Mobilities of Criticality: Space-Making, Identity and Agency in a Youth-Centered Makerspace

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Abstract: We examine in-depth cases of youth makers from non-dominant communities in two makerspace clubs in two different mid-sized US cities. We argue that through their making practice, they are involved not only in "artifact making" (the prototypically viewed outcome of makerspace work), but also in space-making within and across the worlds of STEM, makerspaces, and community. The data suggest that such space-making fosters new forms of interaction among scales of activity, and supports the movement of ideas, resources, relationships and bodies in support of youths' emerging practices and how they might be recognized for them. As the youth engage in their making practice, they inscribe new meanings for what it means to make within the worlds they inhabit, refiguring participation in these worlds and the possibilities for becoming within them. We used a mobilities of learning framework to guide our analysis.

Keywords: Science, youth, making, mobilities of learning

When little kids are playing outside football and it's getting too dark and they still keep playing and somebody might get hit in the head or something cause they can't see the ball really so I 'm going to light up the football so you can see where it's going. (Stephan, artifact, interview, May 2014)

Introduction

In this manuscript we examine the stories of youth makers from non-dominant communities, and argue that through their making practice they are involved not only in "artifact making" (the prototypically viewed outcome of makerspace work), but also in space-making within and across the worlds of STEM, makerspaces, and community. Such space-making fosters new forms of interaction among scales of activity, and supports the movement of ideas, resources, relationships and bodies in support of youths' emerging practices and how they might be recognized for them. As the youth engage in their making practice, they inscribe new meanings for what it means to make within the worlds they inhabit, refiguring participation in these worlds and the possibilities for becoming within them.

Our research questions are thus: 1) What making practice do youth from non-dominant communities, ages 11-14, take up in a afterschool community-based makerspace? 2) In what ways does their practice inscribe their spaces of making with possibilities for doing and becoming in making for community sustainability?

To answer these questions, we present two in-depth narratives of youths' engagement in a community-based makerspace. The first case involves Samuel's efforts to build the light-up football when he was in the 6th grade. The second case involves Jennifer and Emily's efforts to prototype a heated, light-up sweatshirt in the 7th grade. While our telling of these narratives revolve directly around the youths' making of artifacts, we hope to show how their practices for doing so alter the landscapes in which they work, and their opportunities to do and become within and across those spaces.

Findings indicate that the youth in our study have engaged in making practices that led to the creation of new artifacts that mattered to people in their communities. Further, youths' making practices were undergirded in what we think of as "mobilities of criticality," as they remixed and repurposed tools, practices and relationships from various communities towards space-making. In particular, we show how the youths' making practices are rooted in community, and are reflections of their deep and critical knowledge of the needs their communities face within and across the spaces of making. We also discuss how the youth's in-the-moment actions – a reflection of their making practices – served as critical "pivot points" in their design work (Holland, Lachiotte, Skinner, & Cain, 2001). The pivot points connected scales of activity, including STEM inquiry, making, community and action taking, in how they provided analytical foci for driving technically oriented design work, and opportunities for social negotiation towards new possibilities of doing and becoming in STEM, makerspaces and community.

Conceptual framework

We are interested in questions of youth engagement and identity work in making as it relates to how the spaces and places of making get re-organized, disrupted, and/or expanded through the youths' making practices. In particular, we are concerned with how youth's making practices take shape across multiple scales of activity simultaneously, but also over time – e.g., locally among peers in small group work in makerspaces as well as in the real and imagined spaces of STEM. Thus, we draw from mobilities of learning studies and social practice theory to frame our concerns. We are particularly interested in those studies that take a critical orientation, weaving in issues of power and positioning.

A mobilities of learning framework is centrally concerned with movement – of people, ideas, tools, resources, bodies and relationships – and how such movement shapes and reshapes the spaces and places of learning, and the social practices enacted and made possible therein (Leander et al, 2010). As individuals move through space and time, the sociohistorical narratives around them shift, shaping and reshaping how they inhabit or reinhabit space (Gutiérrez, 2012). For example, Kwan (2008) describes how Muslim American women's movements within public spaces have become restricted in the US since 9/11 in response to rising political narratives even though the actual physical access to these spaces remain unchanged. At the same time, she illustrates how such limitations in physical movement sit in juxtaposition with increasing access to new digital spaces. These arising digital spaces have become new homes for exposing oppressive narratives experienced by the women, as well as for opening up new opportunities for relationship building practices across cultural difference.

Examining the critical literacy practices of migrant youth in Southern California, Gutiérrez (2008) describes how youth use their "complete linguistic toolkit" – toolkits made up of linguistic practices of home and community, such as testimonio, in addition to the practices that are sanctioned in school settings – to navigate "the paradoxes of migration, immigration, and schooling" in the US. (p. 150). These hybrid practices helped students to link their past and present to an imagined future, and to reorganize everyday concepts acquired through social interaction in joint activities of school-based literacies. She suggests that these "rich interactional matrices of practice" lead to a new dialectic between the "the world as it is and the world as it could be" opening up new spaces for learning and transformation (p. 160).

In both of these studies, who individuals are and who they can be across the spaces –temporal, physical, and virtual – of their lives, and the practices they take up within and across those spaces, emerge from and transform the meanings of those space as constructed through social activity.

Mobilities of learning studies remind us that learning always takes place *somewhere,* both in "relation to history (time) and context (place/space)" (Bright, Manchester, Allendyke, 2013, p. 749). One thread of work that is particularly salient to our own work is that which examines space-making as a part of more expansive views of learning. We use the term space-making in ways similar to that of place-making (e.g., Cresswell, 1996, 2004; Massey, 2005; Lombard, 2014). An individual's opportunities to be and to become are shaped by place. At the same time, who one is also gives meaning to place; "places do no have intrinsic meanings and essences . . . the meanings of place are created through practice" (Creswell, 1996, p. 17).

However, by drawing attention to spaces over places, we acknowledge the itinerant over the fixed nature of learning, where space reflects "a territory defined by practice-based learning, inhabited by a network of people, ideas, and objects in movement" rather than a fixed geographical area (Fendler, 2014, p. 787). We also use "space" to suggest that the possible platforms for being and becoming are not only solely contingent on the structural landscape of geographical places but are also tied to norms and power structures. "Space" also connotes for us the plurality of spaces (platforms for being and becoming) that are connected to a singular geographical place, e.g. youths' residential neighborhood.

Gutiérrez (2012) work on expansive learning helps to unpack the importance of movement across both vertical and horizontal dimensions of learning. Here, movement refers to the ways in which ideas, tools and practices are re-authored and re-mixed towards new possibilities for becoming in-practice across setting and over time (Engeström & Sannino, 2010). Through learning activity, new activity structures are produced as vertical and horizontal dimensions interact, leading to new forms of activity. Gutiérrez describes these new forms of activity as the kinds of hybridity that emerge as the tensions and contradictions that arise within and between activity systems. In these studies, *hybridity* refers to the novel combinations of different repertoires of knowledge and practice (e.g., science and peer/family/community) as individuals who horizontally move ideas and practices. However, it also refers to the hybridity that exists at multiple levels of the learning environment, where many activity systems come together (e.g., science, student, teacher, schooling, etc.). This perspective, thus, allows us to better understand youths' horizontal movement and hybridization toward making/engineering designs that are both meaningful from a disciplinary perspective and compelling to youth committed to their communities.

Methods

Our study was carried out as a critical ethnography over a two-year period. Critical ethnography was selected as our methodology because of its explicit focus on participatory critique, transformation, empowerment, and social justice. Critical ethnography is grounded in the idea that researchers can use the tools of ethnography to conduct empirical research in an unjust world in ways that examine and transform inequalities from multiple perspectives (Trueba, 1999). Critical ethnography provided an approach in which to "politicize" the interaction between actors and the social structures through which they act, grounded in the belief that these relationships are never neutral. This approach was important as we attempted to make sense of how youth, who are positioned in particular ways due to race, gender and class, engage in makerspace activities.

Our study is grounded in middle school youths' experiences in two different makerspace contexts, Michigan and North Carolina, over the course of two and one years respectively. The makerspaces in both locations are housed in Boys and Girls Clubs [BGCs] (community-based clubs focused on youth development, homework help, and sports) in mid-sized cities, both facing some degree of economic depression. We have worked together with staff at the BGCs to establish these makerspaces, with the primary goals of supporting youth in developing productive identities in STEM, while also learning about making/engineering design in culturally sustaining ways. In both locations, we sought to engage youth iteratively and generatively in maker space activities and in community ethnography as one approach to embedding local knowledge and practice into making and engineering design.

Student and school sample

During 2013-2015, 36 youth participated, of whom 11 participated for 2 years (2013-2015), and the remaining 25 participated for 1 year (2014-2015). The youth were primarily from grades 5-8 (ages 10-14), and from lower-income families. Most are African American, although a few are white or biracial (See Table 1).

Table 1: Number of students in each site

Year	Location	Total Participants	Demographics
2013-2014	Michigan	14 youth	2 White 10 African American 2 Biracial
2014-2015	Michigan	21 youth	2 White (both returning) 17 African American (8 returning) 2 Biracial (returning)
	North Carolina	15 youth	14 African American 1 Biracial

Data were generated, 2013-2015, from artifacts, weekly youth conversation groups, and video analysis capturing youth interaction with STEM and community experts at various stages in their design process (See Table 2). In addition we used mid- and end- of year course artifact interviews, researcher field notes (per session), and youth created multimedia (e.g., video blogs) showing progress on their design to community members and STEM experts.

Table 2: Date Types Generation Strategies

Data Form	Specific Data Generation Strategy	MI (2yr)	NC (1yr)
Participant Observation	• Makerspace sessions/activities: Video recordings of twice weekly sessions and field notes in two sites • Makerspace Community Events	72hrs/yr 8hrs	70hrs n/a
Conversation Group	• As a way to debrief what was happening in the club as well as to plan for future activities	30 hrs/yr	30hrs
Artifact	• Allowing youth opportunities to talk about their	4	3hrs

Think Aloud	engineering design work in detail (mid and end of year)	hrs/gp/yr	
Artifact Collection	• Youth's sketch up notebook, 3D Google SketchUp model of design, worksheets, prototype, movie, etc	ongoing	

Analysis

Data analysis involved multiple stages and levels of coding based on procedures for open coding and method of constant comparison (Strauss & Corbin, 1998). Our first pass involved reading through artifact interviews transcripts (conducted yearly at mid year and end of year) as well as our fieldnotes and the students' sketch-up notebooks kept during the course of their participation. The goal of this initial read through was to surface points and open codes of a) tensions and connections among the various youths' forms of engagement in making, b) critical design moments (e.g., sticking points, changes in direction, etc.), and c) generally how youth talked about and framed what it meant to participate. For example, in trying to open code for critical design moments, we noted times when youth made shifts in design, became deeply frustrated or disengaged, or otherwise more explicitly noted for us (e.g., artifact interviews) when they felt they were stuck or had important turning points. Weekly conversations were held between the authors on these insights as a way to work towards a more "expansive consensus"; that is to say that any differences in view were debated until new meaning was generated as a result of our differences. A detailed list of emergent open codes were kept with analytic memos attached to them, which we then brought to bear on other data sources, such as group conversation transcripts and various student artifacts not included in their sketch up notebook.

Our second pass involved identifying important resources and practices used by youth in their making, in relationship to the previously identified critical events, tensions and connections. With the help of our theoretical framework (mobilities of learning), we worked to make sense of what it meant for the youth to move, repurpose or remix the ideas, practices and resources they leveraged within these events. This axial phase of coding was used to uncover relationships and connections between the youths' making and the tensions that emerged from the data. In developing these coding schemes, we paid attention to how, and where, youth engagement appears greatest and the forms such engagement took, how they move ideas and resources across spaces, the different forms of learning, and the identity work that take place within and across these spaces. We took these data points as significant markers of equity – opportunities to access and activate traditional and nontraditional resources and to be recognized for doing so, as important to the making process and outcomes.

The relationships and connections identified in this second stage of coding, in turn, guided our selective coding, and became categories and themes, from which our example cases were selected for a final round of analysis and presentation. This final phase involved writing the narratives related to students' participation in the two makerspaces under study.

Findings

For the purposes of this proposal, we share one shortened narrative followed by a discussion of core findings.

In-depth vignette

Interviewer:	Samuel, why did you decide to make a light-up football?
Samuel:	Well, when little kids are playing outside football and it's getting too dark and they still keep playing and somebody might get hit in the head or something cause they can't see the ball really so I 'm going to light up the football so you can see where it's going.

Samuel joined "M4C" a makerspace club at his local Boys and Girls Club during the fall of his 6th grade year. While he did not have friends in this club when he joined, and had never heard of "engineering" before, he said he wanted to join because he "kept seeing" what other kids were doing, and he wanted a chance to do "something like that" too. Samuel lived alone with his grandmother, after his mother ran into social and legal programs, a point that plays into his design work as we will see later.

Samuel designed a prototype of a "light up football" while working in the makerspace over a period of five months. His light up football has LED tube lights that wrap around the ball to provide maximum lighting with minimal added weight, friction, or power expenditures. Because the lighting it so efficient, it would also keep hands from getting burnt. The lights are powered with rechargeable batteries that can be recharged at a

solar docking station, limiting environmental impact and saving money. The football, itself, is constructed from nerf material to further minimize added weight and to reduce the possibility for injury if one were to be hit in the head. The batteries are stored in a pocket at the center of the ball, accessible by a small door, to keep it weighted properly and to minimize their potential contact with rain water and sweat.

The idea for a light up football grew out of Samuel's desire to make something that would be helpful to people in his community. As he states:

> [My football] say about me that I really care about people. And I could, like, do stuff in the community so it could, like, do stuff together, like, peers can do stuff together, like, neighbors or school neighbors could like, go outside and do stuff together. . . Cause, like, some kids don't really play football, don't have no friends and stuff, so I go find people to help out a little bit.

Samuel's idea of care is nested in an understanding of the special needs of the young people in his community. Samuel knew that lighting was a concern at night due to limited working streetlights in his neighborhood. He also felt that the game of football was a positive peer activity that helped young people his age make friends and stay out of trouble. He knew that most families could not afford an expensive toy, and that inefficient designs were costly to the environmental as well.

Samuel worked tirelessly on his design for five months seeking help from family, friends, and engineering and football experts alike. He was proud of his efforts. As he stated, "I was really proud 'cause it just made me feel good about myself so I could, like, acknowledge people what I could do. . . Like make what I did, a light-up football. I wanna make more stuff like that."

A light up football presented Samuel with many design problems of both technical and social consequence as well. For example, lighting a football requires power. As Samuel noted, powering the lights costs money. His initial solution was to use rechargeable batteries because "*mine's is rechargeable batteries so we can see all the time but so you won't have to keep going back to the store and buying, like, batteries to reuse.*" Saving both money and time by not having to return to the store to buy new batteries were both important in order for Samuel to keep the lights powered.

But, rechargeable batteries also addressed another design concern: environmental sustainability. Samuel was worried in particular about the problems created when non-rechargeable batteries are thrown into the trash. As he states, "Rechargeable batteries save energy and money so you won't have to, like, keep buying and buying batteries, so. [They] make the world greener. When you throw batteries away, those critters can get inside your trash, like the racoons, can like, take your batteries, take your trash and batteries out."

Powering the lights was, in fact, the "biggest design challenge" Samuel stated he faced. He noted that two batteries did not light the ball well enough, but more than two batteries, he felt, made the football too heavy, and too expensive. This insight seemed to spur Samuel to expand his design concerns to also include the weight of the football, and the location of the weight. Having his football like a "regular football" in terms of size, shape and weight, were all important, but all impacted by his desire to have a light up football.

Samuel sought input on these concerns from local football experts, which included a local football star. When recounting how these different experts helped him in his design, Samuel noted that the football star helped him to think about how to make the ball balanced, so that it would not be too heavy on one side or the other. To solve this problem, Samuel had to cut deeply into his prototype to place the batteries in the far center. As he stated, "Yeah. Yeah so I used that and so when I went back and tried to do it, I made sure that when I cut it, I made sure that it could be deep enough so it won't, like, make it so heavy. So it could be, not be so light, it could be just right. So *like a real NFL football*."

There were many other design challenges that Samuel confronted as he progressed in his project. He sought out many different kinds of experts to help him out, from his mother to his peers, to football experts, to engineers, to the internet. All of these perspectives representing different kinds of expertise and needs mattered to him.

Discussion of findings grounded in vignette

Youths' making practices are rooted in community, and are reflections of their deep and critical knowledge of the needs their communities face within and across the spaces of making. Youth's in-the-moment actions – a reflection of their making practices – served as critical "pivot points" in their design work. The pivot points connected scales of activity, including STEM inquiry, making, community and action taking, in how they provided analytical foci for driving technically oriented design work, and opportunities for social negotiation towards new possibilities of doing and becoming in STEM, makerspaces and community.

Rooted in community

Practices as rooted in community. The youth in our study, in on-going ways, position themselves as a part of, or inside, the urban ecology, rather than outside of it. Their making practices, as rooted in a wide range of community spaces, draw upon expert knowledge on issues inside to these spaces, such as the funds of knowledge one has because of where they have grown up and with whom. These practices also incorporate insider positioning status, such as that which grants access to the social networks and contexts necessary for gaining deeper insights and access to resources when needed.

The youth brought to their investigations a wide range of funds of knowledge and relationships that played a role in how they defined the problem they wanted to work on, and its various dimensions. These funds are tied to particular community spaces where youth have insider status. For example, knowledge of where streetlights have historically not worked, why kids at their school get bullied, fashion, how to work with one's hands to build, or the reasons and impacts of major economic concerns of the home, all reflect their insideness – their membership and experiences in the community spaces that they inhabit. How the youth drew from these funds across spaces reflect their attempts to author interconnecting corridors for traversing between these community spaces, and their STEM-infused youth makerspace. These different points of intersection become meaningful sites of negotiation.

Practices as enactments of their deep and critical knowledge and care for the needs their communities face. There are nodes of criticality in many of the funds of knowledge deployed by the youth, and in how they sought to leverage these funds towards engaging more deeply in the technical dimensions of their work. All communities face risks that result from geographical, socioeconomic, and political challenges. However, the risks are greater for young people growing up in lower-income communities of color, where environmental and social injustices loom large.

We see such criticality enacted by these youth in their making work as tied to four domains in particular: *Economic* (e.g. making their designs affordable), *environmental* (e.g., designs that reduce their communities carbon footprint and support local ecologies), *social* (e.g., fostering positive peer relationships, healthy well-being, community ownership, and preventing bullying and gang activity), and *urban infrastructure* (e.g., providing lighting and warmth on cold, dark days).

For example, Samuel worried about dangerous peer friendships, such as gangs, and believed some of these peer-related challenges might be remedied with positive play, such as with football. Samuel persisted in refining his football so that it met the needs of a wide range of peers. He first sought peer input on lighting – weight and design. He then pushed for input on weighting and feel. He tested his football with peers his age and peers younger than him. He pressed them for feedback on what functionality they needed, which is why he ultimately sought to make sure his ball was waterproof. Each interaction required Samuel to consider many new technical factors in his design that he had not previously considered, but he was deeply motivated by how and why his football would serve his local peer community.

Pivot Points and their functions

As youth engage in such rooted making practices over time, their in-the-moment actions served as critical "pivot points" in their design work. The pivot points connected scales of activity, including STEM inquiry, making, community and action taking, in how they provided analytical foci for driving technically oriented design work, and opportunities for social negotiation towards new possibilities of doing and becoming in STEM, makerspaces and community. Here we refer to Holland and colleagues (2001) use of the term pivot to refer to "mediating or symbolic devices" not just to "organize responses but also to pivot or shift into the frame of a different world". When youth leveraged their funds of knowledge, for example, towards work on their projects, they etched their insideness onto their engineering design, in ways that impacted the design process and how/where it unfolds, as well as their role in it. As pivots, these funds were not simply complementary to the youths' engineering design, but *essential* to *both who they are and their design work*. Pivot points include tools (e.g. sewing machine, Google Sketch Up), relationships (e.g. Samuel's ties to his cousins and peers) and the innovations themselves (e.g. Samuel's light-up football), all of which are able to shift the nature of STEM engagement for the youth, and potentially transform their possibilities for becoming and being within particular spaces (e.g. Samuel's peers and cousins engaging in safe play at night in their neighborhood).

The three key functions of pivot points are 1) Using funds as navigational indicators to secure a productive launching space to begin their making project; 2) driving technically oriented design work in dialog with community interests, and 3) facilitating social negotiations towards novel space-making endeavors to broaden possibilities for becoming in STEM.

1) Using funds as navigational indicators to secure a productive project launching space. The youth (including Samuel) took on a making project because they belonged to the same makerspace club. They were

not told what to make or how to make it. Rather they were charged with a fairly wide open task: design something that "uses portable energy" and that "attends to a particular community concern." We have been concerned with how youth locate or author productive starting places for projects. Such initial location work can be challenging, for it involves social negotiations of who to work with, along with considerations of what challenges might be worth spending time on. In both cases presented in this manuscript, the youth leveraged their funds as navigational indicators to author a productive project launching space.

Samuel drew from a wide range of funds – M4C youth makerspace, family, peer, and residential community funds – in order to locate a productive project launching space. As Samuel noted in his interview, his light-up football was an idea he "thought, and thought and thought about" while home at his grandmother's house unable to find transportation to the club nor able play outside after the dark. These considerations – limited streetlights, personal safety, and friendships – made that much more salient by his move to his grandmother's care became points of negotiation for how and with whom he would work. Samuel switched group memberships twice, before he felt he had the space to tackle the issue he really cared about. Samuel's initial ideas were legitimized by his cousins and peers who also knew that he had extensive experience playing football with friends, and had the expertise to design a football.

2) Driving technically-oriented design solutions in dialog with community interests. We also see imprints of youth's rootedness in how they worked across scales of activity in their systematic efforts to refine their design constraints and evaluate possible solutions towards optimization. New design cycles were initiated on both technical and community terms. For example, youth-set end-point assessments required them to seek multiple perspectives, both community-oriented and technical. As community funds initiated more complex design conditions, Samuel needed to deepen his knowledge of energy systems and environmental and economic impact. Working with a mentor, Samuel figured out how to calculate power requirements of different lighting systems. He read information on the Internet on the affordances of LED lights, when his friends told him that bulky lights would not work on the football. He spent time figuring out how to assembles the components in a circuit with a switch. When he became concerned about the affordability of batteries as well as the impact on battery disposal on the local ecology, he thought about rechargeable batteries. But even then he had to figure out how to charge the rechargeable batteries in environmental friendly ways.

As Samuel began working on his design, he brought to bear a set of fairly *specific* community concerns, as discussed, to a fairly *vague* technical challenge. However, these specific community concerns helped Samuel to functionally break down the work he needed to accomplish from a technical standpoint – e.g., work on the lighting, the weight, and the shape of the football. Samuel's funds of knowledge also gave him starting points for where, within his social network, he might look for feedback.

3) Facilitating social negotiation towards novel space-making: New possibilities of doing and becoming in STEM, makerspaces and community. The youth's making practices iteratively and incrementally built on each other to expand their STEM expertise and rootedness in community. Both the merging and layering of STEM and their funds of knowledge onto and into each other were accomplished not only in the service of their design work, but also *in the attempt to change the real worlds in which they are working and becoming* (Fendler, 2014). That some of the youth have said they want to get smarter on these topics so that they can return to their community – not leave it as they move on up – speaks to this point well. In short, new possibilities in space-making operate both at the level of the making process, and the potential resultant impact of the youth-created innovation.

The playing field *in makerspaces* (*one area of space-making*) literally and figuratively transformed for the youth as they incrementally, but systematically, refined the problem and design they were working on in both technical and social ways, expanding their connectedness to others, and thus the access they had to ideas, tools, and resources for advancing their developing expertise. As Samuel walked through the main club rooms with his ball, kids gathered around him asking to test it out, and where and when they could buy one. His picture with the pro football star hangs on the wall, and other youth have since joined M4C to "do what Samuel did", which included "making" things and "meeting famous people." Becoming an expert involved a form of vertical development in his deepening scientific knowledge and practice, but it also involved interative movement and engagement of such developing expertise with his cultural repertoires of practice (Gutiérrez, 2012).

What is more, the youth's designs helped to transform the playing field *in community* (*another area of space-making*) for themselves and their peers. Samuel's football will allow his peers to practice throughout the off-season, so that they can "get better at the - for next year - for the next season they play football."

Equally as significant are the *playing fields of STEM, both real and imagined* (a 3rd area of space-making). The youth's practices served as new tools to expand the very purposes and goals for engaging in science. At the heart of each youth's design is an effort to work at the intersection of science and the public good, as a way to transform both. Their engagement with the problem was not simply motivated by individual

interest. Engagement was framed, in part, through collectively formed interests as they sought out feedback from a wide range of others, at the powered boundaries of race, power, care and danger. These tensions required greater engagement with STEM as they demanded more complex problems to be considered. At the same time, these tensions made possible recognition within STEM worlds while also exposing the challenges youth face in seeking recognition in these same worlds.

This kind of repositioning in STEM amidst these tensions is important. Dominant discourses position the youth as outsiders and non-experts in science and engineering. What we see is a reinhabitation of the spaces of STEM; one that deterritorializes STEM routines and practices, making as Perumal (2015) writes "physical entry into and living in previously forbidden places" a process of taking back and reclaiming the space of STEM in ways that recognize and care for the rootedness of young people (p. 26).

Conclusions and implications

For many of the youth with whom we work, gaining access to STEM is an uphill battle. We also see how the youth pushed back against these low expectations through engaging in mobilities of criticality. Their making practices, as rooted in community, allow for the reconstruction of the spaces of STEM, making and community, in how the movement of people, ideas, and relationships interrupt practices and ways of being.

The youths' work suggests that leveraging both community insideness and scientific expertise is about much more than bridging these two worlds. While such bridging is important, it is in how this bridging makes possible new and more expansive opportunities to learn and to become in STEM, that we need to pay increasing attention to. Indeed, by engaging in mobilities of criticality, the youth speak back against the normative accounts that often frame their communities in deficit ways. At the same time, their enactment of their criticality through their making practices call attention to the prosaic and micro-level processes involved in making spaces – STEM, maker, and community – more habitable (Lombard, 2014).

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