in science content and practice, for example, she was able to see where she could better support those efforts as legitimate and worthy in their shared ISL space. This was a radical step towards reclaiming science learning and practice.

5 | DISCUSSION

In this study we have sought to attend to the political and ethical dimensions of equity work in ISL. Our findings suggest that orienting pedagogies towards justice requires attention to what it means to *be in relation to* science, not only as content to be learned, but also as a disciplinary system of power and interaction made up of discourses,

practices, communities, and relationalities. In the moments of disruption, where youth sought to have their ideas, perspectives, experiences and lives made present in their ISL experiences, educators positioned themselves as colearners, codisruptors, and codesigners of more just forms of science learning alongside youth. They sought to see these disruptions as moments of learning how to welcome and legitimize youths' lives, communities, histories, presents, and desired futures to reimagine what ISL could be. They regularly invested time and energy into learning about and with youth, even when that meant the inconvenience of shifting plans, roles, and expectations in their programs. They also sought opportunities to bear witness to the oppressions and frustrations youth encountered in daily life both inside and outside ISL, bringing those experiences to the center of science programming to examine and address those experiences with science tools and adult support.

These pedagogical responses thus involved reseeing youths' activities in new ways that made visible how the ISL experience limited youths' opportunities to have their lived lives and communities rightfully present in ISL. In many instances this meant interpreting what might have ordinarily been construed as push back or disruption as both a standing up by youth to be seen, and a call for transformation. The responsive practices centered the political and ethical dimensions of teaching and learning.

We thus view these pedagogical responses as fundamentally directed towards shifting power—who has the power to name and legitimize what and who matters in ISL, how and why—and about how youths and educators alike engaged each other towards affecting their lives, social relations, and possibilities. This commitment to allied political struggle is a commitment to *making present* youth lived lives and experiences in ISL, on their terms, through the discourses, practices and relationships enacted therein. Youth, through interactions with peers and educators, sought to make their already-present brilliant, rebellious, and agentic acts of everyday practice and its transformative potential visible (Ryoo et al., 2020). We thus concur with Philip and Azevedo (2017) who describe the work of justice in ISL as about “studying the authentic struggles of groups, as it exists alongside, overlaps, intersects, and conflicts with other human practices, this discourse can reveal the potential of everyday science learning as a part of social change” (p. 529). At the same time, however, we see this study in disruptive dialectic with what it means to learn, become and take action with and in science.

While we documented pedagogical practices as real-time actions in fraught moments, we think these are pedagogical practices that can be deliberately practiced, and institutionally recognized, designed around, and supported, to promote more justice-oriented ISL. Below we discuss how educators' pedagogical responses support youth efforts to disrupt and/or get recognized in learning interactions towards transformative possibilities for learning spaces and relationships.

5.1 | Generative movement

Centering youth efforts to be rightfully present involves a dynamic process that continually retakes shape in practice. This process is *always under negotiation* by those historically with power and those historically marginalized by those in power. Institutional forms of oppression and privilege are not immediately reformed in a moment or without collective engagement. Thus, seeing how these pedagogical responses work together, or inform each other, to foster new on-going opportunities and to reorganize activity towards these ends, is important. We observed how these two practices were generative in several ways.

First, we noticed how engaging in one practice opened space for engaging in the other. For example, when Lulu pushed back on norms of after school participation, Starr needed to *be with* Lulu in critical ways to better understand why and how she could help Lulu to *collaboratively critique* norms in their shared ISL space. In doing so, Lulu was able to make space for her entire authentic self to be visible, including her race, gender, frustrations, desires, joys, and concerns. We observed such generative educator engagement with youth efforts across many identified moments. What appears common is that this generativity was made possible when moments disrupted some participation structures, leaving unsettled terrain that allowed other participation structures to expand.



For example, Chris refracting Ivy's critique into the whole group allowed other youth to expand their own maker activity engagement.

Second, engaging with one youth's moment led to collective engagement and transformation. Central to this point, and as further made visible through our framework of consequential learning is how pedagogical practices simultaneously happens along the individual *and* sociohistorical. To challenge/disrupt practices tied to power structures, students' lived lives must be viewed as resources for collective learning, and in ways that attend to the historicized nature of learning and of ISL (Philip & Azevedo, 2017).

Importantly, educator engagement in cross-cutting and mutually informing components of justice-centered pedagogy were generative not only to individual youths, but also to ISL groups as a whole. When Starr worked with Lulu to create the sewing station, she supported Lulu in authoring a new role for herself and her peer helpers, and she also legitimized an alternative engagement structure that provided a useful resource to additional youths in the space. These new roles and structures themselves became visible reminders of what ISL could be (e.g., as Louise stated to parents, it could feel more like "home").

Third, educators' engagement with youth efforts in any given moment led to a rippling change over time. As educators further engaged with disruptions, they came into contact with how such disruptions opened up new possibilities for not only youth engagement, but also adult educator practice and institutional policy change moving forward. This allowed for reoriented power relationalities that made visible previously unaddressed or unseen layers of tension inherent in ISL program and institutional structures. In this way, ideas that made for a transformative change in-the-moment often necessitated confrontations with broader-reaching dominant narratives and assumptions of power that ruled before as shown with the moment focusing on William.

5.2 | Making time for response-ability

The political and ethical dimensions of pedagogies center relationships. Together, they call attention to what it means to "encounter each other" in the learning/doing of science in ways that are open to difference and to a kind of "response-ability" (Villenas, 2019, p. 156) that centers such difference as the possibility for response. As educators took up moments, they worked with youth to challenge and transform what participation in ISL entails or what meaningful representations of learning look like. They worked to humanize participation and value youth as cultural and whole people through shifting discourses, norms, and relationalities.

This kind of relational work took dedicated time on the part of the educators. Each of these practices involved slowing down the moment to listen and learn from youth; a kind of pausing for justice. Here we call attention to the micro-scale of time, as in "in-the-moment." To accomplish this youth-adult collaborative work, educators literally had to *pause-and-rethink* what was happening in-the-moment from youth perspectives, and what this meant for youths' opportunities to be and become in ISL. This required a critical awareness and a vulnerability on the educators' part to see and acknowledge how the structures and interactions of the ISL experience made youth more or less present. To support disruptions in activity norms/routines as valid and worthy disruptions, educators needed to forcefully pause their own norms/routines. They needed to take the time, and make the space, to explore with youth why/how particular forms of political struggle mattered to youth, and what that could/should mean for how educators made space to share ISL program engagement as opportunities to be and learn together as partners rather than inadvertent adversaries in an oppressor/oppressed power asymmetry. In these pausing moments, educators strategically positioned youths as educators and themselves as learners. This repositioning helped to legitimize youth nonstandard actions and practices as valid and necessary components of a critically evolving ISL practice, especially in front of powerful others and in the context of institutional norms/expectations for ISL programs. These practices often took place in-the-moment as educators recognized, supported, and leveraged youths' hybrid, transformative, unsolicited, and disruptive discourses and practices. They also actively listened for unsolicited youth critiques that emerged in-the-moment during activity.

This study required a shared commitment among educators and youths, where the burden was not exclusively borne by youth experiencing ISL inequity. These youth–adult collaborative practices embraced disruptions of assumed structures and binaries that were upholding asymmetries of power. Reaffirming that youth knowledge, practices and experiences mattered, adults took up the responsibility of working towards a more equitable spatial presence of possibilities. For example, Ivy's critique of the maker activity as reconstructing the norms of formal schooling ("this feels like school" ... "no one really cares") underlined her experiences of dehumanizing invisibility in schooling, while making visible the parallel aspects of her maker club's activity. When Lulu and Louise presented their work at the open house and described their club as "home," they shared a critical relationality reflecting a sense of being loved and cared about, being able to count on others, and being counted on by others within a place of joy.

As educators responded to critiques about programming constraints on meaningful engagement, they remixed tools/structures with youth to recreate activities in-the-moment. This supported youth to engage new forms of legitimate activity that centered their critiques, needs, and desires, pushing open boundaries of science practice and institutional expectations.

5.3 | Pedagogies of local practice and the remediation of systems

Responding to youth efforts to assert their presence in ISL shifts the analytic reform frame from focusing on youths as in need of remediation to rethinking new arrangements, tools, and forms of participation in ISL. To engage in this study, often introduced by youths in unapologetic and unsolicited ways, educators had to recognize how inequities are reproduced in ISL environments through dominant practices, narratives, and structures often grounded in White supremacy, patriarchy, and citizenship (e.g., Madkins & McKinney, 2019). Educators had to be willing to either pause-and-further-amplify their efforts which were already oriented towards such disruptions or they had to pause-and-re-direct their efforts towards engaging this political struggle as committed allies in learning and accomplices in disruption. This often involved recognizing the legitimacy of youths' already present knowledge and ways of being as integral to science as the "stuff" upon which such re-direction could take root. These pedagogies are collaborative, in the sense that they require engagement by both educators and youths, and can be initiated by multiple actors.

Further, moments were often rendered in tensions—tensions around what kinds of activities count, whose knowledge is viewed as expert, and how and whose lives are made visible in practice. Engaging these tensions, as educators did, orients towards more expansive opportunities for learning in ways that connect to youths being fully present in ISL. Science learning that happens in informal spaces and programs is meant to provide a greater diversity and/or depth of connections to broader fields of science practices and futures. Adult educator engagement with youth experiences opens the door for youths to see themselves and the richness of their life contexts as valid center points anchoring their science engagement and steeping it in deeper meaning. Social transformation can happen with and in an ISL program.

6 | CONCLUSIONS

The pedagogical practices we discussed incorporate justice as the core of what pedagogy can and should include and support. These practices not only relate to the routine work of ISL, but also work to shift the essence of ISL in equitable ways and towards just social futures for youth, and in particular those most marginalized by dominant power structures. These practices made youths' lived lives and communities visible and present—with experience, knowledge and practices that integrally matter in learning and doing in ISL. They gave witness to how youth routinely experience dehumanization and delegitimization in ISL through the enactment of dominant norms in

practice. They also created spaces and opportunities for youths' agency to name/critique how they have been dehumanized/delegitimized, and to organize new learning structures around their assets, while not limiting access to science itself. This required educators to engage with youth in political structure to reorganize the dominant and unjust power relations which have prevented their rightful presence in ISL.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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