Towards Critical Justice: Exploring Intersectionality in Community-based STEM-rich Making with Youth from Non-dominant Communities

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Abstract:

We investigated how community ethnography as a pedagogy approach to STEM-rich making supported youth makers from two low-income urban communities engaged in sustained STEM-rich making towards making a difference in their communities. Data is drawn from two-year long ethnographic data across two community-based, youth making programs. We highlight two cases. Case # 1 focuses on one African American girl's making endeavors across one school year. Case # 2 looks at how two youth engaged in critical sense-making with regards to the currently available how-to making resources they could locate online. We discuss how these pedagogical moves supported the youth in making towards a more just future in ways that addressed intersecting scales of injustice.

Keywords: STEM | science education | youth | making | intersectional experience

Article:

Introduction

"In our makerspace at the boys and girls club, you must feel that you are wanted there."

Sasha, African American girl, sixth grade

"I want to make stuff [in our makerspace] that I cannot even imagine."

Kairee, African-American girl, sixth grade

For many youth living in poverty and youth of color, gaining access to STEM is precarious. The maker movement has evoked interest for its potential role in breaking down barriers to STEM learning and attainment (Martin, 2015). Characterized by hands-on working with materials (cardboard, fabric, wood, etc.) and digital components (e.g., 3D printing), often in a specialized makerspace equipped with tools, making is highly sought after by educators as a productive

STEM activity for youth. However, as makerspaces in and out of school are proliferating, few studies exist that investigate how youth are supported in working towards robust and consequential STEM-rich making projects through sustained engagement. Most making resources promote the "keychain syndrome"—making experiences that are trivial and without prolonged meaningful engagement towards more complex projects (Blikstein & Worsley, 2016). Of equal concern is the fast solidifying maker culture, characterized by white, male, upper middle class norms and practices (Brahms & Crowley, 2016). Thus, the knowledge and practices of communities of color, and of low-income communities, have not become central to dominant makerspace discourse.

Although some research studies within the making movement have revealed insights into the facilitation of making in more equitable ways, such as suggesting that facilitators encourage young makers to document their design thinking as part of the learning process (e.g., Norris, 2014), how facilitation in making is tied to culture is under-explored. What might youth want out of their making experiences and why? How might these concerns be attended to by making space designs and pedagogical approaches? These are questions that concern us given our work in STEM-rich making with youth who have been historically marginalized in STEM and in the commodified culture of making. The maker movement has been touted as the latest panacea that would democratize STEM education and bring the populations previously left out of STEM into its fold, but there is little evidence that the dominant culture of the maker movement has been broadly shaped by a diverse audience over a sustained period of time. Although there are powerful pockets of making and making spaces that serve families and youth from historically marginalized communities (see Bang & Barajas, this issue), the status of the movement requires caution.

We are interested in uncovering how youth-focused community making spaces can support youth, through pedagogical approaches, in becoming youth community makers, with STEM and making knowledge and expertise legitimized not only in their home making spaces but within the making domain.

Our research questions include:
1. What do youth draw upon from their lived experiences in STEM-rich making?
2. How are these efforts by youth supported in the making space through pedagogical approaches that integrate community ethnography with STEM-rich making?

These interests build on the work of scholars who have investigated youths' engagement as critical learners in afterschool STEM programs across a range of disciplines, including digital technologies, graphic design, and music making (Kafai, Peppler, & Chapman, 2009).

A critical justice stance on equity

Current views of equity in the making and makerspace movement have tended to focus on issues of access and opportunity, often from an individual lens. This distributive stance on equity is grounded in a liberal political view of equality (Rawls, 1971), with its focus on the equal distribution of goods and services to individuals (Young, 1990). In the making context, such a distributive view of equity assumes that broader access to makerspaces, materials, and mentors

will be sufficient to support more people in making. Such a view takes an impartial stance towards what access and opportunity may mean and fails to disrupt assimilatory practices and approaches (see Bang & Barajas, this issue).

Some have argued that maker education can become more equitable by valuing a wider range of cultural practices that reflect individual lives (e.g., Vossoughi, Hooper, & Escudé, 2016). There is much to learn from this literature, including how culturally sensitive approaches to making can help integrate and legitimize previously unsanctioned forms of knowledge and practice alongside more traditional ones (e.g., Kafai, Fields, & Searle, 2014). However, calling attention to how youths' historicized experiences are always a part of making is inadequate on its own. Opportunities to make, even in culturally sustaining ways, are always tied to, constrained by, or otherwise impacted by institutional and societal structures that shape those opportunities (e.g., Anderson, 1999; Young, 1990). As Sturman (1997) and McDonald (2007) argue, the limitations of taking an individualistic view of equity elides the role systemic, structural oppressions may play.

This stance presents a complex challenge for the maker movement. In addition to considering who might be involved in the maker movement or what that participation may look like, relations in making also need to be restructured, in ways that position youth-makers legitimately with power and authority. We thus situate our work in a critical justice view of equity (Balibar, Mezzadra, & Samaddar, 2012; Young, 1990), which calls attention to how individual experiences of injustice intersect with systemic injustice through sanctioned power hierarchies. By power hierarchies, we refer to the ways individuals are recognized, valued, and positioned with status and authority—or not—as a result of sociohistorical structures and practices imbued with racism, classism, sexism, and heteronormativity. *Who* is making and mentoring, *what* is made and *why*, and how outcomes are defined and measured, can position youth as marginal, at their very starting point in making just because of who they are and what they bring to STEM-rich making (Yosso, 2005). Specifically, Young (1990) reminds us that understanding and achieving justice requires a close analysis of particular social settings and how oppression and privilege unfold and interact—understanding power hierarchies within structures and systems. A critical justice view of equity works to disrupt the systems that historically have shaped inequalities *and* how they mediate day-to-day experiences, while also cultivating empowering teaching and learning interactions, outcomes, and structures.

We believe this stance on equity is important. The cultural assets that youth from nondominant communities bring to learning and engaging STEM are often perceived as deficit or are delegitimized by sociohistorical narratives and systemic practices of oppression (Calabrese, Birmingham, Takumi, Tan, & Calabrese, 2013; Tzou, Scalone, & Bell, 2010). Such injustices are experienced at the local scale. The places of learning and doing STEM (including STEM-rich making spaces) are not particularly safe places for such youth. The youths' comments on wanting to feel safe and supported in making that helps to imagine new social futures (Sasha and Kairee's quotes, above) is a strong push back against these oppressive narratives. Working to disrupt such systemic structures is closely tied to how local practices play out in the day-to-day.

In seeking to enact a critical justice stance on equity in making, we worked collaboratively with youth growing up in lower-income communities, most of whom are African American and some

of whom are white, to design making spaces and pedagogies towards a more authentically empowered experience. We turned to the theoretical framing of intersectionality (Crenshaw, 1991) as a way to imagine how youth and maker educators might disrupt and reshape making towards equity-oriented ends.

Conceptual framework: Intersectionality

In the context of our study, we see the world as youths' embodied experiences in their everyday lives across spaces (school, home, community club). Both groups of youth had visited other makerspaces, including established ones at local universities, museum-based makerspaces, and membership-paying makerspaces. While the youth were awed by the sophisticated tools in these professional making spaces (e.g., laser cutters, different kinds of 3D printers) they also had strong opinions on how their own youth makerspace at their community clubs should "feel different." They observed that the "beautiful makerspaces" are "full of cool stuff we can't touch," and they expressed some level of anxiety being in those spaces. The makers in these spaces the youth visited, and the maker literature featured in these spaces, mostly reflected male, white adults. Such observations signaled particular messages to the youth about the dominant maker culture. Making—as a practice—is never separate from individual and social histories that unfold across space and time. Who can make and who cannot, whose knowledge matters and whose does not, are all a part of making itself, and related to who youth are in all their embodied experiences. To make sense of youths' multiple embodiments (e.g., along race, gender, and socioeconomic status) and how to draw from their experiences towards STEM-rich making, we turn to the theory of intersectionality.

The concept of intersectionality, put forth by legal studies scholar Kimberlé Crenshaw (1991) crystalized the critical ideas coalescing among black feminist scholars around the relational dynamics among race, gender, socioeconomic class, and politics. Intersectionality is helpful in foregrounding the multidimensionality and complexity of forms of oppression that can operate in concert but in varying degrees, in subjugating individuals and people groups. Interconnected oppressive forces do not operate in a linear, cumulative manner. Thus, no two African American girls from low socioeconomic backgrounds will experience intersecting marginalizations along race, gender, and socioeconomic lines in the exact same way.

Intersectionality provides the tools to make sense of how youth can be supported in their making experiences in ways that acknowledge their social histories while leveraging everyday experiences and wisdom towards their making endeavors. Intersectionality calls our attention to how places are always constructed from multiple perspectives, with differing experiences based on how one is positioned within matrices of power. At the same time, intersectional studies caution against overstressing individual "uniqueness" without structural power analysis (Rios, Bowling, & Harris, 2016). Intersectionality not only highlights the tangled webs of oppression, but also urges the formation of dynamic alliances towards social transformation (Nash, 2008; Unterhalther, 2012). Working toward a making pedagogy that provides a way for reframing youth makers as agents, "acting within the constraints of existing structures, but also embodying the possibility of resistance to and even disruption of these structures through incremental change" (Lombard, 2014, p. 13), is our approach in our collaborative work with youth in their

community making spaces. In what follows, we explain how community ethnography as pedagogy is one productive way of attending to youths' intersectionality to support their making.

Working towards a critical justice approach to making

Pedagogies shape how people are welcomed, positioned, and recognized in making spaces, which in turn shape the opportunities youth have to learn and become in these making spaces. We sought to enact community ethnography as pedagogy to expand opportunities for youth to make in ways that incorporate youths' diverse interests and ways of being in the world, the critiques those experiences bring to bear, and on the agency to make a difference.

Supporting youth in becoming community ethnographers of their own communities entailed the youth learning research methods to be participant observers of the worlds that they inhabit. Through community ethnography, youth investigate their communities, STEM, and making, concurrently, to build a more just world. Positioning and supporting youth as community ethnographers are explicit pedagogical goals of community ethnography as pedagogy. We sought to help position youth as insider experts, with access to and owners of collective community wisdom for both framing making, and for potentially disrupting the systems of inequalities they experience. As such, community ethnography as pedagogy can broaden who the stakeholders are in the youths' making process.

Ethnographic tools provide useful and unique insights into local knowledge in contextually meaningful ways. Thus, a central aspect of community ethnography as pedagogy is creating opportunities for youth makers and their mentors, throughout the making process, to leverage tools that support them in (a) careful observation of people and phenomenon and the relationships among them, (b) interview and conversational techniques that engage others in dialogue, and (c) capturing images of people and phenomenon of interest. For example, throughout the making process, youth conduct interviews and surveys with club peers and staff members, university personnel (including teacher educators, graduate students, and making space mentors), and family and community members in their residential neighborhoods. They also hold community forums and feedback sessions, welcoming community members into their making space to provide input on their work. These tools are applied towards generating a range of multiple perspectives, including local community knowledge (e.g., peers, parents, community members) and expert science/engineering knowledge (e.g., science teachers, energy experts, engineers, government officials). Paying attention to our conceptual framework of intersectionality, we conjecture that who constitutes the "we," how we can be together, in what particular scenarios, across which spaces, and doing what kinds of activities could be made more tangible and experiential through community ethnography.

However, we would be remiss if we also did not work to intentionally and consistently weave in opportunities for young people to work towards deepening STEM knowledge and practices in support of robust STEM-rich making. The maker movement has been critiqued, and rightly so, for potentially increasing the inequalities in STEM because it may further position those with the technical know-how to build upon that, while leaving others to make in less technically robust ways. This is a particular challenge as we seek to employ approaches to deepening STEM in ways that disrupt, rather than advance, knowledge and power hierarchies. The question we faced

was how we could support youth in learning the STEM they may need, as they engage in more technically robust making (e.g., power requirements, energy transformations, circuits, etc.) in ways that are informed by their community knowledge, practice, and wisdom.

Thus, a second aspect of community ethnography as pedagogy is what we refer to as codesigned "just-in-time" STEM experiences (JiTs) that mentors engage with youth on an as-needed basis, when particular STEM knowledge gaps are surfaced through community ethnography. The goal of JiTs are to allow youth to work towards more robust STEM-rich making projects that more fully responded to the needs they identified and sharpened as they engaged in making and ethnographic work. JiTs are short, emergent experiences meant to teach critical content and practices in-the-moment that youth need, as they engage in more technically robust making (e.g., power requirements, energy transformations, circuits, etc.). However, unlike a STEM expert teaching others STEM content knowledge before making happens, as is typical in formal STEM classes, JiTs are co-initiated and codesigned experiences that arise because they have been identified by youth, their mentors, or members of the community with whom they interact during the making process as being important in their making projects. Sometimes JiTs are designed and led by community members. For example, when one group of youth sought to hack a baby gate in order to motorize it to help elderly caregivers, one of the youths' fathers was recruited to help with his knowledge of minimal-damage, furniture take-apart techniques. Sometimes they are led by mentors and youth as they seek to collaboratively figure out how to address a technical challenge, such as when a mentor and two girls sought to figure out how to construct a multi-circuit so that their light-up scooter could be seen from the end of the block, a problem one of the mom's stated was important to their project. However, they are always initiated by a need to know as youth dig more deeply into the problems and possible response to the problems they seek to address.

Methods

Context

Our work with upper elementary to middle school youth takes place in two making space programs across two states, both housed in in Boys and Girls Clubs (BGC). These are community-based clubs with a focus on youth development, homework help, and sports for youth from low-income backgrounds. In our dual researcher-teacher roles, we collaborated with BGC staff to establish these making spaces programs, with the primary goals of supporting youth in sustained engagement in STEM, while also learning about making in culturally responsive ways. BGC staff participated periodically (when available) as co-mentors. The program ran weekly during the academic school year. Over the two years of this study, we worked with 48 low-income youth, the vast majority of whom are African American (90%). 95% of youth stayed for at least one full year of programming, 50% stayed for both years.

Methodology

We employed critical, longitudinal ethnography over two years. Critical ethnography values multiple perspective (Trueba, 1999) and foregrounds dialogic interactions between researchers and stakeholders, facilitating critical critique of potentially oppressive relationships between

structures and actors (Calabrese, 2001). We took seriously the critique of the lack of an anthropological approach in education research (Ladson Billings, 2006) focused on sociocultural perspectives. To make sense of youths' lived experiences in community settings, we purposefully engaged in a *longitudinal* study to immerse ourselves in those settings, both to gain legitimacy as members of said settings and to develop an authentic understanding about the culture therein. We are cognizant that our own positionings as adult researchers-teachers from local universities (one White, other Asian) would influence how we experience the norms as opposed to the youth. In sum, we have at least 160 contact hours with the youth across two school years of weekly interactions.

Data sources include: field notes, biweekly conversation groups with youth about their making experiences, artifact interviews, informal conversations with club staff and parents, and the youths' work. Data were analyzed in the grounded theory tradition, using a constant comparative approach (Straus & Corbin, 1998). First phase open coding involved surfacing (a) critical episodes of youth making that featured particularly salient performances in talk and actions that were further invoked by youth subsequently in time and space, (b) the knowledge and practices youth drew upon during critical episodes, and (c) relational dynamics that linked knowledge and practices. Guided by our theoretical framework, we then engaged in subsequent axial coding to identify the axes of oppression, locate the nodes of intersection, and examine the impacts of the resultant relational dynamics on youths' making processes and made artifacts. Across these phases, analysis was member checked with youth and club staff.

Findings

The youth have thoughtful and critically-oriented views on making they deem as consequential to their lives and how such making might be supported. Youth expressed that they wished to "feel wanted" (Sahsa, sixth grade), "safe" (Samuel, eighth grade), and that they could "make whatever you want and the teacher cannot say no" (Lisa, sixth grade). Youth also want others to believe in their abilities and "set high goals" and expect them to "accomplish those goals" because "nothing is impossible" (Shernice, sixth grade). They pushed back against dominant narratives around who can be a maker and what that means. As Brianna, a seventh grader, noted, "Nobody be thinkin' you can't do stuff when they don't even know you." Lastly, youth wished to be supported in growing their knowledge and in imagining a world not yet (Kairee, sixth grade).

We suggest that community ethnography as pedagogy supports youth in authoring their own opportunities to engage in STEM-rich making—identifying the problems they care about from different vantage points salient to them, and how they wish to address these problems in ways that feel safe and productive. Not only are their STEM-rich making practices grounded in lived experiences of both privilege and oppression, the ways in which their work is seeded often revealed the nodes of intersectionality, challenging and transforming, even if it only to a small degree, the systemic oppressions they experienced. Youths' STEM-rich making involves an ongoing process of negotiating across scales of injustice and intersecting identities as they work locally and in-the-moment but seek to also challenge and transform existing narratives and locations of experience. To illustrate these claims, we first present two detailed cases of youth makers, over the course of one school year.

Case # 1: Tonya

Tonya is a vivacious 10-year-old African American girl classified as an Accelerated Learner (AL). Enthusiastic about science, Tonya chatted animatedly about science phenomena (such as how DNA works) whenever there were pauses in our making-related conversations. We describe two critical moments in Tonya's participation in what follows. These are critical both in terms of (1) how Tonya evinced a critical awareness in how Tonya evinced a critical awareness in how she identifies and describes the injustices in the worlds she inhabits; and (2) how these episodes significantly impacted her making process.

Critical moment #1: The intersectionality of identities as salient to making. In the fall of her first year at making club, Tonya's family had to relocate to a homeless shelter. The week after the move, Tonya attended making club with her usual enthusiasm. She experienced some teasing from peers for her appearance, particularly relating to her hair. While she used to style her hair into different kinds of braids with decorative accessories (e.g., beads) previously, she wore her hair naturally more often during the times that coincided to when her family situation was less stable. With humor, Tonya brushed off her friends' teasing, and expressed loudly that her hair was "beautiful." In another making session, Tonya had a conversation with an older teen boy, Kalvin (who was unaware of her home situation) about homeless youth in his middle school:

> Kalvin: You can tell when some kids is homesless cuz they be wearing all this mismatched clothes and they be smelling bad…
>
> Tonya: That is NOT TRUE [emphasis Tonya's]. Just because a kid's homeless doesn't mean the kid will look ratchet. You shouldn't say that, it's not nice.
>
> Kalvin: I'm just sayin' you can tell … some of the kids at my school are homeless.

Although Kalvin's remarks were insensitive, he and Tonya continued to have a quiet conversation between them about kids and homelessness during the making session. The adult mentor nearby did not shut down this conversation, made eye-contact with both youth, acknowledging the legitimacy of their discussion in the making space.

In another session, the youth used the 3D sketch-up Tinkercad software to create 3D name-tags with a perforated hole for a chain. Tonya was first to successfully render the hole in her sketch-up design. This involved some complicated steps—selecting the correct cylindrical tool, dragging the tool to the 3D, scaled name-tag model, lengthening the tool to perforate the depth of the name-tag, grouping the action together for confirmation. As she completed this process, she proclaimed loudly, "I really am the genius scientist! I am really good at science!" All the other youth were having trouble, most of them tripping up at the "lengthening" part. The maker teacher asked Tonya to walk around and help her friends, which she was delighted to do. Calling herself a "genius scientist," she helped eight other youth, all of whom were older than her. As she walked towards each peer, she would say in a sing-song lilt, "Here comes the genius scientist to help you!" In these episodes, the maker teachers opened up space for Tonya to engage in conversations relevant to her life (homelessness) and further recognized Tonya's identity as a capable science student by asking her to help her peers with Tinkercad. The intersectionality of

Tonya's identities—a strong science student, a youth experiencing homelessness, an enthusiastic youth-maker—were legitimized by the making community.

Critical moment #2: Staying true to her lived realities in the making process, changing her making project from the SafePax bag to the Cautious Cap through engaging in community ethnography and JiT activities in circuitry. Tonya initially teamed up with Tricia and Lisa to work on a safety book bag to help the children in their community be safe. During the community ethnography session on safety, the girls discussed bullying at school and the difficulty in summoning help while "being attacked in the girls' bathrooms." For a month the three girls worked together. Using tablets, they surveyed community members at the club through conducting short interviews on how much such a bag should cost and other features that would be helpful to include on their "SafePax." They used littleBits (snap-together magnetic electronic pieces) to build circuits, including a button sensor and a buzzer, to test how loud the buzzer would be. Tonya started to diverge in opinion with her teammates over the features on the bag. In addition to the alarm, Tricia and Lisa wanted to include a solar panel powered cell-phone charger as an added feature. Tonya disagreed about the necessity of this additional feature, stating that "not everyone has a cell phone, especially kids at school." She was concerned about keeping the price of the Safepax affordable, and that having that extra feature would be expensive. Tonya already had concerns regarding the cost of the Littlebits components. When the girls could not agree, Tonya decided to work on her own project, saying to the maker teacher, "nobody will be able to afford that bag." After a discussion with all three girls to ensure that everyone was ok with Tonya's decision and that no other underlying group dynamics were in play, the maker teacher supported Tonya's decision to work on a separate project.

Tonya quickly came up with the idea to create a "Cautious Cap" for youth and children who may find themselves in potentially unsafe places, "like a shelter." Tonya had talked to Author 1 about feeling uncomfortable at the shelter because of being forced to be in close quarters with strangers. She stated that she was especially uncomfortable about "men who are always talking to [her]." Drawing from these experiences, she wanted her Cautious Cap to have an alarm that can be pressed by a button to summon help when needed, and an LED light for added safety at night. Recalling her conversation with Kalvin, she reiterated her point that "homeless kids are not ratchet." Her goal is for youth to be able to wear the hat and be safe, while still being fashionable. Tonya sketched up what her Cautious Cap would look like on paper. While prototyping, she started with a baseball cap and found it structurally difficult to work with. She explained, "This [front] part is hard and this scissors is not cutting through for me to have the light in the front and I need the light to be in the front."

Although this idea originated with Tonya's personal experiences, she engaged in community ethnography, actively seeking community input (especially amongst her African American girlfriends) for how the hat should be designed to complement "our beautiful black hair." With feedback from her peers, Tonya agreed that it would be "too ugly" to have the wires visible around the cap. When she tried to hide the wires by positioning them on the inside, further conversations with peers convinced her that the wires would make it uncomfortable, that the wires would "mess up" hairdos, getting caught in the delicate braids the girls often wore. The girls talked about how long it took to braid their hair, and that it would be awful if the cap then

messed up all that work. Tonya decided to switch from a baseball cap to a soft knitted beanie hat, which the maker teacher sourced for her from donated items.

Tonya worked to hide the wires between the folds of the double-layered beanie hat so that the circuitry was completely invisible and that the wires would not protrude against the scalp. However, this necessitated sewing little loops to secure the wires within the folds, an added technical challenge. Next, in order to power the LED light and the alarm, she constructed a circuit that would be powered by a solar panel with energy stored in rechargeable batteries. It was necessary to Tonya to provide her hat with a renewable energy source, primarily for financial reasons ("cos nobody has extra money for batteries when you live at a shelter") and also for environmental reasons ("I don't want my hat to be polluting the earth"). Author 1 engaged in JiT activities with Tonya to address these technical challenges raised by working to address her peers concern into the technical elements of her design. They discussed the function of a diode in maintaining directionality of electron flow from the solar panel to the rechargeable batteries so that charge would not "leak backwards" and figured out where a diode should be inserted into a circuit. Once confident, Tonya inserted a diode into her hat circuit with careful sewing. Author 1 then showed her some tools (plastic terminals) that could secure wire connections by crimping the wires together. At every step, she checked the connections with the LED light to see that it "lights up and works" before crimping components together. Tonya added a switch to the circuit and used three plastic terminal sets to crimp the wires together. On her own, she figured out there was a crimping notch in the wire stripper tool which made the task much easier, and eagerly showed Author 1. To add a sense of fashion to the hat, she embroidered a heart with purple thread before finalizing her circuit. Once the circuit was done, and after her friends' opinions were sought, Tonya decided to unpick the original sewn heart and resew one so that the LED light is nestled right in the very center of the heart. She also switched the color of the thread from purple to dark beige, to match the beige trim of the hat. Tonya was very proud of herself, saying, "I really am the scientist genius" when she completed her project.

Case #2: Thomas & tara the do it yourself green energy (DIG) kids

> People say that African Americans and girls are not interested in STEM. Did it surprise us that most of the videos we did find were done by white men? Not really. That is great, but we wanted to see videos made by people like us. We also want to show people like us that we can do this work, too. –Thomas and Tara explaining why they want to make their project.

Thomas and Tara joined their community making space at the same time. Both youth defied their gendered stereotypes, forming an alliance to make making more accessible to "kids like us." Thomas, African American and in the sixth grade, had been a long-time member of the club, coming daily after school. He was not interested in school science, but expressed an interest in being able to make things that he could use to help others. He also had an interest in fashion that he felt he could work on in this space. He sought an environment where he might be able to find more quiet space and smaller groups with which to interact. The club setting, which houses over 350 youth daily, can be a loud and vivacious space. Tara was not as regular a member of the club. She attended less regularly, attending on the days her mother worked at the club. A white seventh grader, Tara loved science and math, although she did not like art as much. Like

Thomas, she was quiet, and appreciated smaller group settings where she felt like her ideas would be valued. She gravitated to Thomas as a partner when he was working alone and she looked for a project to join. We describe three critical moments on Tara and Thomas' project, how they were supported by their teachers, and how the youth sought for legitimacy in their STEM-rich making.

Critical moment #1: Engaging in JiT through seeking expertise to becoming the expert → Figuring out how to use piezo pads. At the beginning of the school year, Thomas and Tara wished to make a solar-powered light-up backpack for commuting to school. They came to this idea in response to a survey they conducted with community members who indicated concerns about safe commutes for young people. Tara noted: "This is actually a big issue. Lots of us have to walk to school in the dark, for like most of the year." Their internet research showed that for over half of the school year, the time of official sunrise was later than the time they had to leave their homes for school. Conversations with peers and parents at the club showed that others shared this concern.

The two youth spent about eight weeks planning their backpack, including style, color, lighting patterns, and the energy source—a solar panel. During one of the feedback cycles, where members of the community come in to offer their input on designs, a visiting engineer, "Crazy Bill" whom the youth had developed a familial relationship with over his visits, suggested that the youth might consider using piezo pads, small plates that helped turn the vibration energy they produced while walking (with their packs bouncing on their backs) into electricity.

> Crazy Bill: So you want to power this with solar?
> Tara: Yeah, that is what we have here [points to their drawing].
> CB: How do you think that will work?
> Tara: It's good for the environment. We won't have to use batteries.
> Thomas: The solar panel will just get energy from the sun and we'll sew it in right here [points to drawing].
> CB: That is a good idea. But if it's dark when you walk, how will it get energy from the sun?
> Thomas: I guess we could keep the backpack out in the class during the day?
> Tara: My teachers don't let us do that.
> CB: You could think about another energy source that is also good for the earth. What if you could turn all of your energy from walking into the energy you need for the lights?
> Tara: I don't know. Maybe.

Crazy Bill then explained more about piezo pads to the two youth before moving on to talk to another group. Before the session ended, Tara asked Author 2 (her teacher) to order piezo pads because they "might" use them on their project. However, when the order arrived, it contained a set of piezo pads, but no directions. Both Thomas and Tara turned to Wendy, another teacher, and Author 2 for help. But, neither teacher had worked with piezo before either:

> Tara: This is stupid. They don't give any directions. I don't get it.
> Author 2: Well, let's look online. Maybe we can get some direction there.

Tara searched exclusively within YouTube. Thomas searched across a range of possible sources, including websites that included technical documents. However, the searching process only enhanced frustrations. According to Thomas, the only helpful information they found was a lengthy word document describing in technical detail how piezo pads work, but not actually how to put them into a circuit.

Author 2 did not know how piezo pads worked either, but she noticed familiar things about the pads, such as their black and red leads, that might connect to deepening knowledge around circuitry. Author 2 suggested that they spent time observing the pads to figure out what the important parts of the pads might be. The youth took one of the pads apart, examining the components carefully. Tara noticed what Author 2 too had noticed—that the pads had both a black and red wire. Thomas suggested that the two colors of wire looked just like the multimeter, which, too, had red and black wires. He suggested they put wires up to the multimeter to see what would happen. When nothing happened after shaking the pads (as if one were walking), they decided to tap the pads, as if they were dancing (e.g., the light up dance floor). They thought they saw a momentary jump in the meter. Author 2 suggested that they hook the pads up to an LED light to see if they could get it to light up. Thomas and Tara tried, unsuccessfully. Each time they tried to tap the pad the wires would jiggle loose from the LED.

Critical moment #2: Intersectionality of identities: Moving from backpack design to a video on piezo pads. Thomas and Tara were frustrated by their piezo pad investigation. They struggled to get the LED to light up, and they could not find educational videos online to help them. Tara explained: "At first we couldn't find any videos at all about piezo pads. Probably because piezo pads are not well known. But then we did find some, but they were really complicated. We couldn't really understand them."

When they were able to momentarily light the LED with four piezo pads, they screamed in glee. This led them to discuss changing their project from a light-up backpack to a Do-It-Yourself video series, "made by kids for kids." They were deeply concerned that other youth have opportunities to learn about things they "can't learn about in school" or "even on the internet." As Tara noted,

> Some students will not have a problem reading adult materials, but some will … Even if you understand the materials you still might not know how to put them together into your invention. Once we were able to get some piezo pads, we had no idea how to put them into a circuit or even how to make them work. We eventually got it to work, but it took a lot of extra time as we had to figure this out on our own.

At Author 2's encouragement and in an effort to foster further community dialog on their new idea, the two interviewed peers, maker teachers, and others around the club to see if they felt the same way about the available internet resources. After interviewing, they decided to expand their rationale to address new related scales of injustice: the stereotyping of people like them (girls and African Americans) in STEM. They noted the lack of STEM resources for people in their community to do STEM because of local economies and practices. As Thomas said, "In [city]

there are not many afterschool STEM programs, and definitely not many kid-friendly makerspaces. Where will kids learn these skills? In our videos, of course!"

The two youths' video was playful, informative, and centered on their making success. The video began with a scene of the two eating a snack talking about their interest in the movies. They were laughing and joking, when Tara asked Thomas if he wanted to learn about piezo pads with her. As the video cuts into a scene where they are assembling their circuit, their voices in the background explained how to assemble a simple circuit with piezo pads. They covered safety concerns, the elements of a complete circuit, and instruction on how they assembled theirs. They then zoom into their working circuit, again, explaining how piezo pads work to power LED lights. When the explanation is finished, they zoomed back to their snack time, and make a final joke about the movies. They were pleased that their story line showed girls and African Americans teaching others how to use piezo pads in a circuit.

While the two youth started a video on piezo pads, they developed plans to make videos on other forms of renewable energy, and green energy related makerspace skills and activities. They wanted to ensure that "Our DIY videos will help kids learn about different types of energy and how to incorporate that into their DIY projects at home or at a makerspace" and to help other youth see that "there are many different types of energy that are better for the environment."

Discussion

Reading injustices along axes of oppression and locating intersectionality

In the what, why, and how of their making, we noticed that the youths' STEM-rich making practices were grounded in their intersectional experiences of privilege and oppression. Furthermore, these experiences of privilege and oppression were challenged, expanded, and legitimized through different perspectives surfaced through pedagogical approaches incorporating community ethnography. By talking with members of their communities, the youth became more cognizant of these axes of oppression that played out in their lives, and also in other, as well as their own agency to act against these axes. In this way, their making involved a process of learning more about how their own everyday experiences were tied into broader systemic narratives.

Tonya, Tricia, and Lisa shared experiences of being bullied and witnessing bullying in their schools, often in hidden spaces like secluded stairwells or the student restroom, where adult intervention is not readily available. These experiences, together with gathered community feedback, led the girls to make an alarmed, light-up backpack as a solution to their community problem. The girls were able to read the injustices inherent in bullying in their school and to seek an agentic response through making. This ability to locate systemic injustices also was evident in Tonya's decision to make the Cautious Cap. The different intersecting axes of oppression that Tonya struggled with were reflective in her experiences as an African American girl with specific hair-wearing practices, a homeless child, and as a target of school and shelter bullying.

Tonya operated from this intersectionality in her making endeavors. The different scales of injustices she sought to address with her innovation included: (1) personal safety at a potentially

dangerous setting like a homeless shelter; (2) providing winter accessories (hat) to youth who are homeless and thus struggling with a limited wardrobe; and (3) a knitted beanie being a useful accessory for a quick solution to "big hair" (Tonya's description) when you do not have the time, space, or wherewithal to create a braided hairdo, which can occur when youth are struggling with stressful circumstances like homelessness.

Similarly, Thomas and Tara made sense of injustices in the larger making resource world when they could not locate youth-friendly DIY videos related to piezo elements. Ethnographic research into others' opinions expanded their sense making of the maker world, helping them to critique its adult, white, male-centered norms. Tara and Thomas described multiple layers of injustices in their critique, along different axes of systemic oppression, as Tara explained: "Our videos have five features: They provide useful information but it is not just someone talking at you. They are funny, cool, and fresh. They show "how to" steps that are clear and easy to follow to help you do different things. They are made by kids; kids are the ones who talk and show the steps. And, they are all under five minutes but they get the point across."

Community ethnography granted legitimacy to the youths' framing of issues of injustice to address through making by bringing multiple, related voices to bear on these injustices. This shifts the lens away from that of "problematic individual" to expose normalized, systemic oppressions. In this case, where the only maker teachers represented online were white male adults, the oppressions included: (1) age discrimination; (2) racial discrimination, and (3) gender discrimination. As with Tonya, Thomas and Tara also operated from the nodes of intersectionality of these particular oppressive axes when they embarked on making DIG videos.

Privilege and oppression intersected in these two cases. In Thomas and Tara's partnership, Tara's sociocultural capital as a white girl intersected with Thomas' experiences as an African American boy from a low-income background. Together, they brought their lived experiences to critique the lack of representation of girls and African American boys in existing making culture. Tara articulated with nuance the problems inherent in only white, male-authored how-to maker videos. Thomas and Tara mutually informed each other's experiences as marginalized others within the dominant making culture—while Tara as a white female is victimized by patriarchy but privileged by race, Thomas as a lower-income African American male is victimized by race, class, and to a different degree that is connected to his race and class, his gender, especially because he does not display the prototypical characteristics of maleness. In the context of representation in how-to maker videos, both were slighted on account of their youth.

For Tonya, her privileged identity as a "genius scientist" which was validated both in school and at the making club, intersected with her homeless and African American girl identities. Performing as a genius scientist, she was perhaps able to shade the reality of (and thus fend off stereotyped assumptions) homelessness from operating through oppressive social processes along the axis of economics. Her competence and quick uptake in STEM making practices (privileged STEM identity) steered her making of the Cautious Cap to incorporate design features that could blunt oppressive social processes targeted along racial and gendered axes, in the body of a homeless African American girl with her natural hair.

Who is a maker and what counts as important to make in a STEM-rich making space

Understanding youths' intersectionality helped us to see how their making involves an ongoing process of negotiation—of the STEM-oriented making processes, the emergent making culture, and of the problem spaces youth hoped to impact through their making projects. This process is always occurring along different and intersecting scales of injustice, as youth work locally and in the moment but seek to also challenge and transform existing narratives and culture. We examined how these making processes took place, and how they were supported by community ethnography and Just-in-Time STEM activities.

Taking an intersectional lens helped us gain insights into how community ethnography and JIT pedagogical approaches worked in concert to support youths' making. We noted how community ethnography as pedagogy was powerful in solidifying the legitimacy youth sought to bring to their making, in both broadening the base of salient issues (e.g., safety in the community through multiple angles) and layering complexity to salient issues (e.g., how being marginalized as a homeless youth intersects with the place of "beautiful black hair" in societal narratives of normative (white) beauty.

As adult facilitators who are ultimately still outsiders in youths' communities in spite of our longitudinal presence, we supported youth in these decisions and collaboratively figured out with them what "next steps" could look like in terms of materials and making practices. As teachers, it is not always directly obvious when or how to infuse JiTs into lessons or to solicit for community perspectives. An essential dimension of employing these approaches is to consciously cede power to the youth, in-the-moment, with the assumption that youth-led activities, however "tangential" they might initially appear to us adult mentors, can yield this valuable insight. Listening carefully to the conversations they are having, to their ideas and decisions to make changes to their projects, or from whom they may want to learn, all provide important insight regarding when JiTs and community ethnography may be employed.

We believe that building these youth-centered norms in the making space fostered productive spaces for youth to engage in potentially uncomfortable conversations necessary to creating an authentic making culture in their communities. Such conversations also are productive in helping youth identify interconnecting webs of oppression, such as when Tonya gained a deeper understanding of how the state of being homeless can be experienced beyond dealing with instability, when school peers displayed negative assumptions about homeless students in the space of school.

The nuanced and layered concerns collectively garnered through community ethnography led to particular design features of their making projects, which necessitated technical know-how informed by JiT. Youth displayed a willingness to engage more deeply with STEM and to re-interpret/re-package STEM in ways that pushed back against injustice, such as when Tonya delved into more complicated circuitry work from a desire to hide ugly wires without messing up the wearer's hair, as well as using a diode in conjunction with a solar panel for pecuniary and environmental concerns. Through these acts, the youth reclaimed material space in their community making space, spaces where they felt vulnerable (e.g., homeless shelter, school) and for Thomas and Tara, cyberspace related to making, when they posted their DIG videos on their maker website. These maker artifacts have the ability to endure across space and time, furthering

youths' efforts to collectively create an authentic, youth and community-centered making culture in expansive ways, while pushing back against systemic injustices. When Tonya's Cautious Cap became an exemplary artifact of the community youth making space, the injustices embodied in the hat gained legitimacy as political texts that youth making can address. As Thomas and Tara built up a repository of youth-authored making how-to videos, they expanded and solidified their presence in the digital making space. Youths' subordination along race, class, and gender lines therefore gain legitimacy as injustices that can be addressed and potentially ameliorated through critical justice-oriented making.

Conclusions and implications

The intersectional analysis we have undertaken with the two illustrated cases helped us to consider the interconnectedness of different axes of systematic oppression and gain insight into how these axes operate as social processes to subjugate youth along gendered, raced, and classed lines in the context of STEM-rich making. The presented intersectional analysis also allowed us to begin to tease apart where particular nodes of intersectionality are located for particular youth, going beyond simply claiming intersectionality only as a research "buzzword" without rigor or nuance (e.g., Nash, 2008; Nunez, 2014), or homogenizing people groups (e.g., black females from low income backgrounds) as suffering from the same kinds of oppressions. In addition, we gained insights on both oppressive intersectionality as well as alliance building intersectionality, when privilege and oppression converge.

We suggest that actively supporting youth in seeking community data and integrating such data into STEM-rich design work, is productive in working towards equity for youth enduring oppressions. We also encourage teachers to consider when STEM content is relevant and pertinent to the project, in the mode of Just-in-Time STEM activities. Finally, we want to stress the risks and tensions youth and maker teachers lived with as they collectively engaged in critical justice-oriented making endeavors. Exposing, critiquing, and acknowledging marginalization requires vulnerability, courage, and ambiguity in collectively figuring out a "just" response. Such a "just response" could very well remain an "unsettled matter that neither reconciles present grievances, nor forecloses future conflicts" (Tuck & Yang, 2004, p. 3) but, we argue, is an essential, concrete act towards youth becoming agentic makers. The field needs more research insights to figure out how to more robustly support marginalized youth in critical, justice-oriented STEM endeavors that can not only support their STEM learning, but also help make their lives more just in the here and now.

Funding

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