A CO-EXPLORATION AND CENTERING OF YOUTHS' FUNDS OF KNOWLEDGE IN A STEM-RICH MAKERSPACE

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ABSTRACT

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Science, technology, engineering and mathematics (STEM) subjects often fail to engage youth of Color, especially girls, by appearing to be unaligned with their everyday experiences and knowledge (Brotman & Moore, 2008). Makerspaces have been hailed as sites of possibility for engaging youth in STEM practices by encouraging an interest-driven approach to making work (Ryoo & Calabrese Barton, 2018); however, there is limited attention paid to how makerspaces can concretely take up issues surrounding equity in STEM. Understanding that fostering connections between STEM-rich making and youths' funds of knowledge (strategically developed skills, practices, knowledge that support youths' everyday well-being) may contribute to a restructuring of power around whose knowledge and experiences are valued in STEM.

In this study I worked with three Black girls to examine how, when, and where their funds of knowledge influenced the STEM-rich making work they produced while participating in an after school, community-based makerspace program. Through the stories my youth co-researchers told and the analysis they supported, it became apparent that part of equitably engaging with STEM-rich making involves recognizing and welcoming their Discourses — ways of being, talking, valuing, interacting (Gee, 2008). These Discourses are embedded in the social and cultural histories of youth and helped explain the development and leveraging of youths' funds of knowledge. Discourses influenced how youth navigated the makerspace and opened space for youth to call upon their funds of knowledge in STEM-rich making.

To work with youth in conceptualizing how they understood equitable making, we co-planned a making activity they understood as demonstrating design principles that open space for youth makers to bring their out-of-school expertise to bear on their STEM-rich making work. The design implications that arose from this activity demonstrate the importance youth assign to defining how STEM-rich making matters to them, offer suggestions about pushing against the culture of power that permeates education and STEM, and recommend that educators consider humanizing approaches to developing relationships with youth makers. This work shares youth-developed insights into how makerspace educators can cultivate a culture and activities that value youths' Discourse and funds of knowledge.

I dedicate this dissertation to the three co-researchers who supported this study, my friends Onie, Jazmin, and RaeRae. You are among the most wise and kind individuals I have ever had the pleasure of knowing.

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CHAPTER 1

INTRODUCTION

Onie is a thirteen-year-old Black girl with big plans. She wants to be a gamer, a scientist, an engineer, a basketball player, and a YouTuber. When Onie and I met in the fall of 2016, she had just entered the sixth grade and thought science was "...boring. Like, really, really, REALLY boring." This is a familiar refrain. The way in which science, technology, engineering and mathematics (STEM) subjects are shared with students often perpetuates narrow, prescribed ways of engaging with content. STEM subjects are often presented in inequitable ways that do not align with or value the everyday lives of youth – particularly youth of Color, youth from low-income communities, and girls (Bang & Medin, 2010; Brotman & Moore, 2008; Mutegi, 2011). The impact of these socially constructed barriers is evident in statistics that show disparities in science scores between white students and students of Color (Black, Hispanic, American Indian) remain at the same levels they were almost ten years ago (National Science Board, 2018).

Despite the "boring" presentation of science at her school, Onie's friend Jazmin convinced her to come to GET City (Green Energy Technology in the City). GET City is an after-school makerspace focused on designing STEM-based solutions to community problems. Here, Onie began to develop an appreciation for STEM as she used practices and content as tools toward ends of her own design. She made paper circuits, used power tools, and started a YouTube channel that shared GET City happenings. Her perspective on STEM has shifted, and science is now one of her favorite subjects (though not always at school).

Makerspaces – places of iterative invention, creation and playful experimentation – can be sites of empowerment that engage youth in STEM through their own interests and questions. To reach such aspirational goals, adult educators in the makerspace must recognize and respect

the cultural knowledge that youth bring into these spaces. Such principles are not reflected in the broader 'maker movement' which has largely formalized around the making practices of middle-class and middle-aged white men (Halverson & Sheridan, 2014). Few makerspaces pay explicit attention to what it means to support youth in building from their lived experiences, interests, and out-of-school knowledge.

Recognizing that the strategic knowledge youth develop in their everyday life – their funds of knowledge – are a source of strength and ability, was the crux of this study. Throughout this study it became clear that to authentically honor the full personhood of these three Black girls required not only an appreciation of their funds of knowledge, but their Discourses. Discourses are "the ways in which people enact and recognize socially and historically significant identities… through combinations of language, actions, interactions… beliefs, and values" (Gee, 2015) and proved to be an important thread informing the co-researchers conceptualizations of equity in making.

The goal of this study was not only to better understand the strength and knowledge that youth of Color bring to their STEM-rich making work, but to forge a partnership that engaged the youth co-researchers in the analysis of their stories, offering them a platform to share their expertise and experiences. As a result, I juggled multiple roles: that of a participant-observer and that of a graduate student with a research agenda.

As a participant-observer I followed the lead of the youth co-researchers as they told stories about the issues that they felt were important to address. I supported their reflections about STEM-rich making work they had completed in GET City and followed along when they decided our time together would be best spent making plans for future STEM-rich making work (a website and solar powered light-up skateboard are in the works). As a researcher I considered

the sociocultural implications about what systems of power the co-researchers were pushing against and considered the methodological implications of my participant-observer role. My hope as both a participant and a researcher is that this study amplifies the range of youth voices in critical conversations about STEM-based making practices.

Research Questions

The purpose of this study was to explore challenges and opportunities that foreclose or create inroads to center and validate the funds of knowledge that youth of Color bring to their learning and engaging in STEM-based maker work. I sought to explore how youth understand the practices of a makerspace as contributing to these challenges and opportunities. Building from their lived experiences we developed activities that support their understanding of equitable engagement in STEM for other young makers.

1. How do youth describe their funds of knowledge, and how do these funds of knowledge feature in the stories youth tell about their learning and engagement in STEM-focused making activities? What Discourses emerge in the telling of these stories?
2. How do youth draw upon their funds of knowledge and Discourses in co-designing a maker education activity, and what design implications emerge from that process?

CHAPTER 2

LITERATURE REVIEW

This study draws on literature from several different bodies of work to explain how and where my dedications in this research space have arisen. First, I discuss the importance of conceptualizing equity in historical terms that push against dominant value systems. I layer my conceptualization of equitable concerns onto science (and STEM) as a system of knowledge generation, then consider the implications this holds for these subjects as they are taught in school. I then consider Informal Science Learning (ISL) spaces, including the popular makerspace movement, examining both its potential for opening up access to STEM-based practices and considering such spaces with a more critical eye. I introduce my conceptual frameworks – first the concept of funds of knowledge and its role in science education research, and then Discourses. I conclude by connecting these conceptual frameworks to a sociocultural theory of learning.

Conceptualizing Equity

Within education, equity has become paired with ideas of access, opportunity, and achievement. However, equity is rarely explicitly defined. Defining equity is important to undertake, as doing so helps the field think more deeply and critically about some of the ideas with which it has become implicitly synonymous. As an example, having access to science is not necessarily equitable; the same worksheets spread across all schools do not offer the same opportunities to engage with content – a question about snow would not provide students from Hawai'i the same opportunities as students from Michigan to demonstrate their knowledge. This is one reason that simply focusing on achievement as an outcome can belie a host of inequitable processes that precede it.

In this study I conceptualize equity as an extension of Gloria Ladson-Billings' (2006) discussion of an education debt – a series of debts (historic, economic, sociopolitical, and moral) owed to students of Color, inflicted upon them by a society designed to serve white students. Ladson-Billings (2006) was prompted to articulate this idea of an education debt in response to arguments that presented differences in performance between white students and students of Color as "achievement gaps" that were somehow divorced from the well-established racist history of education, and that placed the blame for such outcomes on the students and on individual school practices. Ladson-Billings (2006) draws out how this series of debts has culminated in injustices that manifest not only in test scores, but also in dropout rates, enrollment in gifted classes, and acceptance to institutions of higher education, etc.

I understand equity then as acknowledging the depth of these injustices as they play out in the daily practices of education and giving space to those who have been oppressed to identify those patterns in practices that maintain inequality (e.g., Golann, 2015). To productively move toward addressing these historicized wrongs, those who have been oppressed by such injustices should be involved in determining how to push against them (Fielding, 2001). Thus, I also understand a commitment to equity to include not only a deference to the lived realities of students who bear the brunt of this educational debt, but a focus on their strength and abilities (Valencia, 2010).

Intersectionality

Before layering an equity-focused lens on STEM subjects and teaching, it is first important to address the varying degrees to which people, as a result of their socially constructed identities (race, gender, etc.) are impacted by systems and actions. Intersectionality, the overlapping and interacting of multiple social identities, explains the dynamic ways in which

social hierarchies (as manifest in the US along the lines of race, gender, socioeconomic status, sexual orientation, etc.) inform who holds power (men, white people, the middle and upper class, heterosexuals) while oppressing others (Cole, 2009). This matters not just in whose voice is heard, but in whose voice is lost.

Hierarchies of power interact with each other while maintaining their own spectrum of privilege. If an analysis focuses on race, the prevalence of the patriarchy presumes that we are considering white men as compared to men of Color. If there is a gender issue, the deep-seeded racism of narratives held in this country presumes it is the experience of white females being compared to white males. The heteronormativity of our country presumes all of these comparisons are among cis-gender and heterosexual groups of people. Assumptions of being able-bodied, middle-class, Christian, etc. inform everything from casual conversations to educational research. Crenshaw (1989) points to the implications of these assumptions in highlighting the experience of Black women who should ostensibly benefit from laws preventing racial discrimination at work and gender discrimination but found their identities intersected along axes of oppression such that they were left completely unprotected.

Holding multiple marginalized identities influences how one is positioned within systems that reflect these hierarchies of power and oppression. It means that when research is done by those implicated in systems of power, the interests and experiences of many individuals whose identities intersect along the axis of oppression are simply not considered. It is for this reason I have chosen to use my dissertation to share the stories and experiences of three Black girls and their navigation of STEM-rich making. In the sections that follow I discuss various ways in which science has been complicit in perpetuating epistemological and real injustices.

Equity and STEM

(In)Equity in STEM fields. In thinking about equity as righting accumulated wrongs, it is instructive to think about the wrongs of "science", broadly, before turning to science education, specifically. The epistemological stances of science have been largely created by a culture of Western, white men, often at the expense of people of Color and women. Harding (2006) elaborates on how the methods, assumptions, and results of research have advanced values and interests of colonialism, sexism, and whiteness. This line of thinking has been largely uninterrupted by any intentional anti-racist efforts, leading to the codification of these cultural values in the systems and approaches that generate scientific knowledge. From Charles Darwin suggesting people of Color to be "savages" to the medical apartheid that still impacts people of Color today (Mutegi, 2011; Washington, 2006). Though I discuss *science* specifically, these arguments apply across the component STEM disciplines: engineering and technology continue to struggle with a focus on innovation on behalf of specific groups of people (white, wealthy), and mathematics is assumed to be as color-blind as science, allowing whiteness to flourish (Battey & Leyva, 2016).

STEM subjects continue to be largely exempt from being understood as culturally-based. Rather than being understood to represent one way of doing / knowing / communicating information (Harding, 2006), the knowledge produced by scientists, technologists, engineers, and mathematicians is understood to be objective and "true" – rather than information gathered by a particular group of people asking questions based on their specific interests and life experiences. As a result, an incomplete picture of what it means to engage in STEM-based practices is presented to youth who are told that there is a "right answer" to be found, by following prescribed steps.

(In)Equity in STEM classrooms. Inequity is embedded in the system of education in which we ask students to participate but is also re-enacted in the everyday pedagogical practices of many educators (Evans-Winters, 2005). In science education, a focus on equity must then address both larger, social systems and local systems within which both oppression and possibility can exist. This requires developing classroom practices that center youths' wisdom and experiences (Carlton Parsons, 2008) while also recognizing and naming the racist and sexist history of scientific knowledge and practices.

The idea that a culture of power places culturally-informed hurdles in the way of some students' participation in school is a well-accepted analysis (Delpit, 1988). The intensity and strength of these hurdles increases when this framework is applied to STEM classrooms (Calabrese Barton & Yang, 2000). This culture of power builds on the platform of privilege that was preliminarily addressed in the previous section – where ways of knowing, talking, and behaving deemed appropriately "scientific" are rooted in Western, white, middle-class, masculine values. This culture of power often marginalizes or devalues ways of knowing, talking, and being shared by other cultures. For example, valuing the use of technical vocabulary over colloquial conversations about phenomena values specific performances, unfairly elevating students who know how to operate within this culture of power and provide those kinds of performances (Calabrese Barton & Yang, 2000). Students who fall outside of this culture of power are perceived as "disadvantaged" and are identified as the source of problematic performance differences.

The extent to which rigid and "settled expectations" have permeated teachers' assumptions about how science should be taught and communicated (Bang, Warren, Roseberry, & Medin, 2013) is one such example of the silencing of youth of Color, and of girls in particular.

Elaborating on the concept as presented in Cheryl Harris's (1995) analysis of racial hierarchies, "settled expectations" refer to the assumptions and entitlement that white people have come to expect in their lives. Bang and colleagues (2013) suggest that looking for settled expectations in schooling helps bring to the surface "boundaries that tend to control the borders of acceptable meanings and meaning-making practices" (p. 303). In this way, normative ways of engaging with STEM disciplines often restrict the ways in these subjects are valued and communicated, requiring knowledge- and meaning-making to fall within prescribed paradigms of objectivity that use Western white norms as a reference point. Devaluing the knowledge and meaning-making of students of Color has negative consequences for their performance and motivation in science (Lin-Siegler, Ahn, Chen, Fang, & Luna-Lucero, 2016).

Emdin (2011) explains the multiple mechanisms through which the literal voices of Black and Latina/o students are silenced in science classrooms. He builds from Brice Heath's (1982) insight that youth in "mainstream" homes (white, middle-class) are trained as young as two years old in the "initiation-reply-evaluation" model of communication, common in many science classrooms, but a model that stands at distinct odds with the communication patterns of many Black youth. The methods of communication and interactions favored by youth from traditionally underrepresented communities are often perceived as a "mismatch" with school aims which are based in assumptions of whiteness; those students are therefore identified as aggressive or troublesome (Deschenes, Cuban, & Tyack, 2001). Far from being able to build upon, sustain, and celebrate the cultural means of communication that students of Color bring to the classroom, often times teachers instead focus on maintaining order and enforcing didactic step-by-step directions for labs, or vocabulary copying instead of encouraging inquiry-based

exploration —continuing to alienate the potential interest and engagement of their students (Emdin, 2011).

The suppression and silencing of youth of Color in their science learning has largely been explored by researchers on behalf of youth, without direct consultation about what equitable inclusion might look and feel like. Educational researchers take the words and experiences of these youth to better understand the magnitude and specifics of these problems, but students themselves are rarely involved in the development of reform suggestions. Given the very personal and local nature of meaning making, the perspective of youth who are required to engage in these STEM learning environments is noticeably absent in both the classroom and the research. This lack of voice contributes to my methodological dedications, discussed further in Chapter 3.

A focus on Black girls in STEM. Recognizing the inequity woven into STEM education begets a question about how students and their engagement with STEM are impacted. As Ireland and colleagues (2018) discuss, the effort to better understand these embedded wrongs has largely resulted in a focus on "women and minorities" which runs the risk of obscuring the experience of those who are both women *and* minorities. There is an urgent, intersectional need to recognize the distinct experiences and personal navigations of power and social relationships that Black girls undertake as they engage with STEM education.

Much of the literature on Black girls in STEM considers how they develop STEM identities— the extent to which opportunities to understand oneself as a scientist are supported by activities such as out of school clubs (e.g., Scott & White, 2013), or are interrupted and challenged by peers and teachers (Carlone & Johnson, 2007). These studies are often developed

from the premise of tension between STEM identities and girls' personal identities, which are grounded in their racial, gendered, and cultural experiences.

Morton and Parsons (2017), however, shift from looking at Black girls' identities as a response to the contextual and cultural constraints of STEM to examining how Black girls find strength and meaning in their intersectional identities while in STEM contexts. Acknowledging that identities are in part socially regulated, the authors move away from that social regulation as a frame, and instead give voice to undergraduate Black women in STEM to self-author and determine how and where their identities matter and provide power, strength, and success. These Black women share stories of cultivating a strong sense of pride in themselves as Black women in STEM as coming from their mothers and other Black women in their community who shared experiences about persisting in STEM-related careers. Other studies have shown similar success in adopting an assets-based stance and embracing the need to provide early access to STEM disciplines and careers in "safe spaces" that validate the identities of participants as intersectional individuals and people with an interest in STEM (Ong, 2005; Ong, Wright, Espinosa & Orfield 2011).

These studies point to the importance that *belonging* plays in influence participation and success in STEM related studies and careers. Black women often report either feeling invisible or, because of their otherness, unavoidably visible (Herzig, 2010) in STEM learning environments that reflect mainstream STEM values and culture of power. However, reflecting the findings of Morton and Parsons (2017), women who are in STEM programs at HBCU (Historically Black Colleges and Universities) have stronger STEM identity development having been supported in communities where their identities are celebrated and not "othered" (Ireland et al., 2018).

Ashford, Wilson, King, and Nyachae (2017) examined several programs designed specifically to push against these feelings of isolation and alienation that Black girls and women experience in traditional or majority white STEM programs (Brickhouse, Lowery & Schultz, 2000). The authors identified programs designed to support marginalized students (specifically Black girls) and examined programmatic features that contributed to the development of *counterspaces.* Following the lead of CRT scholars, the authors' naming of such spaces reflects an intentional centering of the voices, interests, and lived experiences of Black women. These programs are successful at cultivating girls' interest and participation in STEM by taking a social justice lens and challenging the obstacles of racism and sexism that confront them in STEM and their lives. The programs seek to develop culturally relevant content in a way that makes it clear to Black women and girls that they do belong in STEM and empower Black girls and women to call upon their own experiences, recognizing them as strengths.

A foundational element of successful intervention programs is *critical consciousness*. For Ladson-Billings (1995) critical consciousness is a transformative element that activates and unites academic success and cultural competence. Understanding and critiquing social inequities is a prerequisite step that supports shifting away from staid structures of what "doing science" entails to offering more creative opportunities for Black girls and women to communicate ideas and understandings. Freeing conversation from convention, participants are able to make content personal and engage with issues of importance to them. In doing so, the funds of knowledge and strengths of Black women and girls are recognized as key information, fostering a sense of belonging in STEM (Ashford et al., 2017).

Intentionally including Black role models were another key finding of many programs (Ferreira & Patterson, 2011). Serving as both mentors and showcasing the contributions Black

women have made to STEM fields, having Black women dedicated to the well-being and achievement of their mentees offered the opportunity for youth to see themselves as both belonging – and needed – in STEM. These women also helped students articulate and circumvent hurdles in STEM – providing resources, discussing pathways and options to careers in STEM, contributing to students' ability to not only envision themselves as important in STEM, but capable of persisting.

Synthesizing from this literature cultural tools and resources that promote the personal well-being of Black girls and their identification with STEM, it is clear that supporting Black girls in STEM is uniquely different than simply working to support all girls or all minorities. Working to support Black girls' emerging sense of self in the midst of a restrictive world premised on masculinity and whiteness without imposing a specific STEM identity is important. It requires an expansive and critical stance on STEM and an embedded model of leadership that celebrates community figures.

Attempts toward equity in STEM classrooms. The impact of inequitable science teaching is evident in statistics that show disparities in science scores between white students and students of Color (Black, Hispanic, American Indian) remain at the same levels they were almost ten years ago, despite reform efforts (National Science Board, 2018). For the most part, institutional pushes for equity in science education have focused on bringing students who have been historically marginalized into a dominant vision, the status quo, of what it means to participate in science, rather than disrupting narrow views about what a 'good' science student looks like, or what out-of-school experiences are valued as useful for science learning. For example, the American Association for the Advancement of Science published a popular set of recommendations focused on increasing science literacy known as Science for All Americans

(AAAS, 1995) – still an often-used phrase intending to indicate inclusivity and accessibility. While laudable in its aims, this effort sought to interest students in a curriculum or standards that remain defined by experts, rather than questioning any implicit biases of the curriculum itself.

As a more recent example, A Framework for K-12 Science Education, the foundation of the Next Generation Science Standards (NGSS) identifies equity as a principle of its implementation, explaining "a key to addressing … [achievement] gaps is to pay continuing attention to issues of opportunities to learn science, with qualified teachers and adequate resources" (National Research Council, 2015, p. 21). While qualified teachers and adequate resources are important, there is no acknowledgement of the asymmetrical power dynamics and epistemic inequities that perpetuate inequity in science. There is no critical questioning of what these opportunities to learn science look like – simply inviting students to continue learning in a system that does not value their perspective, experience, way of talking or knowing are not great strides toward equity.

As Rodriguez (2015) points out, the NGSS has gathered all issues surrounding equity, and placed them in Appendix D rather than consistently weaving issues and concerns related to equity throughout the standards themselves. By doing so, issues of equity remain positioned as a "bonus add-on" rather than a central aspect of instruction, indicating that equity is a matter of instruction rather than implicating themselves as contributing to equity (or not). By keeping examples of equitable learning opportunities sequestered, and by offering one, teacher-centered, example of what it might be like to teach "diverse" students, the NGSS contributes to the perpetuation of a traditional narrative about how students should learn, and teachers should teach. As a result, despite a professed dedication to equity, perspectives that historically under-represented students bring to their classrooms remains silenced and un-valued, and their

experiences with scientific ideas in their non-school lives are neither legitimized nor leveraged in their learning at school.

Equity in informal science spaces. Free from the burden of needing to follow a specific curriculum, standardized testing and constrained time, informal STEM learning (ISL) spaces are frequently hailed as being able to garner interest in science where schools cannot (Bevan & Dillon, 2010). Dawson (2014a), however, points out that inequitable access and patterns of participation in informal science education are just as prevalent as they are in formal education – they are simply far less theorized and studied and therefore can be challenging to identify.

Informal science learning can take place in museums, after school clubs, zoos, science centers, makerspaces and other non-school venues. Challenges to equitable participation exist in both obvious ways (e.g., entrance fees) and implicitly, for example, by virtue of the design of the environments themselves. As in schools, cultural and linguistic assumptions are made in informal environments that welcome some visitors while excluding and alienating others (Dawson, 2014a).

Dawson (2014b) elaborates on processes by which marginalization can occur by examining four groups from low-income, minority ethnic communities in Britain who visited an informal science education center of their choosing. She found the presentation of science in 'fun' and 'non-school' ways were not universally engaging or expansively considerate in their presentation. Groups reported feeling unwelcome in these learning spaces in a variety of ways. The museums and science centers presupposed a mastery of the English language and British customs in the display of exhibits, inhibiting the visitors' opportunities to use, understand, and learn from the displays. Visitors were further alienated by museum staff who embodied dominant and repressive norms by scolding younger visitors, not listening to or engaging with visitors, and

assuming background knowledge. These kinds of studies help researchers better understand what issues of equity in informal science learning spaces can look like, and the extent to which systems of oppression in science operate across both formal and informal learning spaces.

Makerspaces. A sweeping new movement within informal science learning spaces is that of 'making' (Ryoo & Calabrese Barton, 2018). Bringing familiar overtures about being able to engage and sustain interest in STEM-based activities more effectively than formal science education spaces, making and makerspaces have gained incredible momentum and popularity over the past ten years as a formalized practice of developing and sharing artifacts across physical and digital communities (Halverson & Sheridan, 2014). Like 'hacking' and 'tinkering', making involves taking things apart, re-building, re-purposing resources to new ends, and designing solutions to local problems. Makerspaces exist on their own, in community spaces, in museums and libraries – and are increasingly impacting the activities within formal science learning spaces. Many proponents of makerspaces see them as means to more equitable ends in STEM, as youth are able to ground these practices in their personal interests and iteratively work toward an end design (Martin, 2015). To support youth in authentically driving their own explorations and engaging in the iterative nature of design work, sustained engagement is necessary – something generally reserved for those able to participate in fee-based makerspaces.

RaeRae, a co-researcher in this study and a maker in GET City, captures the sentiment of potential as she describes the makerspace as a place where you can "use tools and make anything you want to. You can help people out, make friends, I even made a race track for girls." RaeRae did indeed make a very tall, purple and pink, sparkly race track with several of her friends as a direct rebuff to her brother who refused to let her use his. In doing so, RaeRae was able to position herself as both a capable maker and an advocate for girls' interests with her STEM

practices, taking great delight in the popularity the track received at the Boys and Girls Club showcase event (from both boys and girls!).

GET City is largely an exception in the making world. At GET City, making is centered around designing sustainable solutions for community problems that the youth in the makerspace have identified. There is a focus on using green energy, and youth makers engage in ethnographic practices to better understand the social aspects of the issues they chose to address. The community expertise youth bring to this space from their everyday lives is intended to be the crux of their designs. GET City offers a sharp contrast to the norms around which the mainstream maker movement has formalized, as a largely white, middle-class pursuit that requires both extensive background knowledge and access to technological resources. Similarly, the popular narrative around making is focused on the product and entrepreneurial possibilities (Vossoughi, Hooper & Escudé, 2016), positioning students as future workers rather than capable of transforming social norms.

Vossoughi and colleagues (2016) push against the idea of making as it has become most popularly known through intentional branding. They suggest that in order to most authentically engage young makers who are most frequently marginalized through the cultural norms inherent in STEM practices, adult facilitators must critically consider how educational injustices have shaped the experiences of youth from historically marginalized communities. Without doing so the authors argue that making work will simply

> advance the implicit arguments that access to normative making and STEM learning opportunities is sufficient for bringing about equity, and that equity looks like individual success within the current system…rather than a collective reimagining and transformation of the system itself (Vossoughi et al., 2016, p. 215).

This collective reimagination of STEM-focused making practices is part and parcel of desettling expectations about whose knowledge counts in STEM. To disrupt this system requires that makerspaces and their stewards recognize and honor the skills, abilities, and rich out-of-school experiences that all youth bring to these. Vossoughi and colleagues (2016) suggest that making toward equitable aims requires facilitators to look backward and recognize that making practices, such as remixing and reusing resources and creating solutions to local problems, have long been practiced in non-dominant communities. The activities that youth undertake in their everyday lives are often 'making' in the truest sense of the word – and is done so toward strategic and purposeful ends.

Bevan (2017) suggests that in order to provide inclusive opportunities in STEM, facilitators must dedicate themselves as learners to the practice with their students, generating reciprocal relationships that intentionally position youth as experts in their design work. This explicit attention to power-sharing is an important element in the empowering potential of making to enable boundary-pushing explorations in STEM for students who are traditionally marginalized in these fields.

Further pushing educators in these spaces toward transformative and expansive ends, Vossoughi, Hooper, and Escudé (2016) ask that practitioners consider how making can be a sociopolitical process that can push against the neo-liberal agendas informing popular interpretations of the movement. Fields, Kafai, Nakamjima, Goode, and Margolis (2018) suggest that teachers can help address equity concerns related to participation, representation, and learning by purposefully highlighting and legitimizing their students' expertise in the classroom -- making visible the progress and hard work undertaken by the students and encouraging a culture of peer pedagogy.

Additionally, Kafai and colleagues (2018) identify the importance of recognizing and respecting the role of communities in the making work of youth – highlighting the disruptions and resulting opportunities that arise by welcoming community wisdom and out-of-school expertise in considering more expansively what it means to make and what making can look like. Greenberg and Calabrese Barton (2017) elaborate on the need for practitioners in makerspaces to listen, learn, and be directed in action by youth. These are not light calls to attention and require serious critical awareness, self-reflection, and intentional planning on the part of practitioners in these spaces.

The discussion about the roles that practitioners play in makerspaces is appropriately critical and pushes us to recognize that if we expect more expansive and transformative learning outcomes, practitioners are key in how these outcomes are generated toward equitable ends. The advice is helpful, but there is little evidence about what these large-scale suggestions might look like in practice, tensions that accompany them, or how youth understand these pedagogical practices to be making strides toward equitable engagement.

While makerspaces have taken important steps to designing STEM-rich learning spaces for youth who are marginalized by traditional STEM teaching practices, there are a limited number of studies that have focused on what equitable instruction within these spaces looks like. Of these studies, even fewer have involved youth as co-researchers and designers.

Funds of Knowledge: Breaking Deficit Ideologies

The concept of funds of knowledge grew from the social justice-based anthropological and ethnographic studies of non-dominant communities (e.g., Eric Wolf and Oscar Lewis in the 1960s and Shirley Brice Heath in the 1980s) (Hogg, 2011). Inspiring a sweeping research agenda at the University of Arizona from the 1980s through the 1990s, funds of knowledge were used as

a framework to push against deficit narratives of Mexican students and the communities they came from (Moll & Greenberg, 1990). The funds of knowledge framework is built from the asset-based premise that students come to school with strategic cultural knowledge developed within their homes, and that these funds of knowledge are grounded in valuable skills and information-sharing networks that youth engage with every day.

This framework reflects both a dynamic view of culture (e.g. Rogoff, 2003), and the history and locality of families, and pushes against ethnic or racial stereotypes by recognizing funds of knowledge as bodies of knowledge that grow and transform depending on context (González, Moll, & Amanti, 2005). By understanding how students learn and engage with information in their homes, teachers can better create learning opportunities in the classroom that more closely align with the funds of knowledge and social networks that inform their students' out-of-school lives.

A funds of knowledge framework recognizes culturally-based knowledge and practices as legitimate resources with the power to disrupt traditional power dynamics perpetuated in schools as well as racist conceptions of who holds valued knowledge. This is particularly important because it highlights the situated and localized fight that communities and teachers must engage in together to push against the culture of power (Delpit, 1988) that dictates curricula that value specific, cultural, ways of being and knowing. Further, focusing on funds of knowledge requires a deep and purposeful commitment and practices from teachers that move beyond traditional pedagogical approaches, and run counter to normative views about parent-school engagement (Auerbach, 2009).

Funds of knowledge work is most often framed as a teacher/parent collaboration where teachers are encouraged to interview the parents of their students about family backgrounds,

social networks, and labor history. Moll, Amanti, Neff and González (1992) describe these as "neither casual visits nor school-business visits, but visits in which the teachers assume the role of the learner, and in doing so, help establish a fundamentally new, more symmetrical relationship with the parents of the student" (p. 139). Moll et al. (1992) referred to the end result of this process as "participatory pedagogy" constructed by both parents and teachers. Teachers restructure lessons so that they align more with the background experiences of their students and are able to invite parents in to share their expertise and knowledge with the classroom. This transforms the traditional positioning of parents from "helpers" in the classroom to pedagogical partners and establishes the teacher as a co-learner with the students.

While teacher-parent communication and equal partnerships are important steps toward more equitable teaching practices (see, for example, Horsford & Holmes-Sutton, 2012), and parents certainly play an important role in developing the networks that contribute to funds of knowledge students bring to school, parents do not necessarily speak to the full experiences and interests of their children. This approach, while on a productive path toward moving against traditionally held power and leading toward more equitable learning opportunities, still ends up privileging adult perspectives (of both parents and then, ultimately, the teacher) about which funds of knowledge are considered supportive of academic success. This reiterates the need to further include youth in conversations about both their funds of knowledge and their experiences in school. By doing so, educators will gain a more nuanced understanding of what youths' funds of knowledge include, their perspectives on everyday experiences, and a more local foothold that could help them push against the embedded majoritarian narratives about what youth are capable of, know, and are interested in.

Though funds of knowledge emerged from educational research focused on literacy and language development for bilingual students (Hogg, 2011), there have been a variety of studies demonstrating success in using funds of knowledge toward equitable aims in science education. Science education researchers have found the funds of knowledge framework to be useful in the push against dominant norms in science and have explored how students' funds of knowledge guide and influence their participation in school science in a variety of ways.

Moje, Ciechanowski, Kramer, Ellis, Carrillo, and Collazo (2004) used funds of knowledge to think about the culturally and socially situated ways in which students from non-dominant communities come to school with contextually-situated knowledge that could, if recognized as such, offer connections to school science. This study conceptualized funds of knowledge as "sources" of knowledge rather than "areas" of knowledge (Hogg, 2011) and categorized them across family, community, peer and popular culture sources.

This study examined the challenge of integrating these students' funds of knowledge in science classrooms, "because science represents a highly specialized area of study, with a number of unique Discursive conventions and with particular assumptions about what counts as knowledge" (Moje et al., 2004, p. 41). The authors refer to this process of integration as the development of a "third space" — a place where competing and conflicting ways of knowing come into a conversation with each other to invoke critical reflection on practices. Moje and colleagues (2004) found that students were private and selective about the extent to which they would offer connections between science and their funds of knowledge. They suggested that teachers need to work diligently to create third spaces where youth feel all funds of knowledge can be leveraged and contribute to discussions in science class. This requires that educators work to bridge an "epistemological distance" between school and students' out-of-school lives.

To address this kind of disconnect that students identify between home practices and school science, Calabrese Barton and Tan (2009) describe a design experiment undertaken with a sixth-grade teacher that explored pedagogical strategies designed to encourage students to articulate strategic connections between content and their funds of knowledge. These authors recognize that funds are "grounded in students' membership and experiences in the out-of-school worlds that they inhabit" (p. 52) and use funds of knowledge to think about better connecting science to students' lives, but also – more critically – how school science might better take up these funds as legitimate knowledge sources valuable in the construction of scientific knowledge.

The authors found that students had a wide range of funds of knowledge related to the content of this unit (nutrition), and when encouraged to center both the funds of knowledge and Discourses in class discussions, the youth's out-of-school experiences were able to expand not only what it meant to participate in science class, but also who felt empowered to do so. The authors argue that in doing so, a hybrid space that was able to "enrich and broaden the boundaries of official school science Discourse" (p.66) was created.

Looking across funds of knowledge work broadly, in science specifically, several key features emerge as indicators of how funds of knowledge can contribute toward efforts focused on equity in science learning spaces. Most obviously, acknowledging and incorporating funds of knowledge is a centering of youth's experiences, lived experiences, and wisdom in a field that regularly avoids or even actively shuts down such connections. Youths' funds of knowledge expand the legitimacy of what is considered "science" and a "scientific experience", while pushing historical, racist boundaries of who can participate in scientific practices and what that participation can look like.

Further, the very process of engaging in an exploration of student funds of knowledge is humanizing work that forces teachers to see their students as whole people with histories grounded in community, capable of pushing against settled expectations of what they can do and contribute to scientific discussions. It is increasingly apparent, however, that it cannot be left up the discretion and motivation of individual educators to seek the full humanity and experience of their students. As an educational researcher it is in no small part my responsibility to support youth in amplifying their voice and perspective, and proactively affirming the importance of their funds of knowledge.

Discourses

As mentioned in Chapter 1, it became apparent throughout the progression of this study that a funds of knowledge approach alone was not a sufficient explanatory framework for capturing the depth of what the youth co-researchers were sharing. Their very ways of being were bringing important implications to their making work, how they understood fair makerspace practices, and how their funds of knowledge were being leveraged and developed.

I follow Gee (2008) in naming these ways of navigating the world *Discourses* – "ways of behaving, interacting, valuing, thinking, believing, speaking, and often reading and writing" (p. 3). Examining these social languages helped to enhance my ability to explain the dynamic nature of what youth bring to their learning and work. Gee (2008) explains that these Discourses, the way we do things, are "indebted to the social groups to which we have been apprenticed" (p. viii). Building from this I understand Discourses as a social and cultural influence across the strategic skills, practices, and knowledge that are encompassed within funds of knowledge. Discourses not only mediate the development of these funds of knowledge but the ways in which youth participate and call upon their funds of knowledge.

Other scholars have presented funds of knowledge and Discourses together, however, the conceptual relationship they present is different than what I suggest. For example, Moje et al. (2004) collapsed funds of knowledge and Discourses into one collective group. They divide funds of knowledge and Discourses together by source (fund) of knowledge – presenting sublabels within the categories of family, community, peer and popular culture. Calabrese Barton and Tan (2009) discuss how funds of knowledge are "mediated through an attendant Discourse" (p. 52) – also discussing funds as social network and noting Discourse threads within each fund (for example, shared responsibility as a Discourse within family funds of knowledge).

In this study I present funds of knowledge as "areas" of knowledge (as opposed to sources of knowledge stemming from specific social networks). I understand Discourses, as ways of being that are embedded in the social and cultural histories of individuals, to inform how funds of knowledge are developed and the ways in which they are called upon. Taking a close look with three youth co-researchers at their funds of knowledge gave space to recognize that while the content of specific funds of knowledge might ostensibly be similar (e.g., all three co-researchers have funds of knowledge around building) the ways in which they participate in and call upon that fund of knowledge's set of skills and practices is qualitatively different, reflecting the different Discourses they have. To recall Gee (2008) again – Discourses are not just about what you say (or know) but how you say and know it.

Sociocultural Theories of Learning

Educational psychologists use sociocultural theories to gather important insights about how social and cultural interactions with others matter to student learning and development (Göncú & Gauvain, 2012). While expanding an analysis of learning beyond the individual to recognize the influence of other actors has been an important development, recent movements in

educational research have suggested that sociocultural theories engage in conversation with more critical lenses that serve to account for systems of power and privilege (e.g., Esmonde & Booker, 2017; Nasir & Hand, 2006). In this particular study, taking a critical sociocultural lens to issues of learning and engagement helps me explore how knowledge and skills are developed in different contexts, and think about what forms of knowledge are recognized as "legitimate" across different settings. A sociocultural perspective understands student learning, scientific knowledge, and researcher inquiries all as culturally and socially contextualized and bound.

Just as we understand that culturally informed tools and speech mediate and inform student learning (Vygotsky, 1978), we must also consider the role that mediations have played in the development of science and schools. As "the scientific study of the world is itself inseparable from the social organization of scientists' activities" (Lemke, 2001, p. 296), taking a critical sociocultural lens helps us identify how and where scientific practices represent historically embedded privilege and norms that do not align with the lived experiences of many youth from communities that have been historically underrepresented in STEM (e.g., Carlone, 2004). Lave and Wenger (1991) help us by naming how the development of specific behaviors, attitudes, meaning-making and activities are intertwined with learning. This helps make sense of the conflicts that can occur when the values and culture that inform participation in a community of practice (in this case, science classrooms) come into conflict with the experiences and values that students bring with them. As examples, science teachers often re-speak student contributions to reflect a more technical vocabulary (Calabrese Barton & Yang, 2000) or re-frame student contributions so that they align with prescribed performance indicators (Carlone, Haun-Frank, & Webb, 2011). In each of these instances, the values and culture of science conflict with, and prevail over, the ways of being that students bring to the classroom.

Layering a critical lens on top of a sociocultural perspective helps extend consideration to power dynamics, racial relations, and gender dynamics (Carlton Parsons, 2017). Recognizing both local, every-day conflicts (e.g., within the classroom) and larger, macro-level conflicts stemming from historical manifestations of power and privilege requires that conscientization be extended to include the systems that students operate within and the content itself (Nasir & Hand, 2006). These different levels of conflict are informed by larger historical narratives of racism and sexism, and impact the learning experiences that youth from non-dominant backgrounds are invited to participate in. As part of the push against repressive structures within science this study weaves a commitment to sharing power into methodological dedications and underscores the primacy of validating experiential knowledge in educational studies by exploring funds of knowledge and supporting youth co-researchers in composing their own counter-stories.

Funds of knowledge and Discourses are helpful conceptual frames when taking a critical sociocultural perspective of learning, as conversations about learning expand beyond the individual to validate the cultural practices and social networks of students who too frequently have these resources and ways of being viewed through a deficit lens (González, Moll, & Amanti, 2005). A critical sociocultural frame further pushes this work by considering the power dynamics implicated in hurdles that prevent the centering of funds of knowledge in science instruction. It also offers hope and help to challenge the distance between the academic and the everyday, suggesting that multiple forms of expertise are able to exist together toward a more expansive understanding of what learning can look like (Vossoughi & Guitérrez, 2017).

CHAPTER 3

METHODOLOGY AND METHODS

Methodology

The methods through which data was collected and analyzed are undergirded by a methodological dedication to engaging in research alongside youth. I deemed youth participatory research an appropriate methodological choice because it has grown from a dedication to action in response to a problem being studied (Irizarry & Brown, 2014). This aligns with the intertwined goals I set to undertake in this study. The first, is centering youth's knowledge and experiences in developing a better understanding of how we (educators in makerspaces) might better offer equitable access to STEM-rich making. The second, is to develop a more nuanced understanding of how we (education researcher) can better include youth in the work that we do.

I present both my methodological approach and specific methods of data collection and analysis in the sections that follow. The methodology section explains the epistemological assumptions I came to this research holding. I discuss how I understood my role and the role of the co-researchers within this work, although the participants will be introduced with greater detail within their individual chapters. In the methods section I identify the context within which my relationship with the youth co-investigators takes place. I follow by explaining the procedure that we undertook to generate data and the ways in which we analyzed data.

Participatory Research with Youth

My methodological approach to research builds from the tenets of participatory design research which "privileges a bottom-up analysis by involving those most affected by the research and challenging social inequalities as they are understood by those subjected to them" (Cerecer, Cahill, & Bradley, 2013, p. 218). The structures of power that overlap to silence and minoritize

groups of people speak to the importance and methodological necessity including youth as co-researchers in their own right. I made the purposeful choice to work with co-researchers who navigate systems of oppression within multiple contexts (locally, nationally, in STEM). The intersectional identities of these Black girls have positioned them as outsiders in dominant cultures of power, both in school and science. I am therefore purposeful in consistently positioning them as experts who are helping me.

Participatory research, especially youth participatory research, builds from a host of different methodological and epistemological traditions and values (Irizarry & Brown, 2014; Bang & Vossoughi, 2016) that work to disrupt traditional power dynamics both within a specific problem being studied and within the world, more broadly. The principals of participatory research have guided my approach to this study and my relationship with the youth co-researchers; however, I do wish to distinguish the work I have done from youth participatory action research (YPAR), which I do not claim this study to be. In YPAR, youth and adults work together in a process that includes defining a problem, researching, reflecting, analyzing and acting on that problem (Kohfeldt & Langhout, 2012). There are elements of each of these aspects in this study; however, I came to this study with questions that precluded much additional definition by the youth co-researchers, as well as a plan for data generation and a hoped-for outcome (the creation of recommendations and co-planning a making activity). This study is participatory in its collaborative research practices and attention to how and by whom knowledge is generated.

The voice of youth who have been traditionally under-represented and epistemically alienated in STEM practices guided this study; rather than having research done *on* or *for* them, research was done *with* them. In privileging and valuing the stories the co-researchers told, they

became the knowers of important information, and I – as the adult representative of a university – was the learner. This reversal of traditional power dynamics was occasionally clunky and awkward – pushing against the hierarchies assigned power that influence every aspect of our world and identities—but it was important and necessary for both the validity and the authenticity of this study.

The context within which participatory research takes place is an important determinant of just how transformational youth-led change can be (Kohfeldt, Chhun, Grace, & Langhout, 2011). If the goal of participatory research is to empower the stakeholders of an issue to create solutions, then doing so in a place where their knowledge is known to be valued is more likely to open a space for productive thinking and talking than a place where traditional power dynamics are clear (e.g., a school). To that end it was important to me that we start our project in a community setting – the Boys and Girls club. This was a place where the youth felt socially connected and powerful. Friends were invited in and out, snack breaks were easily taken, and other trusted adults were present.

I did my best to not only make space for the co-researcher to talk about the topics at hand but also to follow their lead in discussing broader topics and, indeed, shifting away from the topics we began in favor of different activities that they were more interested in (making phone cases or catching up on SnapChat streaks). We discussed boyfriends, unfair bus drivers, grades, and food. There were moments when deviating from what I understood to be our intended purpose caused me no small amount of angst, as I was keenly aware of the importance of their time and both of our attention spans, and did not want to "waste" our time together on things that did not seem to bear on our work in this project. In moments like this I was able to recall Bang and Vossoughi's (2016) caution that the process of partnering with youth is influenced by critical

historicity, power, and relational dynamics – and that the ways in which these factors are attended to has consequences for the learning that emerges. I was not attending to those considerations and was privileging my own perspective and agenda to the exclusion of theirs. In reminding myself of this I was able to take a more expansive and appreciative view of what the youth co-researchers were inviting me to experience with them.

Moments that required this kind of readjustment reiterated for me the importance of the work the youth co-researchers and I were completing together – not only for the implications it could have for makerspaces, but because it is important to share the successes, the bumps, and the ways in which we were able to build bridges together in the process of undertaking of participatory research. Relational dynamics are challenging to figure out and there is not simply one, fool-proof approach. One of my greatest challenges in this study was maintaining a vigilant reflection of the approach I was taking in working with each of the co-researchers. What worked well to establish an understanding of relational equity with Onie and Jazmine did not work as well with RaeRae. I had to recognize that and reflect on how to present these concerns in a way that was fair to RaeRae, that did not place a burden or assumption of fault on her end, rather, that was empowering and supported her in deciding how we should proceed.

Youth Co-Researchers

I was intentional in working with youth with whom I had an established relationship that had sustained challenges (behavioral, frustration with maker projects, etc.) while remaining respectful and appreciative. All three of the youth co-researchers – Onie, Jazmin, and RaeRae — were most active in the two years preceding this dissertation study (2016 – 2018) while they were in sixth and seventh grades. At the end of this chapter Figure 3.1 shares pictures of each

youth co-researcher, and a brief overview of their goals and favorite making work is presented in Table 3.1.

In asking these three youth to join me as co-researchers, I was concerned that they knew I respected and trusted them. For both Onie and Jazmin that resulted in a relationship that came to look more like a friendship than the educator/maker relationship we began with. I wanted to include RaeRae as a co-researcher as long as she was willing because it was less clear to me that her ways of being were valued – in the Boys and Girls Club, in school – indeed, by the other two co-researchers, one of whom tried to tactfully inform me that RaeRae had turned "ghetto" since their time together in elementary school. This not-particularly veiled comment was hard for me to hear for a variety of reasons. It demonstrated to me the extent to which narratives about "good" and "bad" Black women and girls have been taken up by young people and what real social consequences can come as a result of accepting these pejorative narratives.

RaeRae is a passionate and caring youth whose perspective is rarely heard in research – I could see processes through which her voice was already being excluded through suspensions at school and the skeptical way some Boys and Girls Club staff discussed her group membership in GET City. Our relationship (and our research together) evolved differently from my relationships and work with either Onie or Jazmin. I worried that I was imposing this activity upon her. The laid-back nature of my conversations with Onie and Jazmin was not easily replicated with RaeRae, who was ambivalent about some topics and incredibly exuberant about others. Not sure if she was enjoying her participation or valuing the time she spent with me I continued to remind RaeRae that she was not obligated to continue this work if she did not want to, and that I appreciated all she had already taught me. Still, she continued to come to our conversation groups and would text me apologetic and sad when she had to miss them. In December 2018

RaeRae was suspended from the Boys and Girls Club for fighting with another teen member. RaeRae's mom wrote to me to let me know RaeRae would not be coming back to the Boys and Girls Club and therefore would not be able to finish this project. I spoke with Dr. Calabrese Barton about keeping RaeRae as the third co-researcher to both honor the work she had already completed and because I believed it important that RaeRae's voice be heard.

Each of the three youth co-researchers who undertook this study with me will be introduced in more depth within their individual chapters. Starting with Onie, moving to Jazmin and then RaeRae, I share how each of my co-researchers entered GET City and the funds of knowledge that were most prevalent in the discussions. I then discuss the various Discourses that cut across their stories and our interactions. Woven throughout each of these sections are the stories these youth co-researchers tell about their learning and engagement in STEM-focused making activities, and the ways in which these stories draw upon their funds of knowledge and Discourses. I attempt to embed the voice of the co-researchers as much as possible in the chapters that follow — as a result I do not cite the interviews from which each quotation came; however, the full transcripts of each meeting are available upon request.

These chapters are heavily narrative in an effort to give space to the lived realities and counter-stories each youth co-researcher shared. Their words offer a powerful insight into the everyday experiences of both subordination and strength they engage with. This is an imperfect balance as I was still ultimately in charge of writing these chapters; however, I worked to include excerpts from our conversations that are clear pushes against deficit narratives and showcase the insight and thoughtfulness with which they shared their knowledge.

Figure 3.1, Photographs of co-researchers at GET City. *From left to right: Onie, Jazmin, and RaeRae.*

Table 3.1
Youth Co-Researchers

Pseudonym	Onie	Jazmin	RaeRae
Sex	Female	Female	Female
Age	13	13	13
Grade	8th	9th	8th
Years at GET City	2	3	2
"What are some things you want to be?"	A gamer, a scientist, an engineer, a basketball player, a YouTuber	Culinary artist and engineer	Beautician (make up and braiding)
Favorite making activity	Anything that involves power tools	Making fans with small motors and recycled goods	Sewing the bag to help homeless dogs

My Role(s)

Throughout this study my understanding of the roles I was playing became increasingly complicated. I wrote in my proposal about the issues I knew I would have to navigate as a result of my whiteness and other obvious markers of privilege – coming from a university in pursuit of a higher education degree, being able to provide rides to youth so we could meet, etc. There were moments in conversations when it became clear my youth co-researchers were talking about a world that I had no place, experience, or right to be in; moments where shoe game is everything, where hair must constantly be negotiated. In those moments we were together and could talk, I could learn from them and we could share our perspectives.

I was surprised that my positionality complicated the multiple roles I was playing as a graduate student and co-researcher most fiercely when I was writing, analyzing, and reading. When I was removed from the immediate conversations and thinking about how to offer the words of my youth co-researchers to the field of education, my only baseline was me. Jazmin said she wants the "bad kids" out of the makerspace and that the adult educators are "too nice" when they let non-GET City members come in. How do I honor her perspective and temper that with my refusal to believe that there are "bad" kids? And then how do I report on this while recognizing that narratives about "good" and "bad" kids are often steeped in racist expectations?

As I stepped back from the individual work of writing to focus on the work done in partnership with youth, I realized that my first and foremost role was to listen fully and with only interest, no judgement. While I have graciously been granted an additional fifteen years of experience, these additional years as a learner, teacher, and graduate student do not entitle or enable me to understand the entirety of what the youth co-researchers are saying. Jazmin asking that the "bad kids" be kept out of our makerspace is a reflection of her needs not being met by us, the adults in the space. She knows that to feel like she can fully bring herself to her work she needs to trust that her creations will be kept safe. Even if I can recognize that there exists a larger picture that is more complex and messier than simply allowing kids in or not, this does not diminish or change her needs. My job is to hold our truths together, to be clear about where my writing represents my own analytic dedications, and to recognize that my positionality and experiences preclude a full understanding of the stories the co-researchers share.

Methods

Pre-Dissertation Data Collection

Before beginning this dissertation, I had observed and supported the making work that each of the three youth co-researchers had been undertaking in GET City. Jazmin had been in GET City since the 2015 – 2016 school year; both Onie and RaeRae had joined in the 2016 – 2017 school year. Each youth maker took part in formal "artifact" interviews twice a year while in GET City. These interviews asked youth about their projects and their process of making and asked them to comment on various STEM practices as identified by the Next Generation Science Standards. Although I did not conduct each of these interviews for all of the youth co-researchers, I use the transcripts of these interviews as I have been able to locate them. Across these years, I took field note reflections about my interactions with these youth and their groups. I also use audio and video recordings of informal conversations I had with each youth co-researcher during their time in GET City. While preparing my dissertation proposal I met with each co-researcher individually to discuss this project with them. As each of the co-researchers agreed to participate, we had a follow-up conversation where I asked how they would like to be represented to my dissertation committee (what descriptors, interests, facts did they think were important for these educators to know).

Data Collection and Data Sources

Data collection included group and individual conversation groups (all of which were audio or video recorded) field notes and co-created artifacts. Due to scheduling challenges and social dynamics I ended up meeting with youth co-researchers individually rather than in one larger group. This extended the period across which data was generated but resulted in a deeper

relationship and understanding of youths' funds of knowledge and perspectives on STEM-rich making. Table 3.3 summarizes types of data generated to answer each research question.

Conversation groups. Our meetings began at the Boys and Girls Club in May 2018. I worked with Onie most consistently throughout the summer, so our conversations also took place at locations such as McDonalds and Steak and Shake, which were closer to where she was staying than the Boys and Girls Club. As I result, I also met and spent time with several of Onie's family members including her sister and grandparents, her best friend, and her best friend's grandmother.

Jazmin spent the majority of her summer break visiting family in Texas. We kept in touch through Snapchat – where I shared various projects I was working on (like a failed attempt to solder a belt buckle back together) and she shared her adventures, boredom, and her enthusiasm for returning to GET City. Jazmine put together a "GET City" group on Snapchat that included several other youth members, me, and another adult mentor. Here they all shared various life updates, music.ly videos, and questions about GET City logistics for the upcoming year. When Jazmin returned in late August, we began our conversation groups at the Boys and Girls Club again.

RaeRae asked if another GET City friend, AnDreya, could join our initial conversation groups in May, which I agreed to as this had been a friend that RaeRae welcomed into GET City the previous year, and I did not want to dictate what her participation looked like or deny her a social ally in this work. RaeRae, AnDreya and I met until June, when RaeRae's mom moved her family to be in a new school district, because – according to RaeRae – "She said I act fast when I was at Great Lakes Charter. I think it was 'cause of my mouth. My fast mouth." I was not able to successfully reach RaeRae or her mom until reconnecting on Facebook's Messenger app. In

October of 2018 we began our conversation groups again. As RaeRae now attended a new school and lived further away from the Boys and Girls Club, we were only able to meet on Friday evenings when she was able to get a ride.

Each of these conversations was between 30 and 120 minutes. They were audio recorded, and sometimes video recorded. After each session I would transcribe it and upload the transcriptions into a qualitative analysis software, Dedoose. Table 3.4 shares an overview of our meetings together. The purpose of these conversations was to better understand what the youth co-researchers understood their funds of knowledge to be, and across what social networks / to what ends this knowledge had developed. As a result, our conversations began with a discussion of their family – who they counted as family and why, what jobs they held, the most important lessons those family members had taught them, fun stories, traditions, and what their weekends looked like. We then moved to discuss friendships and different communities that the youth co-researchers felt they were a part of. It became quickly apparent that what they were identifying as funds of knowledge cut across social networks (for example, playing video games) so our conversations turned to focus on the activities and situations most associated with these areas of knowledge.

While I began sessions by introducing the broad topic at hand (e.g., “I’d love for you to tell me about your family!”) the follow ups were organic and directly associated with the stories told by co-researchers; there was no standard protocol. I understand funds of knowledge to be contextually based and appreciate the co-researchers as individuals, so I thought it best to approach their stories with genuine interest and curiosity in the details they provided, rather than letting prescribed protocols dictate our conversation as is often done in conversations with parents, or other funds of knowledge-based work.

As I wanted this project to provide a space where the youth co-researchers felt able to be completely themselves, I did not limit our conversations or their actions while we were talking. During one conversation Onie asked if she could use a glue gun and showed me how she could make a phone case out of hot glue. I share this in part to explain that the funds of knowledge Onie and I discussed were not simply taken from our conversations, but by opening up our time together to incorporate directions she chose, she shared her strategic use of these areas of knowledge and invited me into them as well.

As a result of the space we forged I was able to more authentically develop an approach to getting to know and see the youth co-researchers' funds of knowledge in action; Onie hot glued and showed me video games, Jazmin built and doodled, RaeRae abandoned white boards to cut tubing while she spoke and did her make up. All of these actions opened up a wider lens for me to better understand not only the strategic knowledge they have developed, but better understand their Discourses – their ways of being, thinking, valuing, and feeling – what kind approaches they take to life.

Field notes. Following my conversations with youth co-researchers I would audio record my reflections and observations while driving home. These notes included thoughts about what we had spoken about, what seemed to be going well, hurdles that were appearing (e.g., communication), methodological changes that might need to be made (e.g., an aversion to writing on whiteboards because handwriting wasn't pretty enough).

These field notes served as a helpful reflective tool that allowed me to point to moments of concern and triumph – noting my immediate reactions. They also served to help me keep a critical eye on how my own interactions with the youth and analysis continued to shape my perspective on the unfolding inquiry (Peshkin, 1988). Re-examining the conversation and my

observations helped me better identify ways to tweak subsequent conversations or helped me better formulate questions.

Whiteboards. Each youth co-researcher was given a whiteboard to complete Me Maps – however this method was quickly abandoned after the youth expressed a preference for just talking about the topics that were going to be on the Me Maps. After these initial conversations about funds of knowledge and social networks the youth co-researchers and I met to explicitly discuss the connections they saw between these "important people" in their life and the "things you know about / are good at" (the youth friend language used to represent key concepts within a funds of knowledge framework). This served as a form of member checking and gave them a way to demonstrate how their social networks and strategic cultural resources are intertwined across multiple spaces in their lives.

I presented each youth co-researcher with a board that included a "first draft" of funds of knowledge and social networks I had generated from initial coding of our conversations. We renamed categories as appropriate, added funds of knowledge and important social networks they thought were missing, and they drew lines across the whiteboard to represent connections between important people and the skills / knowledge listed on the board. In some cases, something I thought was a fund of knowledge would be erased, the youth co-researcher feeling it was not important or perhaps that they did not engage with the skill / activity enough for it to be considered a resource to them in the way that funds of knowledge are understood to be.

Digital portfolios. Following our conversation about strong / favorite / powerful GET City memories, I took note of all stories and events that the youth co-researchers mentioned. I spent several hours examining the archive of video and photographs saved as part of the larger critical ethnography that GET City is a part of. I developed portfolios (Google Slide

presentations) that included both images and videos of the important moments each youth co-researcher had identified.

Together the youth co-researchers and I went through these portfolios, discussing additional detail about the making experiences encompassed within them. We had the member-checked whiteboard present, as well. This was used as a reminder of their funds of knowledge and social networks. This discussion allowed us to discuss in concrete terms the ways in which their funds of knowledge did or did not influence their making work. For each story, slide, or picture, we discussed whether anything on the whiteboard had influenced their approach to that making moment. Often this resulted in a conversation that further nuanced the fund of knowledge in question or the moment of making.

Design implications. Following our conversations about connections between funds of knowledge and making, I went through all transcripts of our conversations and previous artifact interviews and made a list of what could be broadly understood as "recommendations" that each youth co-researcher had identified. Together the youth co-researchers and I examined these excerpts in Dedoose, and each youth co-researcher explained what they were thinking at the time. We thought about whether what they were talking about at that moment could have implications for other makerspaces focused on ensuring all youth makers felt comfortable bringing in their out-of-school knowledge and "being themselves" (the framing used to discuss centering funds of knowledge in making work).

This helped provide a narrative base and grounded explanation for how the youth co-researchers understood ways in which makerspaces can be improved or continue the productive and positive work, using our common experience in GET City as a reference point. We were able to examine points of frustration or pride and think about pedagogical and cultural elements that

contributed to those moments. After this conversation I typed up each youth co-researcher's recommendations (including some bullet points that referenced specific stories or nuanced meaning) and shared it again as we began our co-planning. This was both a form of member checking again and a reorientation to what they had identified as important points.

Co-planning. First Jazmin and I sat down together to come up with a making activity that would center the out of school knowledge that kids bring with them, and then Onie and I repeated the process. These co-planned lessons are described in more detail in Chapter Seven. The purpose of these meetings was to navigate the co-planning process and think about how both Jazmin and Onie would incorporate the recommendations we had previously discussed.

Each meeting looked and proceeded differently for each co-researcher. Jazmin was happy to lead the way in our co-planning session, confidently developing a plan for how she thought we could best engage youth in discovering the science of their everyday. Onie was in a fun and goofy mood the day we met for this activity, looking to sing and talk about her Subway sandwich – joking about how we should create an edible solar panel. I had decided to let her lead the plan for the day and schedule another meeting to talk about co-planning if it was not something she felt drawn to, but she began to conceptualize a cake that lit up and launched from there to develop her lesson plan. In engaging in this activity, both Jazmin and Onie helped show me the concrete ways in which they understood their recommendations could be turned into design implications for a wider makerspace audience.

Data Analysis

Funds of knowledge

Analysis took place primarily in Dedoose, a qualitative coding software. The data was organized into separate 'projects' for each youth co-researcher. My approach to beginning to

analyze the data shifted away from focusing on social networks as a way of categorizing funds of knowledge, and as was done by Moje and colleagues (2004) and Calabrese Barton and Tan (2009). This was in part because the stories youth were telling involved a more expansive and interconnected set of social networks and activities than previous studies seem to have found – aunties and cousins influence the knowledge built not just in family groups, but in community groups and friend groups, too. Rather than force a distinction about where knowledge had generated (sources), I followed the path of our conversations and was able to better engage with the data by focusing on *areas* of knowledge.

Building from this evolving conceptualization of funds of knowledge as *areas* rather than *sources*, I read through the transcripts of both our conversation groups and previous years' artifact interviews. I analyzed data using thematic analysis (Braun & Clarke, 2006), recognizing the utility of this approach with large amounts of qualitative data. I began coding based on the funds of knowledge framework, looking for instances when youth co-researchers shared or demonstrated 1) specific references to knowledge, skills, and practices — for example, when Onie explained her phone service had been shut off but she could use TextNow as an internet based app that worked around a lack of service. 2) Stories that included indirect references to knowledge and skills that were helpful in how they navigated their everyday life — for example, when Jazmin explained the elaborate system of rides she had set up to ensure she made it to school, dance, and the Boys and Girls Club. I included both of these kinds of instances under a broad "FoK" (funds of knowledge) code.

As I did this open coding, I kept notes about the topics that were appearing. An example of the kind of note that helped link stories and name these patterns comes from Jazmin's transcripts, "Jazmin talks about safety while looking out for CJ – like story about babysitting

siblings." I was noticing themes around safety and caring for others younger than her – as I examined these together, I presented them to Jazmin as a "Babysitting" fund of knowledge and we discussed how these different aspects (of safety, caring, responsibility) informed her expertise around babysitting. These memos helped me group together different practices and stories into potential funds of knowledge and helped me see how youth might call upon these practices in different ways.

I then sought to assign thematic categories more definitively. To do so, I wrote the list I had generated (Table 3.2) on a whiteboard and brought it to each youth. They corrected my understanding of what kinds of knowledge, skills, and practices belonged category, renamed them appropriately – sometimes collapsing multiple funds into one. For example, Jazmin collapsed music, art, singing, dancing, and drawing into one "artistry" fund of knowledge. Sometimes we decided on what to call these themes together (e.g., "Boredom building" was what Jazmin wanted her fund of knowledge around building to be called) and other times they were more descriptive, left as I had broadly presented them (e.g., "Fixing + Building" for Onie).

I also listed "important people" (social networks) that the youth co-researchers had mentioned in our conversation groups. They drew connections from these social networks to the list of funds of knowledge, supporting my understanding of funds of knowledge as areas rather than sources of knowledge (described in "Whiteboards" section, above). We continued, using this list of funds of knowledge as a point of reference while we discussed major GET City moments. I compiled the Digital Portfolios for this purpose. As we went through the pictures in these portfolios and recalled events, the process of STEM-rich making and other GET City activities, we returned to the board to think about whether any of their funds of knowledge influenced their work in some way.

I completed this process with Onie's funds of knowledge first. I had noted that certain topics were discussed more prominently (e.g., every meeting involved an extended conversation around video games). After our conversations with the white boards and Digital portfolio I began to write up preliminary explanations / definitions of prominent funds of knowledge (ones that she referenced frequently and ones that featured prominently in her stories on STEM-rich making) to better make sense of how the data I had could help support this next phase of analysis. I composed profiles for six different funds of knowledge based on my conversations with Onie. This process helped demonstrate the richness of data in our conversations and was when I began to notice Discourse themes (discussed more in the next section). After writing these initial profiles, two came to bear the most on Onie's stories about making while the remaining four were interesting, they were called upon less frequently and therefore offered less of a window into this research space. As I began to delve into Discourses, it became apparent that her funds of knowledge around video games – while not explicit in her making work – helped make sense of the interconnectedness of Discourses and funds of knowledge. I therefore included that in the next stage of coding and analysis. Being further ahead with Onie than the other two co-researchers, I appreciated the depth of insight that three funds of knowledge could offer and used that as a baseline as I decided which of their funds of knowledge to include in the deeper analysis and present in this dissertation (again writing profiles of funds of knowledge both mentioned prominently and featured in STEM-rich making stories as a process of deciding where data and threads of stories lie).

Having narrowed the focus of each youth co-researchers experience to three funds of knowledge, I returned to the data (which now included transcripts from our analytic conversations) and began to examine the specific funds of knowledge we had identified in more

depth. For example, there were reoccurring instances that I coded where I began to see multiple practices and knowledge – either in how these funds of knowledge were talked about or in how they were enacted. For example, RaeRae's fund of knowledge around dogs involved not just her knowledge of the technical details of how to take care of dogs (they require walks, their food is smelly), but also included a deep care and love for them – loving dogs in specific, almost humanizing way, was an important practice that informed her funds of knowledge around dogs.

To make better sense of the nuanced way in which these funds of knowledge informed youths' lives and their making work, I began to look more closely at "where" and "why" these funds were being leveraged by the youth, both in their everyday lives and in STEM-rich making work. This helped me better understand name different aspects of these funds of knowledge and ways in which they were being called upon. For example, Jazmin calls upon her fund of knowledge around "boredom building" in different ways across different spaces (depending on the kinds of resources in these spaces she will build or draw plans), to different ends (to amuse herself or help others). In her STEM-rich making this helped make sense of how she was calling upon this fund of knowledge when she would show up with plans ready to be built, or in the patience she exhibited in trying to find just the right kind of blades for her fan.

Discourses

As I completed the fifth phase of thematic analysis which involves the writing of a detailed analysis of themes (funds of knowledge) I began to notice similarities in the way that I was describing practices within different funds of knowledge for each youth co-researcher. For example, I was noting that within each of her funds of knowledge, Onie was engaging in practices around "caring" for others. As I wrote about how she used YouTube, I described how she cared for her brother in working to put his music online. As I wrote about where and why she

engaged with Fixing + Building, caring for her grandparents was embedded in several of these stories. Through discussion with other makerspace educators familiar with the youth and this dissertation study, I came to realize that encompassed within funds of knowledge were stories of co-researchers' values, ways of being, etc. Recognizing that these ways of being were aligned with Gee's (2008) Discourses, I had to step back, develop a better conceptual understanding of Discourses, and begin coding for Discourses.

I began this process of coding again by focusing first on the funds of knowledge youth had already identified as most important in their making work. Looking across these stories and examples, I looked to find instances where values seemed to influence their interactions, behavior and approaches. Developing themes relevant to these particular funds of knowledge, I then recoded all transcripts to surface other stories related to these Discourses. In doing so I paid particular attention to 1) the ways in which these Discourses encompassed a critical response to deficit frameworks, serving as a resources in the ways youth navigated their worlds 2) instances where Discourses related to the featured funds of knowledge each youth identified, and 3) how these Discourses were connected to the making work co-researchers engaged in. As I explored these sub-codes I noticed that the relationship between Discourses and youths' engagement in the makerspace was complicated and overlapped with some of the stories about funds of knowledge and making. To better understand this, I developed two additional sub-codes that pulled out how Discourses influenced youths' the navigation of the space (how they made sense of activities and chose to engage) and the ways in which they influenced specific projects — by opening up space for youth to engage in ways they wanted, often calling upon funds of knowledge.

Recommendations

I engaged with the process of thematic analysis to answer the second research question, too. I went through Dedoose and coded for stories the youth co-researchers shared with me that I thought seemed as though could include a suggestion for makerspaces looking to be more equitable in their treatment of youth makers. This was an incredibly broad process – for example, I included a story Onie had told me about being (almost) kicked off the bus, thinking her critique of the bus driver's handling of the situation might offer a starting point for talking about appropriate makerspace educator behavior. For both Onie and Jazmin I took these recommendations to them in Dedoose and they identified broad categories that encompassed the message of several stories. As an example, the story about Onie's bus driver was encompassed in a category about communication between youth and adults – which eventually became her design implication about "going down" to where youth are and teaching from there. We discussed what these larger categories mean and thought together about how the messages within each category (e.g., be respectful in communication, listen to youth, do not assume they know things) would help youth bring their funds of knowledge to their making work.

Analysis for this question continued after each youth co-researchers design implications were finalized. The descriptions were based on the above conversations with youth and the ways in which they were taken up in the co-planned making activity (for Onie and Jazmin). I first analyzed the youth co-researcher's design implications using the lens of their own Discourses – seeing in what ways these values and ways of being influenced their conceptualization of an ideal makerspace.

Taking all ten design implications, I examined them together to see in what ways they were offering suggestions about how to design a makerspace with equity as a key concern. My

conceptualization of equity as a response to the educational debt was important in developing these themes and contributed directly to developing the "disrupting a culture of power" theme. The other two themes that emerged (redefining how making matters and humanizing approaches to relationship building) were developed as I considered how these design implications were extending the existing literature around equitable making and equitable teaching. For example, humanizing research informed my approach to much of this research and is discussed in more traditional pedagogical literature; four of the suggestions that youth co-researchers put forth in their design implications spoke to the need to cultivate such approaches in makerspaces.

Throughout this process I sought to ensure that each of the three youth co-researchers had both control of and access to the resources informing this project, as well as the intellectual freedom to update / change information that they thought I portrayed incorrectly or incompletely.

Table 3.2
List of Potential Funds of Knowledge

Onie	Jazmin	RaeRae
Hot glue Tools Snapchat / TextNow Medical knowledge Navigating schools Slime Cooking Video Games Babysitting YouTube Swimming Basketball Dance Birthday parties Being hilarious / goofy Protection Fixing things / taking things apart Being nice / empathetic / antibullying	Building DIY Babysitting Navigating afterschool activities Decorating Singing Church Dancing Guitar Sewing Art / painting Tech Cooking Sports	Instagram / Snapchat / Facebook Dogs Hair and shoes and shopping and purses! Building stuff Math and numbers (tips and lists)

Table 3.3
Coding Tree

Code	→ Subcodes	Explanation	Example
Funds of knowledge → Themes	Leveraging in life: • Where • Why	Making sense of the ways practices and knowledges helped youth navigate life and support others	Onie uses her fund of knowledge around YouTube to explore phenomena she could not in school, sometimes because school is boring
	Leveraging in STEM-rich making: • Where • Why	Identifying opportunities youth had to leverage FOK in their making work / experience in GET City	Onie leverages fund of knowledge around YouTube in GET City as a way of sharing experiences and STEM-rich making for youth who do not have access to such programs
Discourses → Themes	Critical response / source of strength	Reflection of my asset-based dedications and recognition that youths' ways of being reflect the interactions of the world around them	RaeRae's Discourse of "feelin' myself" showcases pride and confidence in being a Black girl / young woman, a value that forges a social connection with other youth
	Connections to funds of knowledge	Helped explicate the influence Discourses had on the development of funds of knowledge and the ways they are taken up	RaeRae's Discourse of "feelin' myself" influences how she develops and takes up funds of knowledge around "looking cute"
	Connections to making → navigation of space →influence on making process, open space	Helped show relationship between Discourses and engagement, broadly, and within specific projects	→ RaeRae invites others who share this social Discourse into GET City; giving social cache. → Opens space for her to celebrate the funds of knowledge around building that contributed to her ramp and was acclaimed by peers – inspiring future projects
Recommendations → categorized by youth	Discourses	Relationship between who youth are and how they conceptualize equity	Jazmin's Discourse of independence influences how she gives power to youth
	Addressing educational debt + equity concerns	Explicate in what ways these design implications speak to equity concerns of the field	Jazmin's design implication about getting feedback from multiple sources contributes to a disruption of power in whose knowledge is valued in STEM

Table 3.4
Research Questions and Types of Data Generated

Research Questions	Types of Data
1. How do youth describe their funds of knowledge, and how do these funds of knowledge feature in the stories youth tell about their learning and engagement in STEM-focused making activities? What Discourses emerge in the telling of these stories?	• Archival data (interviews, images, videos) • Conversation groups • Field notes • Co-created artifacts (white board, portfolios)
2. How do youth draw upon their funds of knowledge and Discourses in co-designing a maker education activity, and what design implications emerge from that process?	• Conversation groups • Field notes • Joint analysis of "recommendation" codes in Dedoose • Co-produced making activity plan

Table 3.5
Summary of Conversation Group Meetings

Date	**Co-Researchers**	**Topic**
March 2016	Jazmin	Creativity
April 2016	Jazmin	No Home Phone - artifact interview
December 2016	RaeRae	Track - artifact interview
December 2016	Onie	Pucket – artifact interview
March 2017	RaeRae	Ingham County Animal Control Interview
March 2017	RaeRae	Post-Feedback Cycle Feedback reflection
April 2017	Onie	GET City for Real – artifact interview
April 2017	Jazmin	Donator app – artifact interview
March 2018	Onie	Introduction for dissertation work
March 2018	Jazmin	Introduction for dissertation work
March 2018	RaeRae	Introduction for dissertation work
May 24, 2018	Jazmin + Onie	Family, social networks
May 29, 2018	RaeRae + A	Family
May 31, 2018	Jazmin	Friends + Family

Table 3.5 (cont'd)

June 7, 2018	Onie	Text now
June 12, 2018	RaeRae + A	Meeting planning
June 13, 2018	RaeRae + A	Friends
June 14, 2018	Onie + Jazmin	Friends / chores / interests
June 28, 2018	Onie	GET City / phone case
July 24, 2018	Onie	Portfolio
August 3, 2018	Onie	Funds of Knowledge - connections to portfolio
August 23, 2018	Onie	Recommendations, member checking
August 30, 2018	Jazmin	Funds of knowledge
September 4, 2018	Jazmin	GET City memories
September 11, 2018	Jazmin	Funds of Knowledge - member checking
September 13, 2018	Jazmin	Portfolio stories / funds of knowledge connections
September 14, 2018	Jazmin	Recommendations, member checking
October 5, 2018	RaeRae	Funds of knowledge (interests, chores, friends, activities)
November 9, 2018	RaeRae	More funds of knowledge + GET City memories
November 16, 2018	RaeRae	Funds of knowledge -- connections to portfolio
December 27, 2018	Jazmin	Co-planning
January 11, 2019	Onie	Catch up
January 21, 2019	Onie	Co-planning

Ethical Considerations

This study was approved by Michigan State University's Institutional Review Board for Research with Human Subjects (Approval #x-17-650C). All participants and guardians assented

and consented to this study. I reminded youth co-researchers of their ability to leave this study with no consequence several times. Parents were kept informed of our progress, plans, and all meetings.

Limitations

A limitation that permeates the premise of this study is my whiteness. I am representing the words of three Black girls, their experiences and triumphs. I have a small role in their stories, but I cannot know the full depth and breadth of their day-to-day life. Relatedly, this study is limited in its ability to represent those experiences by virtue of the chapter form it is presented. Although I have worked to highlight youth voice and stories, there are fundamentally more equitable ways in which this work could be presented. Given the constraints of degree requirements, it is currently presented in as authentic a chapter form as I was able to compose. Onie, Jazmin, and I plan to enact their co-planned making activity over the summer, and my hope is that we find a way to also re-present the information in this dissertation in a way that continues to elevate their perspective and voice.

Another clear limitation to this study is my inability to finish work with RaeRae. I believe our relationship as co-researchers showcases an important truth about working with youth who are vulnerable to systems of power that police and restrict their ability to participate in certain spaces. Participatory work is a commitment that requires flexibility, and advocacy on more fronts than I was able to foresee and give. Participatory research that engages youth who either seek these opportunities or are able to meet attendance requirements is understandably important but contributes to the silent oppression of youth who fall outside of those bounds.

Another limitation is the ways in which time played a factor in this study. There were natural limitations in each person's ability to recall making experiences or processes that had

taken place years ago. As RaeRae pointed out, “mindsets” change; a perennial challenge of working with humans. I was unable to answer the questions I had posed in as specific and critical way as I initially thought I would be able to.

I asked that the youth co-researchers join me in big tasks that were poorly defined, most notably, the making activity lesson co-planning. I did not define this task because I wanted it to be open to their own interpretation; however, having been in school for many years, they clearly had ideas about what a lesson is. By not discussing conceptions of what this looks like I did not open a space for Onie or Jazmin to disrupt patterns of what they have experienced lessons to be.

A limitation also arises from one of the strengths of this research – I have strong relationships with the youth in this study, which impacts both the experiences they are reporting on and the very problem space we are exploring. I have worked to temper this limitation by supporting the youth co-researchers in thinking about the ways in which my influence on their experience at GET City has been both positive and negative – modeling my own reflection on moments where I feel I have let youth down, etc. I have also encouraged the youth co-researchers to discuss and draw on their experiences beyond this makerspace, including reflecting on spaces where there has been less of an explicit effort to value their voice and individual experiences. Still I recognize this is only a partial compromise. I am unable to report on the experiences of youth who do not have access to spaces that are striving to ensure equitable access to STEM-rich making. I do, however, hope that my transparency in the challenges and successes of building such a research space will support others in working with youth to these ends.

CHAPTER 4

ONIE: INSTEAD OF LISTENING TO A BORING TEACHER, THEY COULD LISTEN TO KIDS

Introducing Onie

Onie joined GET City at the start of her sixth-grade year, in 2016. She was brought to GET City by Jazmin to check out the activities — and the snacks. When she first arrived, Onie was immediately enamored with tools that line the workbench and wall. Onie takes every opportunity she can to use power drills and the jigsaw, regularly reminding us that she is happy to teach other youth how to use them if they need assistance. Indeed, Onie's appreciation for making – and the tools – surpassed the appeal of snack, as she declared, "I really don't even eat the snacks! … I still come 'cause I like science, and because the stuff that we're doing is fun." The "fun" stuff Onie has made represent a wide range of interests and passions she brings to GET City, and are summarized in Table 4.1.

Onie has declared potential future professions to include being "a gamer, a scientist, an engineer, a basketball player, a YouTuber." Many of these interests and pastimes stem from a close network of siblings and older cousins. Onie lives with her mom, sister, and now step-dad. Though she is the youngest of her siblings, Onie is often responsible for babysitting her nephew (her brother's son) and her brother's girlfriend's daughter. She has strong friendships with her siblings, her nephew, and her many cousins.

Over the summer of 2018, when most of our work for this study took place, Onie spent the majority of her time at her brother's apartment or at her best friend's grandmother's house. She also spent some time with her grandparents. Picking her up, dropping her off, and meeting family members helped me develop a deeper understanding of how her funds of knowledge developed and to what ends she calls upon them.

Table 4.1
Overview of Onie's STEM-rich Making

Years in GET City	STEM-rich making projects
2016 - 2017	Circuit shapes, Pucket, *GET City 4 Real* YouTube channel
2017 - 2018	Began solar powered skateboard plans
2018 – 2019	Mentor

Onie's Funds of Knowledge

Onie and I discussed about twenty different areas where she had knowledge and skills that help her successfully navigate her everyday life (how we discussed funds of knowledge). For the sake of clarity and brevity, I am focusing on three specific areas of knowledge that Onie discussed most frequently and that came to bear most prominently in her narratives about her STEM-rich making.

YouTube

Onie's interactions with YouTube encompass a complex number of practices and knowledge that she draws upon in a variety of ways, across multiple social networks and contexts. Onie's experience with YouTube began through conversations with school friends about popular music and dance videos. Since then, she has developed more advanced explorations and uses of YouTube. In the sections that follow I share Onie's descriptions of her funds of knowledge around YouTube. She acts as a consumer, producer, and critic of information by interacting with YouTube to expand her experiences, supplement her education, and inform her everyday activities. This multifaceted understanding of YouTube informed both her YouTube channel, *GET City for Real* and how she seeks information for other STEM-rich making work.

Expanding experiences and interactions. Using YouTube, Onie is able to curate experiences she could not otherwise participate in. Onie enjoys seeing explosions and watching

things burn – phenomena that are challenging to safely witness or access in real life. Onie recalls finding a video of various chemicals changing the color of flames as one of the first times she realized she might like science. She explained, “I love pink fire! … that's what got me into science experiments.” Onie is able to use YouTube as a space to broker connections between her own interests and more traditional conceptions of what science is, changing her opinion of how she might fit in and participate in STEM.

Onie has benefited in tangible and important ways from these explorations on YouTube. Describing her sister’s attempt at frying Oreos, Onie shared:

> FIRE started coming out, like, from the pot there was fire…So we told Boobie [cousin] and she grabbed the pot and put it on the balcony - she dumped the stuff out on there, but the pot was still on fire. I was like - 'cause I was watching a YouTube video once, from one of my favorite YouTubers and she [the YouTuber] said "Whenever something is on fire, don't put water on it - put flour on it." So I was like, "Flour! Flour!"

Recalling this information helped save her cousin’s apartment and points to the importance of YouTube as a platform upon which important information can be shared and retained. Many youth at the Boys and Girls Club have favorite YouTubers and subscribe to channels that feature various topics and interests.

Onie uses YouTube not only to access content and experiences she could not otherwise, but as a platform on which she can make connections with individuals and groups of people she might not otherwise interact with. She follows specific YouTubers who talk about the video games she is interested in and takes the surveys they post as a way to engage with debates they generate. She explains,

> … whenever they [YouTubers] make a video or a post, like, you can post pictures and ask questions. Like you can ask a question and there's multi - and there's things you can ask. And, a YouTuber had asked "What do you like the most in the new update for Fortnite" it was "golf carts, one of the characters you can buy, another one, and then guns" -- I think. I don't know. I put golf carts because that's the first car.

By participating with content others have produced — through surveys and watching their videos — Onie understands the potential of YouTube for engaging youth by offering them novel experiences and interactions. In the 2016 – 2017 school year, Onie and two other group members worked to harness this potential by developing *GET City for Real* – a YouTube channel devoted to sharing work done in GET City. The impetus to develop their technological skills and learn how to create and edit movies about STEM-rich making practices and skills was grounded in a concern that such knowledge was not widely held and would be soon not be funded. The group explained, "We are concerned because of the previous political election [of Donald Trump] and what it could for us as kids who want to learn…. We want to help the world by sharing science and engineering knowledge with other kids on the internet." Recognizing that the experience they were able to have in GET City was not universally available to "kids who want to learn," Onie and her partners developed a series of videos that introduced circuits and solar panels, and showcased other projects in GET City.

Figure 4.1, Onie's *GET City for Real* introductory video. *A screenshot of José, Onie, and Jamal in their introductory YouTube video for the GET City for Real channel. Text reads "Three engineers / These kids know their stuff / And want to share it with the world / On the best YouTube channel / GET City for Real / Fun and hardworking green energy experts / BGC GET City for Real."*

Publicly declaring herself and her partners as engineers who "know their stuff and want to share it with the world," Onie is making a marked comment about who she is that pushes against deficit narratives about who can engage in STEM work, and what that work has to look like. Onie was deeply involved in the editing and creation of this introductory video, drawing on her knowledge of what kinds of YouTube videos are most attractive to viewers their age. She decided to format this introductory video as an action-style promotion of herself, her partners, and the work being done in GET City.

A tool to supplement, not dictate, education. Onie's recognition of YouTube as an educational tool grew from her disenchantment with sixth-grade science:

> I was one of the ones not paying attention because I didn't really get it and I didn't want to ask the teacher… I saw an educational video [on YouTube] and then I just started watching them more and more, like, it's not -- I wouldn't call it a science, 'cause that would make it seem boring to other people.

In this quotation Onie names the hurdles growing for her in school and identifies the potential YouTube holds for navigating them. YouTube offers her a way to get information in a way that did not seem "boring" and would not position her as someone who was unintelligent or underscore her lack of attentiveness. She recognizes the unfair stigma that is associated with science for her peers, and the challenge of shaking that heavy reputation. Although she recognized the content of her YouTube watching was scientific, Onie was also aware that such a label is loaded with connotations of boredom (to "other people", anyway) as she suggests a light touch in connecting the educative materials on YouTube to school subjects.

Realizing that YouTube could help her answer questions and explore science in more flexible and fun ways than she was able to in school, YouTube videos became an important resource for Onie. Her hope was that *GET City for Real* could serve a similar purpose for other youth who were hesitant to ask questions in class. She explained,

> It [*GET City for Real*] is used for people outside of school to learn about science. About the earth, and the city, and science. Mostly kids, but I think adults will use it to tell other kids, or like if they're a teacher, they'll probably show their students… instead of listening to a boring teacher, they could listen to kids that's most likely their age. And they understand, more like them. And they can change it into their understanding.

Onie points to the potential that YouTube has as a middle ground where videos can provide information in a way that is more interesting than "boring teachers" could hope to pull off. Recalling her lack of interest in listening to her own science teacher who was unable to make content relatable or exciting, she names the importance of having that information be presented by youth, divesting the power traditionally held by teachers as "knowers" or as the best suited to communicate information to their students.

Elaborating on the importance of having educational messages designed *by kids, for kids*, Onie pointed to the openness of the making activities they shared on their channel.

> Some people like learning stuff from kids instead of teachers so it's not like they're controlling you – but they're [the kids] just showing you "this is how you can do this, and this is how you can do this" - instead of doing a boring project in school about science. Like, you know - with circuits!

Onie connects her experience of school science as stifling and YouTube as an open arena for exploration in justifying the importance of GET City for Real. Through this channel Onie is able to share her STEM knowledge in a way that she knows is appealing to youth – showing them that they can engage in making to an end of their choosing, without specific outcomes being prescribed and "controlling" their engagement and learning.

Onie's push against being controlled in her learning extends to the ways in which she engages with YouTube videos. She uses YouTube as a resource that helps her develop her own approach to making without dictating that approach. During one conversation group, our discussion had drifted to phones, reminding her of a story she heard from a friend about how to make a phone case out of hot glue. She went to YouTube to double check the procedure, and

together we watched an eight-minute video. Throughout the video Onie narrated her thoughts about the clarity of the instructions and concerns she had about whether the phone would work after we had completed the project. She was skeptical about the safety of her phone, adding multiple layers of protection from the high temperature hot glue in the form of plastic bags. She also adjusted her glue gun pattern after deciding the YouTube demonstration was messy for no apparent reason. Initiating this making project for herself, Onie engaged with this YouTube video in a critical way to inform her procedure. She used the information the video provided but shaped it to her specific wants and needs.

Table 4.2
Onie's YouTube Fund of Knowledge and STEM-rich Making

Overview of funds of knowledge around YouTube	Making work enabled by this fund of knowledge
• Explores STEM phenomena outside of her everyday • Watches videos with useful life information ("hacks") • Uses videos to navigates hurdles in "boring" school science • Tool for expanding science knowledge • Interacts with online communities • Critical consumer of information	• A platform to share makerspace experiences with those who do not have access • Means of democratizing and saving information in case of budget cuts • Developed tech skills to position herself as a STEM expert • Shares content in meaningful ways (not boring) • Uses videos to open explorations rather than dictate making work

Fixing and Building

Onie draws on two primary practices that help her fix different items and construct new ones: playing with objects to understand how and why they are broken and engaging in "random building" with different materials. Through these informal investigations, Onie has developed a set of skills that contribute to her own well-being, as well as her family's well-being.

Investigating and fixing items. Onie's approach to STEM-rich making has been informed by a range of experiences fixing different items. She described a saga that occurred

when her mom purchased an antenna for their family television, so they did not have to purchase cable, and the antennae broke. Onie and her family were left unable to watch the shows they wanted to see. As Onie told the story of her attempts to fix the antenna it became clear that she was both pleased with her own abilities and focused on achieving the end she had decided upon:

> My step dad worked on it while we were at school and stuff and he couldn't figure out what it was and my mom couldn't figure it out, my sister definitely couldn't figure it out - she'd just go on her phone like, 'I give up' and … I kept on trying it and I actually got it!

Onie concluded this story explaining that through fixing the antenna she not only regained access to her favorite television shows but was able to restructure some norms and hierarchies that had emerged in her household around who was able to dictate the television watching.

> …my sister, she like, ALWAYS - just because she's older - she would always be able to pick what she wants to watch... This time she tried to tell on me because I said I'm going to be watching most of it - and she thought I was playin' but I was actually serious and one day, one of my favorite shows was on at the same time one of her favorite shows was on so I said "I'm watching my show because I fixed the TV" and I said "you wouldn't be able to watch ANY TV without me" … And then she tried to tell my mom, and my mom said that I get to watch it because I fixed it.

While Onie was quite happy to leverage her fixing abilities to her own tv-watching ends, Onie also very generously shares her abilities with others. For example, Onie shared that she likes to spend time with her grandparents, helping them with any tasks they might need to be done. She described the experience of trying to put together some outdoor lights for her grandma.

> I didn't know what that thing - what the solar panel was called because it was little square of solar panel right at the top, I was like "What is this?" 'Cause I had put it together, I was like "Okay - weird design, but…" [laughs]. The first time I did it wrong and it didn't light up at night. 'Cause I didn't put the part right. I didn't read the instructions. But yeah, I read them and then put it together right and it actually worked.

Through trial and error, continuing to learn how to fix items and take opportunities to expand and develop this skillset, Onie continues to contribute to her family's wellbeing. This iterative approach informs Onie's approach to her making work in GET City, too. One of Onie's first

engineering designs in GET City was a game called “Pucket” (a walled game where players on either side of the board use an elastic band to fling pucks through a small hole to clear their side and fill the other player’s side up with pucks, Figure 4.2). After constructing the frame, Onie and her partner, José, needed to figure out how to make elastic strings with enough tension to fling the pucks across the board. After experimenting with several materials, they landed on rubber bands. They were next met with the dilemma of how to secure the rubber bands in place. Onie and José eventually discovered that dowel rods worked nicely, but it took many iterations and frustrated sessions of re-threading the rubber bands through small holes before this conclusion was reached.

Once the game was ready to play, Onie and José realized the floor of their game was uneven, stopping the puck from successfully flinging across sides. Their eventual solution was to use sheets of colored cardstock that maintained the integrity of their agreed-upon color scheme. This was a painstaking process of trial and error, adding one piece of paper at a time and testing it to see if it had rectified the problem. Just as with the antennae and solar panel lights, Onie patiently continued to look for new solutions after each fruitless turn in the Pucket board construction, confident there was a solution, but they had not yet found it. The final product was so successful that she and José each wanted to take it home and share with their parents.

Figure 4.2, Photographs of pucket board construction and its use. *(L) Onie and José working on their pucket board. (R) Club members play the final iteration that includes rubber bands and purple cardstock.*

“Random building”. When I asked Onie which funds of knowledge she thought helped her the most in her making work, she responded that it was her ability to play with different materials, discussing one way in which this practice had developed:

> I used to just do random things like put wood together with glue, I don't know I would just do random things - building things randomly. Outside at home. Especially with my nephew, like, the first thing he likes to do when we're outside is make mud things. I used to like doing that, too, like mud cakes and stuff. Like when I did that thing with the popsicle sticks and hot glue - that was random.

Building ‘randomly’, simply for the pleasure of creating with the resources available to her has cultivated a sense of ingenuity and intentional playfulness in Onie’s building. The popsicle stick and hot glue creation she referred to in the quotation above was something that she built steadily over the course of one of our conversations. Throughout this process she learned that popsicle sticks splinter when cut certain ways, that hot glue spots can only hold so many popsicle sticks in place and then the resulting tower is only able to support so much weight. Building simply for pleasure has supported Onie’s ability to create and build toward more directed aims. Onie explained:

> Randomly building stuff helps you know how to build stuff not randomly…if you build something randomly, like if you're just building - you'll know that something and something else don't go together. So you have to do something ELSE to make it go together.

Onie used her knowledge of “random building” to inform how she developed projects in GET City. She purposefully curated situations that enabled her to further explore her ability to build. The construction of Pucket took place during a unit designed to introduce youth to power tools. Onie explained, “...most of the wood was already shaped so it wasn't hard to do it, but I really wanted to cut wood and use a power tool, the jigsaw, so I tried to find bigger pieces than what we needed.” By finding bigger pieces than she needed, Onie was able to make more cuts using the jigsaw and practice connecting more pieces of wood. Making additional cuts and using larger

boards than needed would not be considered standard practice in most woodworking scenarios; however, Onie disrupted that norm to further her personal goals. By taking a somewhat more complicated path in constructing her Pucket board, Onie was able to center her preferred way of building while extending her knowledge of tools and woodworking.

Table 4.3
Onie's Fixing and Building Fund of Knowledge and STEM-rich Making

Overview of funds of knowledge around fixing and building	Making work enabled by this fund of knowledge
• Dedicated, iterative attempts to fix items • Patience with trial and error problem solving approaches • Plays with objects and different materials • "Randomly" builds with available materials for fun, learns how to "not build" randomly	• Dedication to developing Pucket strings • Problem solving with different materials (e.g., paper in Pucket floor) • Leverages knowledge of materials that do and do not go together • Curates situations to play with / explore different tools / materials

Video Games

"Gaming" was Onie's first and very prompt answer when I asked what she thought she was best at. Although the knowledge and practices associated with video games did not come to bear on Onie's making work in as explicit a way as did her funds of knowledge around YouTube and fixing / building, it is a valuable illustration of how funds of knowledge are connected and can inform each other. Examining gaming as a fund of knowledge also provides a helpful context for showcasing how several key Discourses (discussed in the next section) have influenced the development of Onie's funds of knowledge and her making work. In the sections that follow I describe the social networks that have informed Onie's interest and skill development of games and how gaming has helped Onie navigate various spaces. I include Onie's out-of-GET-city plans for developing a YouTube channel with her nephew.

Socializing. Onie learned to play video games by watching her brother and is in the process of teaching her nephew how to play them. Onie likes going to her brother's apartment

because then she can play on his X-Box 1. When I asked if playing video games is primarily why she goes over there, she made it clear that these visits were not rooted in self-interest, rather, gaming was part and parcel of being social and spending quality time together.

> I go over to his house to hang out with him and his girlfriend, and his girlfriend's daughter and my nephew. But yeah - and sometimes when I'm with my nephew, like, watching him, we play a game like - Rocket League together. Which is kind of like soccer but with little cars, so you drive cars and you can flip them and stuff and bump the soccer ball.

Onie and her family enjoy playing team games or learning new video games together. She enjoys spending time with her nephew; playing games lets them build their time together as teammates and develop strategies for beating each other.

Video games serve as a relationship building platform for Onie and contribute to her ability to extend her social network. Onie occasionally posts a picture of a video game she's playing on Snapchat, with text over it asking if anyone wants to play online with her. If she's unable to play with her family or friends, she'll play with "random people" online. Her interest in video games extends her interactions with others as she plays with them and learns from them. She once explained:

> I was playing with my best friend's cousin, Jaden and one time the car had stopped working and he was in the car and Daija was in the car, too, and I was like, 'Why did the car stop working" and he was like, "you need gas" and luckily, he had gas.

This kind of anecdote peppered Onie's discussion of games – she met and learned various strategies from many people because of her ability to engage in conversations about games.

Onie plays two popular games with many of her friends – PUBG and Fortnite – often on their phones at school. Onie and her friends share stories about triumphs, tactics, and failures (like when her friend Marcus had his account hacked and lost about $200). They compare features, resources, and preferences (after the hacking Marcus now agrees with her that PUBG is

superior to Fortnite due to its security and because you can swim and drive cars). Onie's ability to cooperate with others extends beyond the time she spends actually playing the game as she shares strategies, helps, supports, and learns from her peers about their experiences with games. Identifying as a gamer has helped Onie take on the role of supporter, teacher, and learner – all social roles that inform her explanations of why she enjoys gaming.

Finding spaces. When not at her brother's apartment, Onie plays video games on her phone, which was how she walked me through several games. Like many youth who attend the Boys and Girls Club, Onie uses her phone and places with free internet to overcome not having access to a desktop or laptop at home, nor having a data plan on her phone. Although the internet at the Boys and Girls Club is not very fast, Onie knows a variety of different places with free wifi. Her ability to navigate structural hurdles that inform a digital divide help her not only maintain access to the world of games but keep up-to-date on her Snapchat streaks and the Text Now app that she uses to communicate when her phone's service is turned off. The skills and knowledge Onie has built in pursuit of gaming are cultivated with a very pro-social and community-based motivation behind them.

Drawing connections to making work. This particular fund of knowledge influences Onie's approach to STEM-rich making in GET City more through the Discourses it helps to clarify (discussed in the next section); however, it also demonstrates how funds of knowledge can inspire and motivate the cultivation of STEM-focused skills. As we were going through the list of her funds of knowledge, Onie asked if she could draw a line connecting YouTube and Video Games, explaining "I'm gonna make a YouTube channel with my nephew. It's gonna be about gaming and we're gonna do challenges on it and stuff." Working on the *GET City for Real* channel helped Onie develop the technical skills needed to produce and upload movies to

YouTube — skills she intends to harness in support of this other important area in her life. This is a powerful example of how the skills gained in STEM-rich making can be re-purposed and re-centered around ends determined by youth for their everyday use.

Similarly, Onie's interest in skateboarding video games inspired an interest in actual skateboarding which has become the focus of her making work for the last two years. With José, Onie began to develop plans for a solar powered skateboard. During this dissertation work, Onie began thinking more concretely about how she could make her skateboard light up. Onie's plans for her skateboard and video gaming channel both underscore the importance of validating and encouraging youths' funds of knowledge as transformative agents for STEM concepts.

Table 4.4
Onie's Video Game Fund of Knowledge and STEM-rich Making

Overview of funds of knowledge around gaming	Making work enabled by this fund of knowledge
• Forges social bonds • Shares strategies, information with family and friends – learns and teaches • Social cache with her peers • Helps her navigate spaces and tech-based hurdles	• Applies tech skills from *GET City for Real* to support conceptualization of content for gaming challenge channel with her nephew • Inspired interest in skateboarding, influencing designs for a solar powered light up skateboard

Discourses Informing Onie's Funds of Knowledge and STEM-rich Making

Onie's stories from her life and in STEM-rich making demonstrated several ways in which her socially situated Discourses mediated the development of her funds of knowledge and influenced her approach to making. Through Onie's lived experiences she has developed ways of being, valuing, talking, and interacting with the world that reflect her identity (Gee, 2008). These Discourses influence how and in what ways she develops her funds of knowledge and how she prefers to engage in her making work. In this section I discuss how collaboration, care-taking,

and respectful scaffolding are Discourses have influenced Onie's funds of knowledge and impacted the ways in which she presented herself and navigated the space of GET City.

Collaboration – Valuing and Working with Others

Working with others is an important way of being for Onie. This particular Discourse has been cultivated and strengthened through Onie's social networks of family and friends and influences how she tries to move through the world at home, in school and in GET City. Onie describes the development of many of her funds of knowledge as originating through the interactions she has with others. While not surprising that Onie learned how to do many things through working with others, it is noteworthy that she rarely refers to these funds of knowledge as knowledge and skills that she now possesses on her own. Onie continues to refer to her knowledge, skills, and activities in reference to (and with appreciation of) others who have contributed to her abilities. For example, although gaming can be a solitary pursuit and Onie could certainly claim to be in singular possession of the skills needed to successfully engage in many games, she continues to highlight the collaborative efforts that have led her to better understand gaming.

Valuing working with others also comes through in Onie's discussion of her funds of knowledge around YouTube. Her plans for continuing to leverage this fund of knowledge to her own ends by starting a new channel with her nephew are deeply collaborative; though he is eight years her junior she treats him as an equal partner in this venture. When she asked about getting some refresher tips on using iMovie to edit their video she declared, "I want to bring my nephew, so he can learn, too. Like, if I forget something, he can remember."

Unlike many other middle schoolers, Onie is not hesitant to acknowledge and appreciate the role that others play in her work – almost every story she shares about her making work

involves recognizing the involvement of another person. She discusses how her partners brought important ideas to the table while making *GET City for Real* and how other groups helped her YouTube channel by promoting it or doing a feature film, like RaeRae's dog rescue bag. In talking about her work on Pucket, Onie spoke about how she enjoyed working with José, and how their partnership resulted in the invention of her new favorite color – "pinkle" (pink + purple).

Onie's Discourse of collaboration features in how she talks about including others in her future work. During the summer of 2018 as we were meeting, she proposed making a new movie for the *GET City for Real* channel, saying "We should do a new one [movie] with everyone in GET City – me, Jazmin, RaeRae, José, Jamal – is he still in GET City? Well if he comes to the club one day we should get him." This inclusion and desire to work with others stands in stark contrast to the ways in which makerspaces and traditional science practices think about the roles that youth can / should hold. Often rhetoric around makerspaces are focused on an individual's final product, or the STEM content learned. Emdin (2011) argues that cooperation should be understood as one of the "chief signifiers" of productive participation in science. It is a key element of students' out-of-school activities and communities, despite standing in contrast to what are often identified as productive science practices (measuring, investigating, etc.) which are often taught as individual skills.

Care-taking – Working for Others

Taking care of those around her is an important way of being for Onie. It is a value that mediates the ways in which Onie's funds of knowledge are developed and how she calls upon them. Onie demonstrates her care in a wide variety of ways. As one example, she shared that she

had some extra hot glue sticks at home and was experimenting with melting them on the stove while her nephew was around.

> I knew he was going to try and do it after I went to sleep so I broke all of them and threw them outside. And – 'cause I knew that if my sister would've did that and I watched her, then I would've tried to do it while she slept.

Onie displays self-awareness, reflection, and thought in ensuring her nephew does not attempt to repeat her experiment and inadvertently hurt himself.

Onie is able to take care of her family members in ways that leverage her funds of knowledge. For example, her fund of knowledge around fixing and building allows her to make sure her grandmother stays safe:

> … I usually go to my Grandma's a lot. Mostly to help my Grandma. I love helping my Grandma. She needs help with a lot of things. And she has Parkinson's … she was reaching for something in the bathtub and she fell in the bathtub. And fractured her tailbone… I don't like her getting up and walking a lot because, yeah. She can do a lot of things, but I just don't like her doing a lot of things. She likes putting up pictures in her room. I don't know why. So, I always help her put them up. I don't like her holding the hammer or something, because I don't want her to drop it. Like when we were putting up the shower curtain, she would stand on the bathtub, so I would do it for her. But she was like "You don't want me to fall, do you" that's what she said to me when I was trying to help her out. Yeah, so I put it up.

Taking charge of a situation she views as potentially dangerous given her grandmother's previous falls, Onie cares for her grandmother by fixing household items like the shower curtain and making their new apartment fit the aesthetic her grandmother desires by hanging up art work. Onie is happy to be able to call upon this knowledge to make her grandmother's life easier and enacts her abilities as an attentive and helpful member of their family.

Care-taking as a Discourse also mediates how Onie engages with YouTube: the platform has shown her how it can be a launching point for fame, and she is intent on helping her older brother take advantage of it to further his singing career.

Respectful Scaffolding

Onie has a specific understanding about what teaching should look like that is based on her experiences being apprenticed into various family activities. She expects that newcomers are supported in a way that honors and appreciates their current ability level and scaffolds their engagement. Stories that reflect this Discourse were threaded throughout discussions of how Onie learned to cook, play video games, play basketball, and swim. Within each she mentioned the supportive role of the mentor, and a gradual introduction to engaging whatever activity was at hand — often first watching, then engaging in limited ways before fully participating.

The expectations and practices of this Discourse are underpinned by a set of values that respect where a learner's knowledge and skill set is and understands them as capable of engaging fully with the practice they seek. This value set is surfaced in a story Onie told about how she expects learners in GET City to be treated, and how she has helped teach her nephew about video games:

> Say someone just came in - brand new - they don't understand anything about science, so we teach them - obviously - we teach them stuff about science. …Let's say they wanna know how to record, like, they don't even know how to go to the place on the laptop to record - I won't say 'Wow you don't know how to do this? You should know how to do this by now' I would show them - I understand that you don't know how to do it, so I will show you how to do it. And then after, I would show them - just like I do for my nephew - he understands a lot about gaming, now that I taught him about it - so I would show them how to go to it and then I would exit out of it and then see if they know how to do it.

Sharing this hypothetical scenario Onie makes it clear that the learner is in charge, gets to pick what they want to learn, and that shaming or placing expectations on their current knowledge is unacceptable. Onie continued, explaining in painstaking detail how she taught her nephew about gaming – walking me through all buttons on the remote control and various scenarios that

require different combinations. Throughout this story of her faded scaffold approach, comments about how "he [nephew] really understands a lot" were consistently mentioned.

Onie understands the set of values that inform this scaffolded approach to learning are not universally present in educational spaces. She recognizes that other approaches to teaching reflect different, dominant Discourses. In the summer of 2018, her summer school took a tour of a community college. A professor came to give them a sample lesson and she observed, "We were supposed to be learning, but he was just talking." Onie's conceptualization of "learning" stands in stark contrast to an adult who is "just talking", making it clear that the values undergirding this Discourse should be enacted in ways that require both dialogue and respect. This is a much more humanizing approach to teaching than is traditionally practiced – in school or college. Onie's Discourse of respectful scaffolding demonstrates a baseline requirement of intentional conversation, through which funds of knowledge can be brought to bear in the learning process.

Connecting Pieces

Onie's Discourses not only inform the development of her funds of knowledge but influence how and when she calls upon them in her STEM-rich making work. Onie's Discourses influence how she navigates GET City and created space for her to leverage her funds of knowledge. This concluding section describes these connections and relationships. See Figure 4.3 for an illustration of these relationships and Table 4.5 for a summary.

Supporting Navigation of Makerspace

Onie's Discourses – her ways of being – orient how she approaches her STEM-rich making work. For example, Onie's Discourse of collaboration influences how Onie makes sense of and navigates makerspaces: she prefers group work over working by herself, and she seeks

information from others in the makerspaces rather than make decisions based solely on her own opinion. As a result, Onie values flexibility of movement – encouraging youth to move around, supporting different groups where their expertise might be helpful. Onie framed this flexibility as a benefit for all of those working in the space.

> If someone really isn't focused on their own stuff maybe they could go help someone else with their stuff. 'Cause if you're not focused on your stuff and you're just sitting there, you're not helping anything. So maybe you could go help someone else.

In this quotation Onie shares a broad perspective on what successful participation can look like, recognizing that attention will not always be focused on a particular task, but that there can always be moves made to support the work of others.

Onie's Discourse of care-taking informs how she thinks about the purpose of a makerspace, broadly. She explained that makers should "feel like they're helping something". This speaks to the empowering potential of creating something that helps others. Engaging in STEM is fulfilling and interesting when it is connected to an idea, a problem, or a community need that matters to youth makers.

Onie's expectations that come from her Discourse of respectful scaffolding influence how she navigates the learning process in the makerspace. She cultivates relationships with individuals who respect her skills and abilities, shunning those who she perceives as more dismissive in their teaching (the eighth graders who were there when she was in sixth grade and acted "older" and better).

Creating Space to Leverage Funds of Knowledge in STEM-rich Making

The emphasis that Onie places on working with others through her Discourse of collaboration extends her engagement in activities and opens space for everyone to share their funds of knowledge. She understands working with others as a mutually beneficial premise –

everyone has knowledge to contribute around an activity, including herself. By working together, then, all parties gain experience and knowledge. For example, due to the collaborative efforts that resulted in the *GET City for Real* promo, Onie was able call upon her funds of knowledge around building as she posed with power tools as a point of engagement with potential viewers. She encouraged José and Jamal to call upon their own interests in individual shots, too.

Onie's Discourse of care-taking opens space for Onie to leverage her funds of knowledge as she considers who her STEM-rich making work is serving. For example, Onie's engagement with *GET City for Real* builds from a different aspect of this Discourse – care for her imagined audience: youth who are disenfranchised by traditional education. Onie talks about the value of her work in creating and producing videos about STEM-rich making in terms of caring for an imagined audience, providing them alternative ways to understand both content and possibilities. She explains, "they probably don't pay attention because they don't understand it or get it and they don't wanna ask the teacher… so if they go to us [*GET City for Real*] they'll understand it more, probably, maybe, understand it more and pay attention to us and they'll learn!" Onie's Discourse of care-taking helps her empathize with students and call upon her funds of knowledge around YouTube to develop a solution for them. This Discourse opens space for her funds of knowledge to disrupt multiple narratives; she and her peers are not uninterested students, nor does she view individual success as the end goal – she is working to carve a space in STEM for other students behind her.

The values underpinning Onie's Discourse of respectful scaffolding informs how she carves space to leverage and develop her funds of knowledge the learning process. For example, Onie called upon YouTube as a supplementary resource to support herself when her formal education was not meeting the standards of this Discourse. Onie was able to use YouTube to

create scaffolds for herself in ways that her teacher did not. In the same way, her Discourse of respectful scaffolding informed the way she engaged in "random building" to better understand the jigsaw.

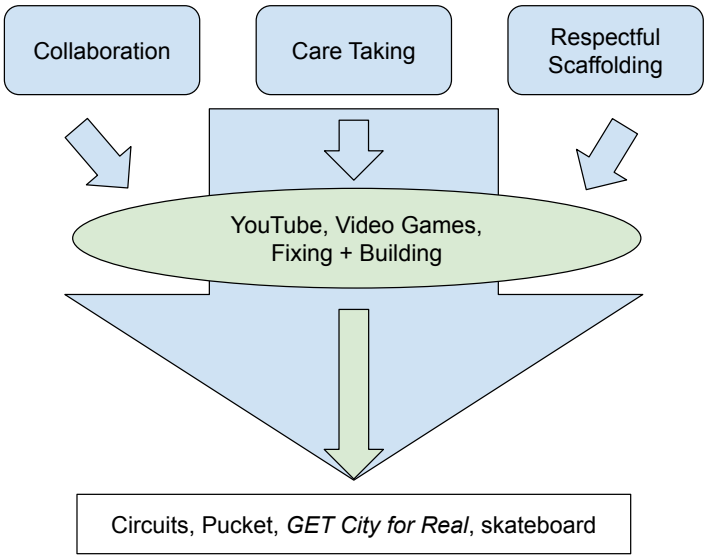

Figure 4.3, Model of Onie's Discourses, funds of knowledge, STEM-rich making

Table 4.5
Onie's Discourses, navigation of makerspace, funds of knowledge

Discourse	Influences on navigating makerspace	Creating space for funds of knowledge
Collaboration	Prefers to participate in groups. Collaborative efforts lead to invention of greater things (e.g., a compromise with José: pink + purple = pinkle). Values groups being able to help each other (e.g., she put a promo on *GET City for Real* for the RaeRae's dog rescue kit).	Collaboration allows her to leverage funds of knowledge around **YouTube**
Care-taking	Thinks all makerspace activities should be geared toward helping others. Wants youth viewing *GET City for Real* to avoid having to feel badly about asking questions in class.	Uses **YouTube** as a tool to take care of others – wants brother to upload his music there to gain recognition for his talent Is careful in how she engages in **videogames** with nephew. Takes care he does not play "inappropriate" ones. Leverages knowledge of **fixing and building** to help grandparents.
Respectful scaffolding	Scaffolds her exploration with tools (e.g., by cutting more pieces than necessary). *GET City for Real* shares information with youth openly – not "controlling" them.	Leverages **YouTube** as tool to support her learning when premise of this Discourse is not met in school. Teaches **gaming** strategies and techniques to nephew, sister.

CHAPTER 5

JAZMIN: WHEN PEOPLE HEAR I MADE SOMETHING, THEY CAN TRUST IT

Introducing Jazmin

Jazmin joined GET City in the 2015 – 2016 school year as a fifth grade "special helper", supporting the work of middle school members. Before joining GET City Jazmin was in the Robotics club which was less interesting because "in robotics we had to follow instructions on how to build things and in GET City we change the instructions a little bit, and we make it. We make more advanced things than if we were in robotics." A brief overview of Jazmin's projects and years in GET City can be found in Table 5.1.

Some of Jazmin's main interests include cooking, engineering, dancing, music, and art. Many of these interests can be traced to family members. For example, Jazmin's GG – her Great Grandmother who is affectionately known as "Granny" by most people at the Boys and Girls Club – makes dinner and snacks for all youth and adults at the club. Though Jazmin has family spread across the states (Arkansas, Florida, Texas, North and South Carolina, Chicago) she still has an extended familial network in Lansing. This network helps transport Jazmin to various practices and after school activities, supporting her extracurricular activities. She lives with her mom, her ten-year old brother, and shares stories of growing up with her siblings from her dad's side.

Aside from regularly being at the Boys and Girls Club, Jazmin participates in other clubs and committees at school, takes dance classes, is involved with church activities, sings in the choir, plays basketball, and she recently joined a local youth science public TV show – The Curious Crew. Appreciating the many activities Jazmin is involved in, I was hesitant to ask Jazmin to participate as a co-researcher, especially once it became apparent that due to her

summer travel schedule, we would be meeting during the school year. Jazmin reassured me that this was the most relaxing of her activities and that she enjoyed it. She is hoping that her continued presence at the Boys and Girls Club will result in a job as a Junior Staff member[1] in the near future.

Table 5.1
Overview of Jazmin's STEM-rich Making

Years in GET City	STEM-rich making projects
2015 - 2016	No Home Phone Button
2016 - 2017	Circuits, Skeeball ramp, Donator app
2017 - 2018	Fans
2018 – 2019	Mentor

Jazmin's Funds of Knowledge

When this study began, I had known Jazmin and several of her family members for over three years. Due to our long relationship, Jazmin was comfortable sharing many personal stories – elaborating on her family's strengths and trials. The intimacy of her stories helped nuance the ways in which her funds of knowledge developed from those around her and informed her making work.

"Boredom Building"

Jazmin will often share stories about inventions she made for others and explorations she has undertaken with various objects -- playing with, improving, or taking things apart. When I asked how she would categorize these kinds of activities, Jazmin said she would them "boredom building" because she tends not to have an agenda while doing these things and is often just making something to keep herself occupied. Still, her experimentation with building often led to meaningful ends. As a small example she once brought a contraption she had developed from an empty cookie canister to a meeting, explaining:

[1] Junior Staff members are high school aged employees at the Boys and Girls Club

> When you're not supposed to, I make little tissue thingies at my desk when I'm sickie. I experiment with a whole bunch of random stuff at my desk, mostly paper because I have nothing else to experiment with.

Jazmin is often sick and runs out of tissue packets too quickly; her paper experimentation helped direct and support her building toward productive ends. In the sections that follow I share how Jazmin's planning practices support her building and the ways in which building has helped her develop an appreciation for engineering as the science of making puzzle pieces work together.

Planning and building. If Jazmin lacks the tools or resources to immediately begin building, she writes her thoughts down. "I'll be like, I'm really bored [at school]. I should just design something to make … and I'll design it, and when I get home, I'm like, let's go make this!" Jazmin has called upon this practice in her making work at GET City, often working on sketches for projects at home, then bringing them in to build from or further develop her plans. When making a skeeball ramp in 2016 Jazmin was drafting plans and continued to realize a number of additional considerations needed to be added. She abandoned this first draft in favor of a larger piece of paper because, as she said, "Big ideas need big paper" (see Figure 5.1).

Jazmin explained that when she comes up with an idea of something to build, "I'd, like, draw a picture of like how I wanted it to look and then draw like little notes and stuff on what it's supposed to be like." The plans Jazmin draws up for her building offer concrete first steps; she then discovers additional design elements to consider throughout the process of executing her plans. For example, as she worked her way through constructing the skeeball game she found "there was a few flaws that I realized how I could fix after the fact." As can be seen in the sketch-ups below, Jazmin carefully measured the length and height of the boards and the size of the holes to ensure the balls could get through. Despite the care with which Jazmin developed

these plans, the angle of the ramp and the ball return was a challenge that continued to vex her as she tested her designs. During the final showcase event she had to reassure younger players that it was fairly built "because they would think that it was rigged and that they couldn't make anything. But that wasn't why, it was just the amount of force and motion that you gave [the ball]". Realizing that the younger kids were not rolling the ball hard enough to hit the holes, Jazmin continued to adjust the structure, hoping to make it an easier game. Jazmin's continues to develop her funds of knowledge around building through this practice of writing down thoughts, building, readjusting plans, and re-building.

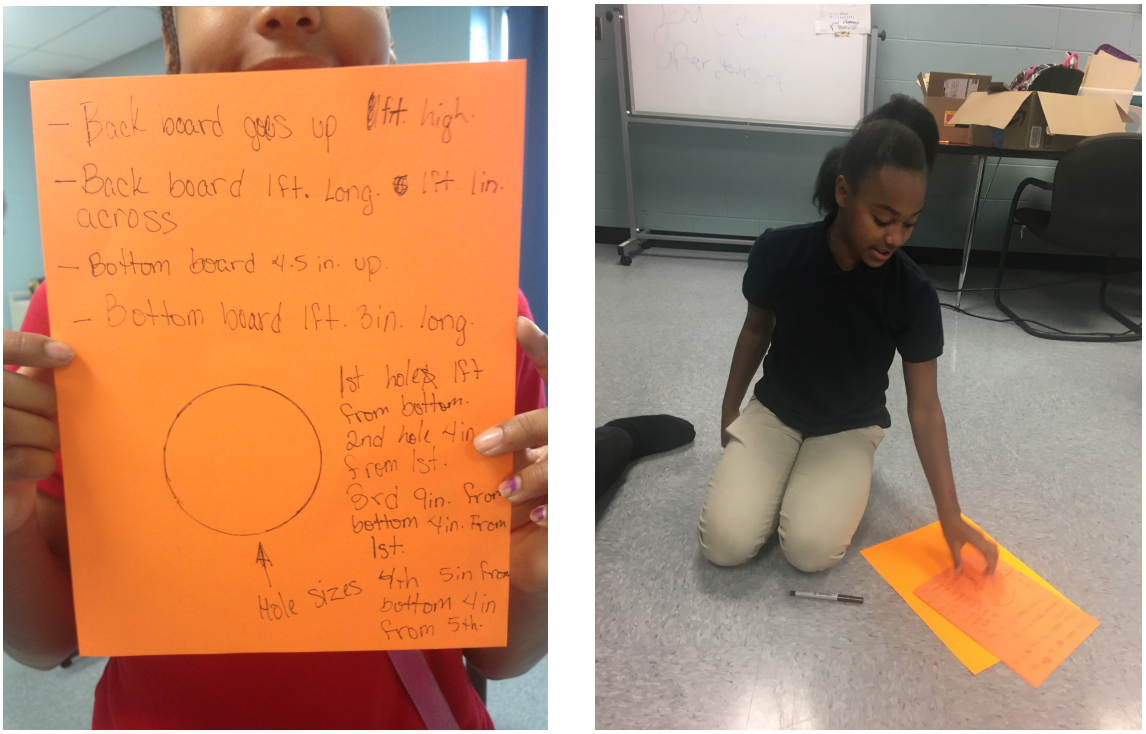

Figure 5.1, Photographs of Jazmin's planning process for skeeball ramp. *(L) Jazmin's original plans for her skeeball game (R) Redrafting plans on bigger paper.*

Experimentation. Jazmin's stories about boredom building often feature experimenting with already-constructed items. She recognizes that pieces belong in specific places for reasons she may not fully understand yet. She plays with items and explores their component parts as a form of backward design that is inherently scientific. She explained:

> …since I like science I try and take things that LOOK like they could come apart, I like taking those apart and trying to solve it and put it back together…So, like a puzzle, so that I can try and get the feel of how scientists make things.

By taking things apart and rebuilding them Jazmin is able to explore how different elements of an object serve a purpose and build an identification with scientists as people who are interested in figuring puzzles out. Upon receiving the gift of an additional calculator, Jazmin approached it as a puzzle to deconstruct and re-build:

> And since I had a calculator that my friend let me have, and since I already had one, I thought I should experiment, and I should start taking apart the calculator. And when I tried putting it back together I kind of forgot where pieces went- and I put one thing in the wrong part, and NOTHING worked anymore. And I realized, these things are put in a certain spot for a reason.

This approach to figuring out how objects go together informed the entire process of making for Jazmin. Jazmin called upon this approach throughout her process of making; while working on the No Home Phone Button project[2] in 2015 she took apart her entire cell phone to demonstrate her knowledge of its inner workings and to see if her SIM card would fit in the Arduino.

This kind of experimentation informs how Jazmin understands the importance of finding the right component parts, a dedication which can be seen in her process of making motorized fans at GET City. The impetus for this invention came from a desire to help her GG:

> My GG, she's a diabetic and she's so, so she sweats a lot. And so at church, she'll be like, "Jazmin, go back there and get me two fans." She has done this while singing! She'll be up there singing and then be like [arm motions] flagging me to go get the fans … So I'm like if I just get this [motorized fan], I wanted it to make it a necklace, but I'm not 100 percent sure on how that's going to work anymore, but I was going to make her fans so that she could keep it in her purse and I won't have to go all the way back to the back of the church to go get her a fan. Because I usually sit by her purse in church … plus it's like she doesn't have to worry about taking it back. And she could keep it with her here because she also has a fan in the canteen. And she usually has paper towels to wipe her face when she, like, she's always, she always finds something so that she's not too hot.

[2] The No Home Phone button was a programmed Arduino microcontroller – it called numbers stored on a SIM card so youth could communicate with their parents. It is described in more detail later in the chapter.

Jazmin began this process imagining a small necklace fan that could easily fit in her GG's purse but after her first prototype found that the fan blades needed to be much larger to create a meaningfully cool breeze.

To accommodate the larger blades, Jazmin made a heftier base from a water bottle. She stored AA batteries in the base of the water bottle to make it more stable and to ensure power was on hand for the motor. This system meant that Jazmin had a stock of batteries at various stages of being used. She soon noticed "… a lot of time the fan would be going and be really cool and then I'd notice … it wouldn't be as cold as it was before because the battery was dying." The dying batteries slowed the rotation of the blades, reducing effectiveness of the fan. Realizing she had not yet solved the puzzle she set for herself, Jazmin developed a new design that relies on solar panel power and is contained in a cardboard box. Jazmin's boredom building led to an appreciation of scientists as the creators of puzzles that have things "put in a certain spot for a reason" has helped her stay committed to this iterative design process.

Table 5.2
Jazmin's "Boredom Building" Fund of Knowledge and STEM-rich Making

Overview of funds of knowledge around "boredom building"	Making work enabled by this fund of knowledge
• Develops plans for inventions, • Iterative engagement with plans after attempting to enact building • Experiments with different materials • Figures out the "puzzle" of putting objects together	• Plan making supports iterative design (e.g., skeeball ramp) • Takes apart objects to understand making work (e.g., SIM card) • Works to figure out "puzzle" of fan pieces for her GG • Experiments with different materials for fans

Artistry

Jazmin is engaged and passionate about a wide variety of art forms. She tells stories of being younger, trying to impress her Big Dad (Grandpa) by sharing artwork where she colored in the lines, of working with her cousin who made beautiful pottery, of rapping in her uncle's

recording studio, and her mom teaching her dance moves. In the fall of 2018 Jazmin printed out business cards advertising her art work for sale and ability to paint commission pieces. Counterbalancing her public engagement with these many art forms, Jazmin also uses these activities as a way of tuning out an occasionally-chaotic world to relax and be herself. Jazmin brings the knowledge, skills and practices from these artistic pursuits to bear in her presentation of STEM-rich making projects.

Public and personal engagement. Jazmin's funds of knowledge around artistry encompasses painting, sewing, painting, dancing, singing, and instrument playing. Each activity is embedded within familial networks; her stories about these activities almost always feature support or advice from a family member. Pursuits that result in tangible products are often gifted to family members as presents that demonstrate both her skill and love. Activities that do not result in tangible products are still developed with family in mind – for example, Jazmin knows that being a part of the youth choir in church makes her GG happy.

Jazmin engages with these artistic pursuits both formally – through dance teams, talent shows, art competitions – and informally – dance offs at GET City, singing for fun in the car, painting for herself, etc. Across these different spaces, she appreciates the multiple ways in which this fund of knowledge can function. For example, she described the painstaking care and attention with which she would copy images over and over again to perfect her drawing. Slow and intentional drawing featured in drawing competitions with her cousin, Paris, where the goal was to copy an image as closely as possible:

> When we do draw at the same time if I finished before her, she'd be like, "Does that look exactly like the picture?" I'd be like, "It's close enough." She'll be like, "Do you think you can get it to look exactly like the picture?" I'm like, "Yes." She's like, "Okay then, take your time on it. You can get it to look a lot better." … You have to take patience when you draw, just so that you can get it to look as close as how you want to as possible.

Jazmin appreciated the need for this kind of practice and skill building, and credits it for her success in art competitions; however, she also calls upon these skills and practices toward more personally meaningful ends, too:

> … those [art forms] are my go to's when I'm like stressed, I'll be like, all right, well listen to this song, calm down, do this, this and that, or draw this picture to get your mind off this, this and that. Oh, don't you have this art piece? Don't you like the song? Oh, go write a new song about how you're feeling. You'll calm down.

Jazmin is able to call upon this fund of knowledge to multiple ends. Engaging in an artistic process is important to her not only in service of creating beautiful works, but also in helping navigate challenging situations.

Jazmin is able to transfer both her technical skills and larger understanding about the importance of artistry to her STEM-rich making work. She drew a direct connection between the need to "take your time … [and] figure out how you're gonna be able to do it" when learning to paint and dance, and the skills necessary to succeed in science, where "… If something goes wrong you have to be patient enough to be calm and think about what you can do to fix it". This dual focus of skill and patience can be seen in Jazmin's approach decorating her skeeball ramp; she was devoted to ensuring it looked like a professional grade game. She explained "I honestly wanted it to match like the games from actual arcades… So, I painted the balls blue because I knew the fact that at Chuck E. Cheese, they're blue." Developing the skeeball ramp required many patient iterations where Jazmin had to hold multiple elements of the project together at once: its structural integrity and how she could use her artistic skills to ensure its aesthetic communicated the authenticity she sought by modeling it after a specific arcade game.

Stylistic ownership. Through her artistic endeavors, Jazmin developed an appreciate for the role that style can play in sending messages. This style manifests in her art work and also in matters such as decorating her room, where she explained to me, "I like a lot of aesthetic stuff".

Using Pinterest, she shared a vision for her room, which included a polaroid camera ("they're so cool to look at"), lights, and strands of leaves. Jazmin calls upon her stylistic abilities to make decisions about how to best claim space as her own. In a similar way she is able to use this fund of knowledge to claim ownership of another domain she enjoys – engineering:

> …sometimes people would think science as in the first thing they'll think of is like chemicals and stuff, but then art and science is, like, pretty much engineering. And I really love art and, like, who doesn't want to make science look pretty? Like, especially when it's fun science – like … the circuits and how we did the arcade.

Here Jazmin was referring to a showcase event (part of the "arcade" unit) and a creation she developed on her own to support youth learn the basics of circuitry. She designed a series of circuits on a piece of paper (Figure 5.2) that tested knowledge of circuits by having someone first match a color on the left side of the paper to a correspondingly colored item on the right side. Aligning the positive and negative legs of the LED with appropriate pieces of copper tape on the left side, and the positive and negative sides of the battery on appropriate pieces of copper tape on the right side would complete and the circuit, lighting the LED. Jazmin shared this with younger members of the Boys and Girls Club, helping them by holding the battery on and talking them through the options for placing the LED.

Jazmin initially identified her main role in this event as a teacher; however, after some reflection she expanded that assessment, saying, "I was also like an artist and an engineer for that station for the [circuit] board — for me making that, so yeah!" Jazmin articulates a clear connection between being able to engage in artistic practices and being an engineer. The circuit board was important not only for the engineering content she was able to showcase, but because it showcased her skills as an artist – as someone who can make science look pretty and be fun.

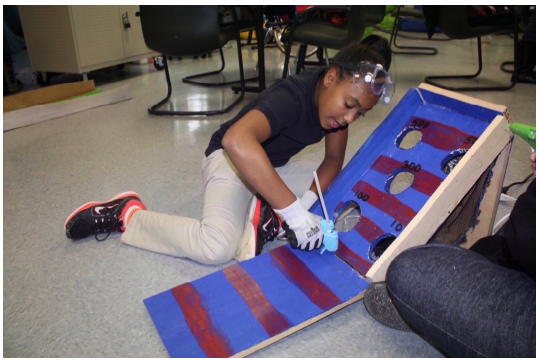
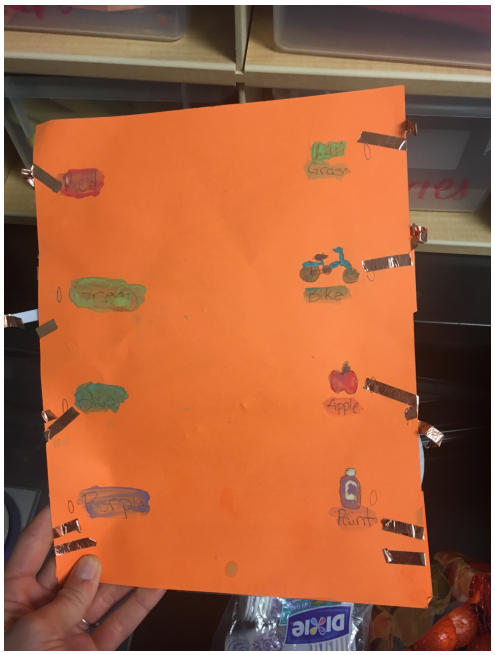

Figure 5.2, Photographs of Jazmin's skeeball ramp and circuitry design

Table 5.3
Jazmin's Artistry Fund of Knowledge and STEM-rich Making

Overview of funds of knowledge around artistry	Making work enabled by this fund of knowledge
• Drawing, painting, dance, singing -- participation is embedded in social networks • Care and attention to technical skill / performance • Public and personal use of artistic skills • Connects artistic style with uniqueness and ownership of spaces	• Skeeball design purposefully developed to imitate "real" skeeball games • Circuit board design – reflects personalization of STEM concepts through artistic additions

Babysitting

Being part of a large extended family Jazmin often becomes the de facto babysitter for younger family members. Though Jazmin now lives with her mom and brother, she still spends time with her father and her siblings on his side with whom she has enjoyed growing up – and – oftentimes, looking after. Through her time babysitting Jazmin has developed an awareness of safety and an understanding of how important the ability to communicate with adults can be.

Sense of safety. Jazmin has told me a number of stories featuring adventures where she is the delegated child in charge. These stories often feature descriptions how she conceptualizes

responsible care-taking. Describing a scenario at a hotel where her younger cousins wanted to play in the pool, her response was, “I'm the one watching all the kids, so I'm like, ‘I'm not taking any of you swimming’ - I don't want them to drown!” Recognizing the potential for a swimming adventure to turn dangerous, she was happy to redirect her cousins’ attention.

On another occasion Jazmin and her siblings were alone at their dad’s house and wanted to go to the Dollar Store but did not have a key to lock the door. Someone suggested they use bricks to prop open doors. Jazmin was concerned someone might see them leave and come into the unlocked apartment, so she decided to stay home, concerned for safety of the group. She explained, “I'm a scaredy cat. But I ain't scared to do stuff” – clarifying that she recognizes potentially dangerous situations but tries not to be intimidated by the danger, just to deal with it smartly.

This appreciation for safety directed Jazmin’s attention when she first joined GET City. As a fifth grade “special helper” she was joining groups already dedicated to solving community problems they had defined. She was immediately drawn to a group discussing youth safety issues. The members of this group presented her with the idea of a purse alarm, to ensure safety while walking different places. Jazmin helped steer them away from a mobile purse alarm (“a lot of people bump into you and it might set it off”) to a button that was permanently mounted on a wall and could serve to keep kids safe when they were home alone. She explained her rationale in helping shift the conversation:

> … nowadays some people aren’t as safe as they used to be because some parents do a lot of things that they shouldn’t, like leaving young kids at home that are, that aren’t old enough to watch their selves. And, or, who don’t have cell phones. So, I really wanted to help with this one [project] so that you could protect yourself while you're at home and it's easy to use.

Drawing on her own experiences and perceptions of safety and danger, Jazmin understands the concerns that youth who are home alone might have. She saw this project as an opportunity to help them feel protected.

Communication. As a result of her time spent babysitting, Jazmin recognized there are circumstantial factors that influence her ability to act responsibly. She explained a scenario that many youth face:

> Even though, even though we always have our cell phones, but not all the time, like, my phone is on. 'Cause, like, if my phone was to go off, we'd have to wait to get the money to pay for my bill. And so, my dad was - he said he's gonna pay it next time … even though some people have unlimited minutes, it's still- you have to pay. You have to pay for having your phone, 'cause they can shut it off and it will shut off if [...] so we try to keep my minutes, um, on as much as possible.

Jazmin understands that simply having a phone does not necessarily mean she can communicate with it if the monthly bill has not been paid. Although Jazmin and many of her friends can make use of internet-based apps (such as Text Now and Facebook Messenger) to communicate when their phone service is off, access to wifi is not guaranteed and can mean youth are unable to contact adults. Additionally, she noted that few people have a home phone line, which resulted in the name of their invention: The No Home Phone button.

Jazmin shared that having a No Home Phone Button would have been useful in her own experience as a younger child left alone and in charge:

> … my dad sometimes has to go to the store and he doesn't have a car and doesn't wanna, like, have all of us little kids walking to the store. And sometimes he would just have us stay at home and not open the door for anyone and he'll make sure he has his keys and make sure everything is perfectly fine before he leaves. But once when he left, um, one of our brothers accidentally "fell" … and [laughing] got hurt… And so, if we had that [the No Home Phone Button] it would've been a lot easier, so we could call my dad, because none of us had a phone and the oldest person there was six, or seven, so, we definitely needed that.

The "falling" incident she referred to occurred from sledding down stairs and the injury was not severe; however, Jazmin recognized this scenario as representative of the kind of incident that

warrants parental involvement. Her focus on communication with parents was specific. Adults in GET City suggested that the No Home Phone Button be programmed to call the police in case of emergency and Jazmin staunchly defended the position that communication with family members was most important, reflecting a preference for and reliance on family networks over forms of authority that are traditionally understood to align with dominant systems of oppression.

Table 5.4
Jazmin's Babysitting Fund of Knowledge and STEM-rich Making

Overview of babysitting as a fund of knowledge	Making work enabled by this fund of knowledge
• Responsible for the safety younger family members • Appreciates the role of communication with adults as part of being responsible	• No Home Phone Button – the focus on communication and safety • Understands potential fear of youth, need for button, focus on contacting parents

Discourses Informing Jazmin's Funds of Knowledge and STEM-rich Making

Spending years with Jazmin and working closely on this project, three Discourses rose to the surface in meaningful ways during our conversations about her funds of knowledge. In the sections that follow I discuss how her independence, her focus on being recognized as a "good influence" on others, and fierce advocacy for the well-being of those she cares about. These Discourses cut across the ways Jazmin has developed and leverages her funds of knowledge, and the ways in which she navigates our makerspace culture and making projects.

Independence

Jazmin is proud of being able to accomplish things for herself as a way of supporting those around her. She has learned a lot about forging an independent path by watching her mom, who balanced becoming a nurse with raising two young kids alone, determined they would participate in any and every extracurricular activity they desired. Jazmin took note, explaining, "I had to figure out how to help my mom help me." Jazmin has taken on the responsibility of

arranging rides for herself and her brother, so her mom does not have to worry about getting her to different places with a busy work schedule. Jazmin set up a whiteboard at home to ensure everyone is on the same page about appointments and rides.

During one of our conversation groups, Jazmin's mom called to ask why she was not at a hair appointment. Jazmin was in tears that her mom had not checked the white board and moved this appointment to a time we were meeting. Although Onie (who was meeting with us) and I were not worried about the conversation group and offered to take her to the appointment, Jazmin was upset that her system had been ignored and felt her mom was unjustly frustrated with her. I mention this only to reiterate the importance Jazmin places on this Discourse being recognized and respected by others, and to avoid implicitly adultifying her (Epstein, Blake, & González, 2017). She is young person working to do big things to support her family, but it is important to recognize she is still a teenager, navigating a world where her agency and power are still easily mitigated.

Jazmin's Discourse of independence has influenced the development of her funds of knowledge; for example, Jazmin's boredom building has manifested as a form of independent preoccupation that is often undertaken for the good of her family (e.g., the cookie-canister tissue box). Similarly, her approach to engaging with her artistic funds of knowledge as a way of calming herself down in the midst of family turmoil aligns strongly with this Discourse of taking care of herself.

"A Good Influence"

Jazmin has a clear vision of how she would like to be perceived by others and what kinds of behavior she wants to maintain to be understood as a "good" person. She explained that from school to the Boys and Girls Club, at GET City and at home, adults expect her to be responsible

and a leader – a positioning she embraces. Jazmin often talks about being a "good influence" on other youth at the club, at school, and in her family – an attribute she connects to her intelligence, rule-following behavior, and leadership. By embracing this role, Jazmin has cultivated an understanding of herself as a high achiever who is capable of managing challenges.

Jazmin works to present herself in ways that beget success for a young person with ambition, intentional in the way she showcases her funds of knowledge and creates opportunities to continue developing them. For example, she recently printed business cards that advertise her art for sale and offers a price range for commission pieces. These cards are kept at the sign in desk at the Boys and Girls Club for parents to pick up. She welcomes conversations with parents, who are often impressed with her motivation, and she has told me about a number of canvas paintings she has completed since beginning this venture.

Similarly, in GET City Jazmin will proudly and publicly display her plans for other groups to see and emulate. She welcomes both compliments and constructive dialogue about her designs – pushing her thinking and future skill set. Babysitting also represents a body of knowledge and skills that Jazmin cultivated by presenting herself as a person who is "mature" and "responsible".

The ways in which Jazmin navigates being part of the makerspace is influenced by this Discourse. She is happy to call upon her participation as confirmation that she is the kind of person who could build fun things and would be a successful engineer:

> I was, like, proud of myself [for constructing the skeeball ramp] and my mom, my mom takes -- my mom kinda thinks that I'm the leader, like literal leader of GET City, which I let her think that cause I am the leader of some things and it um, so I would rather her know this as me being a leader but I think my mom just brags about me a lot, and so she brags about me and my brother a lot… so she always is like um saying how good of children we are and so, um, I really like telling her stuff about GET City.

Jazmin appreciates her mother's praise as proof that she is successfully engaging in this Discourse, and motivation to continue. She is happy to contribute evidence that supports this image of her as a "good" child who is a leader in GET City.

Advocacy

Jazmin is surrounded by thick networks of support and love made up of individuals dedicated to pushing and pulling each other to new opportunities. The Discourse of advocacy embodied in these networks have helped Jazmin become part of a wide variety of activities, including GET City. Jazmin describes her entrance into GET City as a "set up" orchestrated by her GG – a practice frequently enacted by her family members. Jazmin explains that her GG (who we know as Granny) called upon her relationship with GET City mentors to forge an introduction with Jazmin, telling each party that the other was looking forward to Jazmin's joining GET City:

> I wasn't old enough to be in GET City but um, well I really wanted to be in a science program at the time, GET City and Robotics were the going around the same time. Robotics was for my age group, GET City wasn't… So, my GG was like, "Oh yeah, some people in GET City want to meet you, they've been begging for you to come to GET City." I was like, "Oh really? Okay!" And she introduces me to everyone and I'm like, "Oh cool." And then Whitney goes, "So I hear you really wanted to be and GET City?" And I was like, "What? I never said that." She was like, "Oh Granny said that you really want to join GET City." I was like, "She told me that you really wanted me to." She was like, "Huh, well you're here now!" So I was like, well I'll see what it is and if I don't like it, you know, I'll leave. I ended up liking it.

This kind of advocacy on behalf of others is an important part of how Jazmin understands caring for others. She has described this familial Discourse in her mom's actions, too. For example, her mom managed to advocate on Jazmin's behalf to get her into an engineering program at her new school although "she said it was rare to get".

Jazmin has taken this Discourse to heart, working to facilitate connections to secure activities for her brother that she thinks would be helpful for him. She described bringing him to

a local science museum Youth Action Council meeting, hoping he would like it and find his own foothold in the group. Having seen this Discourse open opportunities when enacted on her behalf, Jazmin wanted to advocate for her brother to be given similar opportunities.

This Discourse has impacted the development of Jazmin's funds of knowledge in a variety of ways. Several family members have supported her developing funds of knowledge around artistry. Most recently Jazmin's mom took her to a youth start-up event where Jazmin showcased her art business. Her mother was persistent in bringing judges over to see Jazmin paint, collect business cards, and talk with her about expanding the reach of her business.

This Discourse of advocacy also influences how Jazmin considers the audience of her making work. In 2017 she worked with another GET City member on creating an app that was intended to support homeless shelters. Their initial vision was to enable a connection between homeless shelters and people who might want to volunteer, using the app as a way to communicate opportunities to donate goods and time (it was appropriately called the "Donator" app). After meeting with a local homeless shelter, Jazmin pushed to include a more humanizing aspect of the app. She wanted to share stories of homeless individuals and expand awareness about situations that can lead to homelessness. Jazmin explained that the app was in part a way to ensure that the people using it become less "ignorant" – working to advocate for a group of individuals she was increasingly aware were being victimized unfairly:

> … We're trying to pretty much stop people from blaming them [homeless individuals] because a lot of people are really hurt by that. The fact that everyone's like, "Well you should have never did this, this and that. Maybe you'd have a house."… But even still, we're trying to make it where it's like not every -- make people see that not everyone was on drugs or an alcoholic or did this, this and that to become homeless. Some people were sick, couldn't afford it. Some people got put out, like, it's not everyone's fault.

The Donator app is a reflection of Jazmin's dedication to advocacy. Working to reverse deficit narratives about homeless individuals echoes a set of beliefs that have contributed to her own well-being: people must work to advocate for others when in a position to do so.

Connecting Pieces

Onie's Discourses not only inform the development of her funds of knowledge but influence how and when she calls upon them in her STEM-rich making work. Onie's Discourses influence how she navigates GET City and created space for her to leverage her funds of knowledge. This concluding section describes these connections and relationships. See Figure 5.3 for an illustration of these relationships and Table 5.5 for a summary.

Supporting Navigation of Makerspace

Jazmin's Discourse of independence informs how she engages in makerspaces, particularly in terms of how she approaches working with others. This Discourse was developed a way of supporting her mom, so she views being independent as a helpful to others as she explained, "Hey, if I work on my own, if I'm not here then no one else has to suffer with me not doing it. That means I'll easily be able to take it [a project] home if I have to fix it." Not wanting to frustrate or hold back team members with her occasionally-haphazard attendance – and likely happy with the idea of being able to take a project home by herself – Jazmin very rarely elects to work in groups.

Jazmin's ability to take care of herself and focus on specific tasks at hand has left her with limited patience for working with youth who are unable to match her abilities. Her preference while making is to work alone, something she knows about herself and easily explains that it is "… 'cause I just like being able to be in control". It was with great frustration that she shared a story of a making experience where she was unable to be in control and work

independently. Jazmin had been forced to work with two partners she deemed inept, as they did not listen to her or share her vision for how their making goals could be met.

Jazmin's focus on being a "good influence" is rooted in a sense of responsibility and care for those around her. She understands being perceived as a "good influence" engenders trust. She wants to be known as someone who is here to "help the community and trying to really help out and make the world a better place… when people hear that I made something, they can trust it. Because of who I am and how people know me." Jazmin is intentional in "how people know" her because she understands the importance of being trusted by the community her STEM-rich making work is geared toward.

The Discourse advocacy can be seen in Jazmin's navigation of the makerspace – she is strategic in placing requests that we allow non-GET City members in to support her STEM-rich making work. For example, while filming a commercial for the No Home Phone Button in 2016, Jazmin ensured her younger cousin Le'Asiah was cast as the star of the commercial.

Creating Space to Leverage Funds of Knowledge in STEM-rich Making

Jazmin's Discourse of independence means she is often able to open up space for leverage her funds of knowledge by virtue of working alone; this comes to bear most in how she calls upon her funds of knowledge around artistry. She spent many sessions perfecting the look of her skeeball ramp, wanting it to look professional and fun. Similarly, because she elected to work alone at the multimeter station during one of the showcases, she was able to design a glamorous sign that advertised "Multimeters with Jazmin!"

"Being a good influence" opens space for Jazmin to showcase her funds of knowledge around building, sharing what she has worked on and engaging in conversations about what next steps she might take. Proud of the work she has developed; she will often put up her plans for

others to see and work to emulate. As others suggest designs or pose questions, she adds to her funds of knowledge around building.

Jazmin's Discourse of advocacy has directed her attention to STEM-rich making work that focuses on supporting others. Jazmin generates ideas about how to respond to a problem by calling upon her lived experiences and funds of knowledge – for example, she came to GET City motivated to take care of her GG by developing a fan. Her drive to take care of her GG's needs paved the way for her to engage in building, experimenting with different materials and designs.

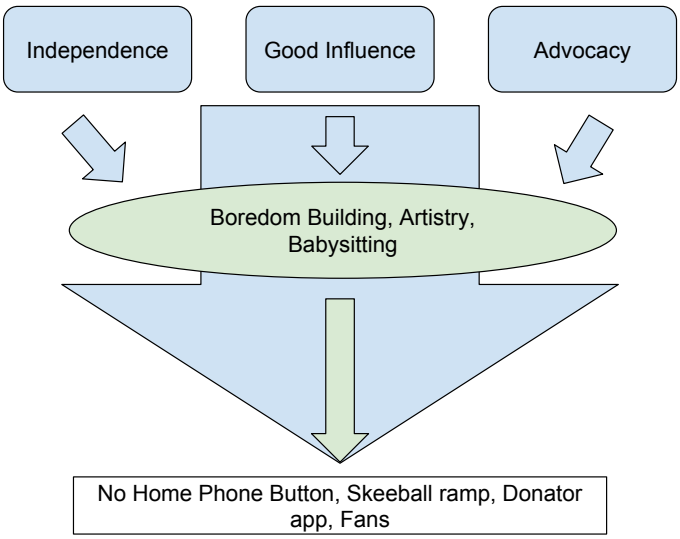

Figure 5.3, Model of Jazmin's Discourses, funds of knowledge, STEM-rich making

Table 5.5
Jazmin's Discourses, navigation of makerspace, funds of knowledge

Discourse	Influences on navigating makerspace	Creating space for funds of knowledge
Independence	Avoids challenging group dynamics by shouldering entire projects	Working alone allows her to center her **aesthetic preference** and call upon her funds of knowledge around **artistry** in presenting making work
A "good influence"	Wants to be known as a maker who is trusted by the community	Works to highlight accomplishments publicly (plans, projects) and receive feedback, improve **building** plan
Advocacy	Cultivates strategic invites to makerspaces	Calls upon this discourse to leverage **building** for others (e.g., GG's fan)

CHAPTER 6

RAERAE: HOW CAN YOU GIVE THEM ALL LOVE?

Introducing RaeRae

RaeRae joined GET City when she began sixth grade at Great Lakes Charter Academy (GLCA). She was encouraged to join by her older brother's friend, Samuel, who was serving as a teen mentor at GET City. RaeRae was excited by the hammers, tools, and workbench area in the newly developed makerspace. During her first year (2016 - 2017) she built a tall, glittery marble track which still commands attention and complements. She also spearheaded a "homeless dog" rescue bag– a project that continued through the following year. An overview of her projects and time in GET City can be found in Table 6.1.

As a member of GET City RaeRae would bring friends in to work with her on her STEM-rich making projects – several of whom became GET City members themselves. She took seriously her role as an ambassador to GET City, inviting siblings and friends to see her projects and participate in showcase events.

Table 6.1
Overview of RaeRae's STEM-rich Making

Years in GET City	STEM-rich making
2016 - 2017	Marble track, dog care bag
2017 - 2018	Dog rescue bag

RaeRae's Funds of Knowledge

RaeRae and I worked closely together throughout her time at GET City. I was often the mentor who supported her group's work and she requested that I conduct her mid- and end-of-the-year artifact interviews that all GET City members completed. As a result, I became well aware of RaeRae's interests and expertise around dogs and building. RaeRae's fund of

knowledge around “looking cute” evolved throughout this time. Each of these funds of knowledge and its relationship to RaeRae’s STEM-rich making is discussed below.

Dogs

In January 2017, GET City members began brain storming how they could use their STEM knowledge to help the community, RaeRae steered her group to consider the plight of “homeless dogs” in the community. Although her partner was willing to go along with this, the two youth makers held different perspectives on the problem. When they were asked to consider what specific challenge they wanted to address, RaeRae thought about challenges from the dogs’ perspectives (dogs without homes face “people” and “starvasion” [sic]) and her partner approached the topic from a person’s perspective (dogs without homes “attack” or “might come into your house”). RaeRae’s empathetic perspective helped shape her group’s development of a fashionable dog care kit. In the following sections I share how RaeRae’s funds of knowledge around dogs came to bear on this STEM-rich making project.

Caring for dogs. RaeRae’s understanding of what it means to take care of a dog developed through experiences with family dogs. RaeRae’s dog, a Yorkshire Terrier named Roxy, is one of her favorite family members. When we were listing important family members during conversation groups, RaeRae ensured Roxy was prominently featured. Across the three years I have known RaeRae, she has been dedicated to learning how to manage being a dog owner. She explained,

> My dog - Roxy, she cool. She chill. But when she get outside, it's a whole different Roxy. It's all different one. She don't pay no attention to you. She will look at you. And then start running again. Or start, like, digging again.

Navigating attention spans, outside, and inside behavior has been a challenge. RaeRae elaborated on some of these frustrations, saying,

> … I would walk her for hours and we come back inside and she pee right on the floor so I be like, "I'm not gonna walk you. I'm not." But I do walk her, I do when it's nice - if it's like it is now on the weekend, I'll probably walk her today actually.

Despite the annoyances that accompany bathroom training, RaeRae remains devoted to Roxy's needs and a dedicated owner; there are many photos of Roxy on RaeRae's phone.

RaeRae's understanding of what is needed to take care of dogs is reflected in her fashionable dog care kit – officially titled the "Diamond Dog Kit." She explained the idea to the Director of Ingham County Animal Control, saying,

> We gon' put, like, a lot of materials in there, …with like food in there and we gon' put bandages in there… Like if you see a dog on the street or something and it's like, really hurt, you could, like, bandage it up.

This vision reflected RaeRae's concern for animals who might be hungry and hurt – indeed she had started off by proposing the kit include medicine. She and her group members were eventually convinced by the Director's concern that they should not directly attend to animals they did not know. The contents of this care kit therefore shifted by the time the group submitted an application to a local entrepreneur start up competition. There, they explained that the kit would include "dog food, a small water bottle and a pop-up bowl, a blanket/towel, and information on who you should call and what you should notice about the dog so Animal Control can best help it." The group thought this was the best compromise possible, still offering some aid to hungry dogs who needed help but respecting the need to keep their distance.

Despite having to shift her vision from directly helping dogs to calling Animal Control, RaeRae's concern that dogs should not be hungry drove several design features of this kit. Knowing that dog food has a distinctive odor and that dogs are well equipped to sniff out food, RaeRae worked on developing a smell-proof pouch to hold the food (see Figure 6.1). Hot gluing material together in a size small enough to fit in the whole Diamond Dog Kit purse, RaeRae

lined the food pouch with a shower curtain she had found in the materials drawer; her theory being that the thick, water-proof plastic would prevent any odors from escaping the pouch. After making this smell-proof pouch and filling it with dog food, RaeRae took it all around the Boys and Girls Club, asking staff members and other youth if they could smell anything in it. The results delighted RaeRae. No one guessed there was dog food inside.

Figure 6.1, Photograph of RaeRae's smell-proof dog food pouch

Loving dogs as community members. RaeRae draws on her experiences with dogs to demand high quality care from dog owners. She described the woman who sold Roxy to them "… had to check our house and everything! She lived in Detroit, so she had to drive all the way here to check our house to give us a Yorkie…. That's why I liked her so much." This helps show how RaeRae understands the treatment of dogs as a reflection of the person. RaeRae knows that such care is not always given to dogs; she has family members who breed dogs and called upon those experiences when she pointed out, "People just breed to get money and don't even care about the dogs." Unimpressed with those priorities, RaeRae does not think much of dog owners who do not demonstrably love their dogs.

RaeRae conceptualizes “caring” for dogs as both loving them and working to actively help them. During her meeting of the Ingham County Animal Control director she very pointedly asked him, “How do you give the dogs love? Like, it's like a lot of dogs. So, like, how you can give them all love?” Not terribly satisfied with his answer, RaeRae continued, pressing him about the ability of dogs to have beds, and get out of their cages if they want.

During a community feedback event where RaeRae was presenting the Diamond Dog kit, someone suggested that she include “… a collar for a choker thing - that made me mad. And the other thing, I like this one woman 'cause she said dog treats have vitamins.” Preferring the feedback from the person who prioritized the needs of the dog rather than the perceived need of safety for people, RaeRae demands a high standard of treatment and concern for dogs. This high standard of treatment is reflected in what she did (and did not) include in the Diamond Dog Kit.

RaeRae calls upon GET Citians and community members alike to help dogs who don’t receive care: “Y'all love dogs? Then help dogs. Don't be like ‘Oh I love dogs.’” The level of thoughtfulness and advocacy RaeRae demands from those who have dogs is also seen in how she positioned her project as responding to a social justice issue, the theme of GET City projects in the 2016 – 2017 year. Understanding that when “dogs don’t get the love” it is unjust and unfair, RaeRae is dedicated to ensuring the needs of dogs who need love are prioritized

Table 6.2
RaeRae’s Dog Fund of Knowledge and STEM-rich Making

Funds of knowledge around dogs	Making work enabled by this fund of knowledge
• Understands how to take care of dogs, what they need: food, water, vitamins, bed • Knowledge of the properties of these things (e.g., food is smelly) • Empathetic conceptualization of caring for animals – includes love and action on their behalf • Understands dogs as members of the communities with equal needs	• Conceptualization of Diamond Dog Kit • Decisions on items it contains • Development of smell-proof food bag. • Interview with Ingham County Animal Control Director

Building

RaeRae is an active person – she enjoys building and using her hands. She is the first to admit that waiting to begin a project is a challenge for her. She explains, "I like to build and, like, make stuff and get right into it and what I hated was to wait and wait." The knowledge and energy RaeRae brought into GET City about tools and building was, as she recognized, occasionally at odds with the tension of having to "wait and wait". This impatience is due in part to a recognition of the empowering potential that can accompany being able to build, and a wish to drive her own agenda. Constructing, exuberance, and agenda building – and their relationships to RaeRae's STEM-rich making work are discussed below.

Construction. RaeRae has long enjoyed building structures using various materials. She mentioned "…What I used to do, I used to take my mom's shoe boxes and I used to tape them up and try to make something out of it." Although she has moved past constructing with shoe boxes for her own enjoyment, she has brought this pastime as a way to keep her mom's boyfriend's godson occupied when she has to babysit him. RaeRae's had learned about some tools and building concepts from her Papa her Grandfather ("I didn't really used to use power drills and stuff like that. Like to play with my Papa, I used to nail and stuff like that") and she was excited to join GET City and learn about more these tools he used. She explained,

> I wanted to join GET City because, like, mostly, my Papa used to work on stuff, like cars and stuff, building stuff, but I didn't know what was a hammer, like what it was used for – well I did [laughs] but I didn't know what those tools and stuff was, and I always used to ask him.

RaeRae's experience of spending time with her Papa helped provide an access point into work with the tools in GET City. She declared when she first came into the makerspace, she realized she had a lot to learn:

> I was like, 'What is this, what is this?' [referring to tools in the makerspace] … I just started takin' them off and, like, doin' something with it – but I didn't know what it means or what it was, so I just started using it the way I think it was, and then I started getting 'what was it' …. I can find out tools – like I never knew exist.

Recognizing RaeRae's interest and experience with tools, mentors were able to help extend her interest and related skills in building. RaeRae used the tools we had available in GET City to construct a marble race track which still stands tall and attracts interest from Boys and Girls Club member today. The structure is a an almost eight-foot-long ramp with a pipe insulation track held up by tall support (see Figure 6.2).

RaeRae was excited to "show our stuff off" at the showcase event where GET City hosted youth at the Boys and Girls Club, inviting them to come play with the games that had been created. There, she told the younger kids that GET City is a place where you can "use power tools, and you could make anything you want to and could help out people." She later added, "…some people don't like to use sharp stuff because they think they gon' cut themselves. And some people just don't like to be building stuff like I do..." RaeRae moved from previously identifying herself as not "the tool girl" to positioning herself as someone who can help others. She now makes it clear she is not only capable of building, but likes to build, and can help others figure out how to use tools they might be afraid of. This is a powerful example of how makerspaces can support youth in positioning themselves as experts in their interests.

Exuberance. Although RaeRae enjoys building, she is occasionally frustrated with the time required between thinking and doing. She explained "'Cause it's so -- first of all -- when you build stuff, I just like to like, [claps hands] just start doin' stuff with my hand and then, I just like to break stuff to get that energy out." RaeRae would find ways to get her energy out during conversation groups by cutting various materials (tubing, paper) and occasionally asking if she

could break items in the room. It was with great glee that she shared her ability to let loose on a house that her Papa was working on.

> My other Papa, he flips houses. So yeah, so I would always ask him can I go over there and break stuff and he'd be like 'You can't do that. It's not like that' but he finally let me broke something! I was so happy, I was wreckin' so much stuff. Because I guess they was tearing that house down because it was so old and nasty, so they - he let me break things and I was like 'YES!!' I liked it - the sink tile - I liked it, it was pretty, but it had to GO! So, I broke that, and I broke a wall and I tore down a door. But one of the doors did not like me, it was like 'I'm stayin' strong.' I could not break that door at all. I was throwin' hammers at the door, it was so fun.

This experience was clearly powerful for RaeRae. She took pleasure in recounting this story and re-enacting her fight with the door; she clearly appreciated the immediately gratifying impacts of her own strength. RaeRae appreciates being able to take immediate action and throw her full energy and abilities into something. This approach was occasionally at odds with the goals she set for her projects at GET City, something she realized about herself:

> We would just, like, be doin' stuff and we really didn't, like, think about it - we would just be cutting stuff and not writing it down because we wanted to get right to it. So, um. We was just like doin' stuff and we'd find out it didn't work and we had to start over and measure and everything and do that kind of stuff.

The desire to "get right to it" was occasionally counterbalanced with frustration at having to return to re-do certain parts of their project. Measuring and "writing it out" were making practices that stood at odds with RaeRae's desire to jump into building. RaeRae is certainly not the only youth whose enthusiasm for building leaves limited time for planning and measuring as we ask it – this is often a tension in GET City. While detailed planning was never a practice she fully embraced, she did become more patient with certain aspects of the group building process. She explained,

> You gotta do a lot of talking, 'cause if you don't do a lot of talking you don't know whatchu gonna do. First, when we started off, they was talkin' and talkin' and I was like, "When do we get to the point of this?" And then when we got to the point I was kinda

> lost, but then I was rememberin' what they was sayin' and like, "Oh yeah! We gotta write our stuff down and everything like that" and then we could start makin' our track.

RaeRae's recognition that talking and planning can help with building offered another way for her to call upon her knowledge around building and expand her skills. This can be seen in the construction of the loop RaeRae proposed they add to the track. She and her group members experimented with a variety of different sized loops but then someone "immediately hot glue it on and when we put the marble in, it didn't work. It went back down. So we had to, like, re-do it and we had to measure how far the loop was and how steep we need it – yeah how steep we need it." Moving from an informal inquiry to a more organized, systemic exploration of loop effectiveness helped RaeRae call upon her knowledge materials (what would help hold a loop up) and building-related physics (loop steepness).

Building as a practice that enables freedom. RaeRae has an expansive vision for what her ability to build could enable. She would watch her Papa create things, telling me, "he always like, makes stuff and now he's making a ramp for my grandma 'cause she's in a wheelchair now." RaeRae understood that building enabled a kind of freedom that she might not otherwise be able to have. She declared "I know how to do stuff now, so my mom can trust me to do, like, build a thing for my room." RaeRae knew being able to build was part of gaining "trust" and as a way to achieve her own ends - making things for her room. She also framed it as a skill she can use to support the happiness of others, telling me "… for Christmas [presents] I'm probably just gon' take some of his tools and just start making stuff."

RaeRae's understanding of how she can build toward her agenda and ends can be seen in the reason she wanted to make a track. She explained,

> Because they don't, like, really make racetracks for girls but they always make 'em for boys, and my brother has a lot of them, and be like "That's for boys not for girls" and I

> try to, like, take it out of his room so I could play with it once and a while, but it never works out.

The injustice of boys having access to race tracks but not girls inspired RaeRae to construct the largest arcade game in GET City. She took clear and concrete steps to ensure the track's décor reflected her intended, feminine audience. RaeRae intended the glitter and paint to be clear signs that this was a race track for girls, because when "they build a track for girls or things for girls, [it is] like in a boy way." Pushing against the lack of tracks available for girls and the aesthetic of the few "boy" items that were given to girls, RaeRae determined glitter to be the answer.

RaeRae not only made something for herself and her peers she felt was missing, she also appreciated being able to take ownership over the process of making it. She said, "I liked to show off and be like, 'I made this.'" Being able to point to something that required power tools, a clear skill set, and patience to build was important to RaeRae. She reflected on how building helped her develop a sense of dedication by explaining, "I'm a hard worker because this little thing can grow into a big thing and, like, I could like, make a smaller thing and the next day it's like a huge big thing." Knowing she can build "huge big" things is statement of confidence and ability that demonstrates the importance that building holds to RaeRae, and the possibility she understands as inherent in these set of skills and knowledge.

Figure 6.2, Photographs of RaeRae using the jigsaw and with her track. *(L) RaeRae using the jigsaw (M) posing by the track with friends (R) the final, glittery product.*

Table 6.3
RaeRae's Building Fund of Knowledge and STEM-rich Making

Funds of knowledge around building	Making work enabled by this fund of knowledge
• Builds for self and as a babysitting tool • Learned from her Papa's tools and projects • Immediate gratification of seeing her impact (both in building and destroying). • Building can help others and help her achieve her own ends	• Learned about using tools, knows how to teach others • Confident in showing off constructions • Learning to balance urgency and planning • Building helped RaeRae achieve ends of her own choosing – making a track specifically for girls

Looking Cute: Black and Proud

Although RaeRae behaves differently in different spaces - as will be discussed more in the *Discourses* section of this chapter - she has a clear conception of how she wants to look that remains consistent across the spaces she navigates. She learns about hair and makeup as a way of staying in up to date on styles, and she and works hard to cultivate a message of independence with her fashion choices. The attention she pays to style and the importance she places on it can be seen in both her personal aesthetic and the level of detail she brings to her making work. Each of these elements are discussed in the following sections.

Styles and independence. Across the three years I have known RaeRae, her interest and attention to cultivating her appearance has evolved. Her desire to master doing hair and makeup reflect the social and cultural context from within which her funds of knowledge about beauty are grounded. She declared, "I am Black, and I am proud… It take me 24-7 to do this hair. For real. It take me a whole day." RaeRae takes great pride in her looks and is explicit about what she thinks is beautiful and the challenges associated with obtaining those looks.

RaeRae researches different looks to decide how her own style should evolve. She explains:

> I use Instagram to basically follow people or like if I'm trying to look up hair styles, I just click it, hair styles … [then] hair styles or feed-in braids be popping up. Or I'll - I got two accounts, one of my accounts is just to like follow people.

RaeRae has an entire account dedicated to following hair and make-up trends which she does not post any pictures on. When I asked if she tried out the makeup or hair styles she clarified, "I look it up and stuff, but I don't really do makeup" and "I haven't been trying them out, but it's like weave… and how to do sew-ins and stuff." Being on Instagram is not just about enacting cute styles, but of keeping tabs on different groups, stylists, and influencers whose styles she wants to watch.

RaeRae's interest in these styles extend beyond her own looks; she wants to go to school for "hair and makeup." However, as she said:

> I wanted to go to hair school but you paying just to, like, dye hair and I don't want to dye hair I wanna braid hair. And stuff like that. But they don't teach that. So what's the whole point of going there?

Recognizing that cosmetology schools are largely geared toward serving the fashion needs white women, RaeRae has limited interest in paying to go to those hair schools.

Part of RaeRae's desire to cultivate specific hair and makeup looks come from a desire to be taken more seriously. She explained (with full air quotes) that her mom stands as a gatekeeper to her fashion choices: "When my mom started letting me be "OLD ENOUGH" she let me start doing more stuff and like, wear these sticky things [fake eyelashes]." RaeRae appreciates the ability to "start doing more stuff." Unfortunately, being able to cultivate an image that reflects how she wants to be seen does not necessarily correlate to being treated "old enough" in the ways she would like. She shared frustration at her mother's boyfriend's attempts to treat her in a way that she deemed juvenile and disrespectful:

> He like, oh my God, he tries to act like my father in the same way he be like, "Oh, I'm not trying to act like your father," but he be telling me what to do. Or he'd be like - oh!

> Because I had these eyelashes on, I walked in the house and he was like, "Oh, you gotta take that off." And then he told my mom, but my mom, she paid for me to get them done. So how you tell my mom that I got eyelashes on and we both got them done at the same time and then... Ugh, he just be getting on my nerves.

RaeRae's annoyance with parenting attempts that do not reflect trust or respect is clear in this quote. RaeRae is thirteen but looking forward to a future where she will be able to command respect as an independent adult. She is looking forward to being eighteen when she will be able to get her own apartment.

Fashion aesthetic. Looking through photos of her time at GET City, RaeRae can identify the year and season by looking at her clothing. Given that she is in a school uniform for these pictures, her clues come from shoes, coats, and hair styles. One of the only ways she and other students at GLCA were able to assert any ownership over their appearance, shoes matter a great deal. During early conversation groups, RaeRae and AnDreya spent a great deal of time talking about Jordan's and the importance of matching each other and other family members. Indeed, the most redeeming quality of RaeRae's mother's boyfriend is that he buys her shoes. She shared,

> He brought me three pair of shoes. Yeah - three pair of shoes. It was Vans - okay. It was Vans first of all because he don't like Jordan's or Nike, but I made him pay for one Jordan's and then the rest of them, the other two was Vans.

RaeRae has a definitive taste in shoes – wearing Jordan's are a symbolic fashion choice that send a message about who she is (Smith, 2018).

RaeRae's eye for detail and recognition that fashion choices send messages translates to her making work. This fund of knowledge can be seen in her demand that the race track she built have glitter. This track that was built specifically for girls so that they could have access to toys normally designated and designed for boys – the glitter made it "pop" and helped her achieve the aesthetic she needed. GET City mentors had to take special precautions and promise care in paving a path for the track to be decorated this way, as the Boys and Girls Club leadership was

concerned about the mess glitter can cause. RaeRae declared, “The most special thing about my race track… the glitter. I really like the glitter.” She determined the aesthetic of the track to have contributed to the success of the event, reflecting, “I think the girls was impressed by it because it was so glittery.”

RaeRae’s eye for fashionable aesthetic also came bear on the many iterations of the dog purse she and her group members created for their Diamond Dog Kit. RaeRae declared immediately

> And for girls we gon' make them a little purse because nobody wanna walk around like, with dog food and stuff like that. So we gon' make a little purse and then for the dudes we gon' make, like a carrying bag.

RaeRae understood the importance of fashion and looking cute to was connected to the fate of her project. She began by making pouches of single pieces of material that were folded, not quite half way, and the seams hot glued together. The group’s first full prototype involved several separate pieces of various material cut out and hot glued together. The handle was made of pipe cleaners and duct tape. Utilitarian, but not meeting RaeRae’s standards of beauty, RaeRae was insistent they try again and learn how to use the sewing machine. Using a pattern and pinning pieces together, RaeRae was very pleased with this next iteration. Still, as we were having conversations for this dissertation study, RaeRae asked if we could make another, improved version. She understood that for her idea of a dog rescue kit to come to full fruition, it would need to be housed in a bag that was so fashionably put together it would really be used.

Figure 6.3, Photographs of RaeRae's iterations of the Diamond Dog Kit. *(L) the first prototype of the Diamond Dog Kit. (R) The final version made using a sewing machine.*

Table 6.4
RaeRae's "Looking Cute" Fund of Knowledge and STEM-rich Making

Funds of knowledge around "looking cute"	Making work enabled by this fund of knowledge
• Cultural pride and references in how she conceptualizes beauty and style • Uses Instagram to research looks • Sends messages about identity ("proud and Black", Jordan's, being old enough) • Attention to stylistic detail	• Dedicated to the appearance of the dog bag, learned to sew to enhance aesthetic • Made track glittery so it would "pop" and ensures intentional message of femininity

Discourses Informing RaeRae's Funds of Knowledge and STEM-rich Making

Over the three years we spent together, RaeRae spent a lot of time and energy navigating and learning how she wanted to present herself in a variety of different settings. These Discourses represent social languages and ways of being RaeRae developed to reflect and protect her identity in two markedly different settings. In the sections that follow I share RaeRae's presentation of these social identities at the Boys and Girls Club where she is "feelin'" herself and at her new school where she works hard to resist participating and ensuring "nobody knows I exist." Informing each of these Discourses, but distinct enough to address separately, is a

Discourse of justice that influences RaeRae's reactions to many of the norms she works to push against. Each informs her approach to, and process of, making.

"Feelin' Myself"

As RaeRae navigated the social worlds of Great Lakes Charter Academy and the Boys and Girls Club she cultivated a way of being where that contributed to her social status and confidence: "People thought I was cute and stuff… I was feelin' myself..." "Feelin' myself" is phrase made popular and emblematic of unapologetic Black feminist confidence in a 2014 collaboration between rapper Nicki Minaj and singer Beyoncé. It is a "mantra of personal excellence on one's own terms" (Willoughby, 2015). The terms upon which RaeRae defined her excellence were defined with her network of peers. RaeRae demonstrated her ability to "pull off" this way of being (Gee, 2008) in various actions that contributed to her social status such as flirting, posting pictures on Instagram, and "playing" with other youth (joking, teasing, etc.). This Discourse was often not valued by adults — her attention to boys resulted in an over-policed reaction from a teacher at GLCA: "… every time I touch a boy or hug a boy he [the teacher] yellin' at me."

After our meetings on Friday nights, RaeRae would go to the "Teen Zone" – a part of the Boys and Girls Club where only teens are allowed and where RaeRae's enactment of this Discourse helped her engage with peers. She explained, "Fridays is the good days because I can come here and be myself… I need to get RaeRae out." By having a space where she can engage in "feelin' myself", RaeRae is able to push back on restrictive policies or social settings that prevent her from "getting RaeRae out".

This Discourse of "feelin' myself" informed the development of RaeRae's funds of knowledge around "looking cute" as she calculated how she wanted to be seen and what styles

she should call upon. It also influenced how she understood the importance of her funds of knowledge around building after the arcade event. She enjoyed "showing off" at the showcase, in part because "…they [the other kids] was like, "really cool" – 'cause people was coming back." She was encouraged by the popularity of her project and was excited to show off her next project (the dog rescue bag) in a similar way. This is a simple but powerful demonstration of how Discourses can mediate how and why funds of knowledge are called upon and developed.

Resistance Against Dominant Discourses

In the fall of 2018 RaeRae found herself in a different social and cultural setting in Big Cliff School District after having worked hard to cultivate friendships at Great Lakes Charter Academy. RaeRae explained that at Big Cliff "they got the good stuff" because "It's a bunch of rich people there." Being in a school that is resourced with "the good stuff" because its students were "rich people" was only part of what made RaeRae roll her eyes as she spoke about it. She shared, "The kids there just weird to me… they a bunch of rich folks and you know how it go… They be naming places where I never went or never heard of. And they shoe game and my shoe game is two different things..." Through their actions of "being weird", talking about places she did not know of, and fashion statements that clearly indicated different cultures, the students at RaeRae's new school implicitly made it clear she did not belong, and that her Discourse of "feelin' myself" would not gain her any new friends.

To navigate this social world, RaeRae developed a way of being that pushed against the Discourses these "rich people" engaged in and worked to her preserve her personal cultural values that were no longer reflected by the student body. RaeRae's way of being changed dramatically – she declared that I would not even recognize her, "…I don't mess with nobody! Nobody knows I exist there." These efforts to minimize interactions were not passive – this

Discourse was one of quiet resistance. The Discourse of resistance she cultivated made it clear she did not want to conform or engage with the dominant Discourses she was forced to interact with. RaeRae avoided sustained interactions in a variety of ways. RaeRae explained "They let us have our phones out and listen to music. So I always have my headphones in." She also spoke to a teacher who seemed willing to compromise:

> I just told her I don't like being by people and I don't talk to nobody in my class and when it's time to partner up I don't partner up… If they make me get in partners, then I just be doing all the work by myself because I don't feel like associating with nobody.

Being willing to do twice the work to avoid having to work with a partner underscores the active and dedicated nature of this way of being. This is not a reflection of RaeRae's response to group work in other settings, making clear this is a context specific move of resistance. RaeRae did not mind being partners with people at GET City because, "I know like, basically everybody here so I'm cool with them and I know how people roll here." Knowing how "people roll" and sharing a mutual Discourse with other youth at GET City made RaeRae far more likely to open up to group work.

Being a person who actively pushes against systems she deems unjust has informed RaeRae's funds of knowledge around looking cute. She refuses to engage with dress codes and the concerns others have over the length of her shorts or cut of her t-shirts, resisting compromising her personal style for rules she thinks infringe on her rights. Similarly, her resistance to narratives about what she is capable of encouraged her to continue developing her funds of knowledge around building, hoping to continue make things for her own agenda.

While the enactment of this Discourse became especially marked at her new school, elements of this Discourse of resistance were present before this setting shift. In the same way these new students and teachers were "aggravating" and worth cultivating a Discourse against, so

to have Boys and Girls Club staff (and GET City mentors) have been accused of being "annoying" and worth resisting. For example, when she was once asked to leave GET City from a senior staff member at the Boys and Girls Club for running in the hall, RaeRae wrote an letter to attempt to regain entry. In this letter RaeRae reframed the charge against her and did not include an apology; she refused to engage with the projected narrative of the incident and her role in it. This resistance is similar to the ways in which she insists on authoring her way of being at her new school, refusing to engage with dominant Discourses she does not want to be included in.

Justice

RaeRae has a strong, personal sense of justice that informs how she interacts with and perceives those around her. These values shape a Discourse that manifests in how qualifies behaviors as appropriate or not. This Discourse of justice rests on the premise that there are ways of interacting that are fair and reflect assumptions of loyalty between parties. RaeRae calls upon this Discourse to uphold a standard of behavior she expects from others. When this expectation is violated, she often calls upon her Discourse of resistance to express her displeasure.

RaeRae's Discourse of justice informed her disengagement at school. RaeRae described how a teacher at her charter school treated her class differently than another, where students were able to use their phones. This other class was, with the exception of two students, all white and known to be "smart or whatever" while RaeRae explained she was in the "slow" class. This was one of several injustices RaeRae identified at GLCA. She accused the teachers there of "dropping my grades on purpose." This led RaeRae to engage in behavior she knew was not accepted by the school; however, the teachers had violated her sense of justice and she was therefore unconcerned about adhering to their standards. Although RaeRae did not like the

cultural mismatch of being at Big Cliff, they did not drop her grades for no reason. With that semblances of fairness intact, RaeRae was quiet and disengaged, but not disruptive, so, she explained, “I don't act the same at my [new] school.”

The set of values that inform RaeRae’s Discourse of justice helped build her funds of knowledge around dogs and inform her interpretation of the many different experiences she had with them. The family members she knew who were breeding dogs for money crossed her perception of an acceptable line of care, and the woman who brought Roxy up from Detroit exemplified what it means to appropriately demonstrate love

Connecting Pieces

This concluding section describes the connections and relationships between RaeRae’s Discourses, the ways in which they influence her navigation of the makerspace and how they open space for her to leverage her funds of knowledge in her STEM-rich making work. See Figure 6.4 for an illustration of these relationships and Table 6.5 for a summary.

Supporting Navigation of Makerspace

RaeRae’s Discourse of “feelin’ myself” can be seen in the approach RaeRae took to engaging with the makerspace. RaeRae brought peers to GET City with whom she shared this Discourse. Bringing AnDreya in allowed RaeRae to continue her STEM-rich making and maintain her social clout. It expanded the social standing of the makerspace as a place where these confident girls were able to succeed and contribute to their own empowerment, opening opportunities for AnDreya to join in RaeRae’s making work.

When RaeRae’s Discourse of justice was violated (e.g., when she thought makerspace mentors were being unfair or when group members would make decisions without her) she would often engage in her Discourse of resistance. Her Discourse of justice influenced how and

where she pledged allegiance, and her Discourse of resistance informed her rejection of behaviors or Discourses she did not agree with. She would often leave the makerspace when upset, and not return until she felt an educator who met the standards of her Discourse of justice would have a conversation with her about expectations in a mutually respectful way.

Creating Space to Leverage Funds of Knowledge in STEM-rich Making

As RaeRae was able to center her Discourse around "feelin' myself" and present herself as a proud and capable STEM-rich maker, she was able to bring her funds of knowledge around building and dogs into her projects to elaborate on their importance. She was particularly proud of her ramp which got "the cool words" from her peers, and encouraged her to continue calling upon her funds of knowledge around building to improve the loop.

RaeRae's Discourse of resistance against dominant narratives also shaped the tenor of her making work. In subtle but meaningful ways she pushed against the direction of narratives she found unjust. As seen in her presentation of the Diamond Dog kit, dogs are not "stray" they are "homeless" and concern should be directed to their well-being, not the needs of humans around them. RaeRae gives her projects a stance of opposition in refusing to participate in dominant narratives about issues. This can be seen again in the way she makes clear her track is for girls, not boys, by virtue of its creators and décor. It stands tall and glittery as a symbol of defiance — a refusal to participate in narratives that suggest certain toys can only be for boys.

RaeRae's Discourse of justice helped her make sense of these different experiences and build a critical take on how she incorporated additional information in this fund of knowledge. For example, in RaeRae's meeting with the Director of Ingham County Animal Control she asked several questions about protecting vulnerable dogs from injustice, including whether there were repercussions for individuals found to have violated her understanding of the care required

to own a dog. RaeRae asked, “How about like … if someone has dogs and they didn't really care. They, like, care about the money - can you like, take all their dog rights from them? So they won't have any more dogs?” RaeRae calls on both her funds of knowledge around the kinds of situations dogs might have to live in and her Discourse of justice to shape her inquiry. Making clear her sense of where dog-owning conduct crosses a line - not really caring - she has clear ideas about the kind of repercussions they should face - losing their “dog rights”.

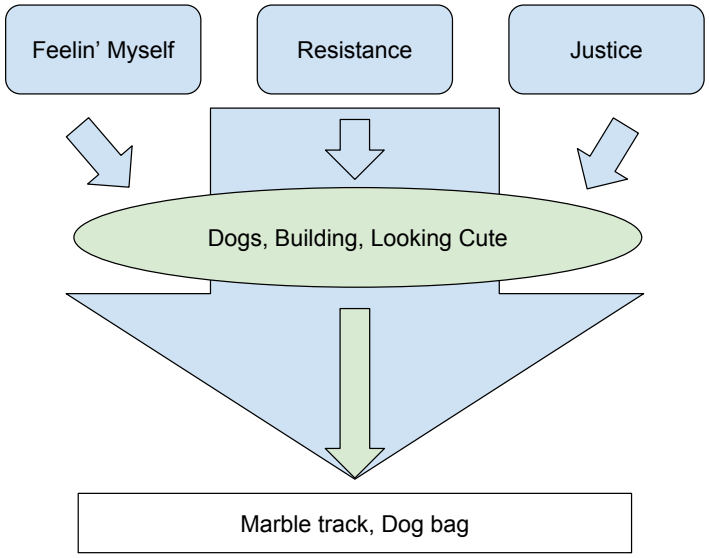

Figure 6.4, Model of RaeRae’s Discourses, funds of knowledge, STEM-rich making

Table 6.5
RaeRae’s Discourses, navigation of makerspace, funds of knowledge

Discourse	Influences on navigating makerspace	Creating space for funds of knowledge
Feelin’ myself	Brings friends into makerspace to maintain her own social clout and advance the standing of being in this afterschool program	Proud of her accomplishments, showcased **building** projects for social clout – opened more opportunities to develop
Resistance	Leaves makerspace when opposed to rules / ruling	Resistance to narratives about what she can do informed desire to **build** Making work an act of resistance against negative narratives about homeless dogs, what toys girls can have

Table 6.5 (cont'd)

Justice	Requires loyalty of her group members and adult mentors in makerspaces	Influenced how RaeRae understands knowledge, boundaries of acceptability for those owning and taking care of **dogs --** Sense of justice informed trajectory of making Diamond Dog Kit, questioning of Animal Control Director

CHAPTER 7

CO-CREATED MAKING ACTIVITIES AND DESIGN IMPLICATIONS

This chapter shares the co-planned lessons that Onie and Jazmin each developed and the design implications that were generated through this process. I also share design implications that arose from my conversations with RaeRae. The Discourses of each youth co-researcher are foregrounded in the discussion of their design implications. Parsing the influence of these Discourses is messy and imperfect; I highlight the Discourse I see as most prominent in youths' explanations as to why these design implications matter to them. Figure 7.1, below, demonstrates the way I understand Discourses (blue) to inform the development of funds of knowledge, and how these influence each co-researcher's experience in the makerspace (the findings discussed in Chapters 4 – 6). These experiences in the makerspace shape my co-researcher's sense of what an equitable makerspace could / should look like, and therefore their design implications.

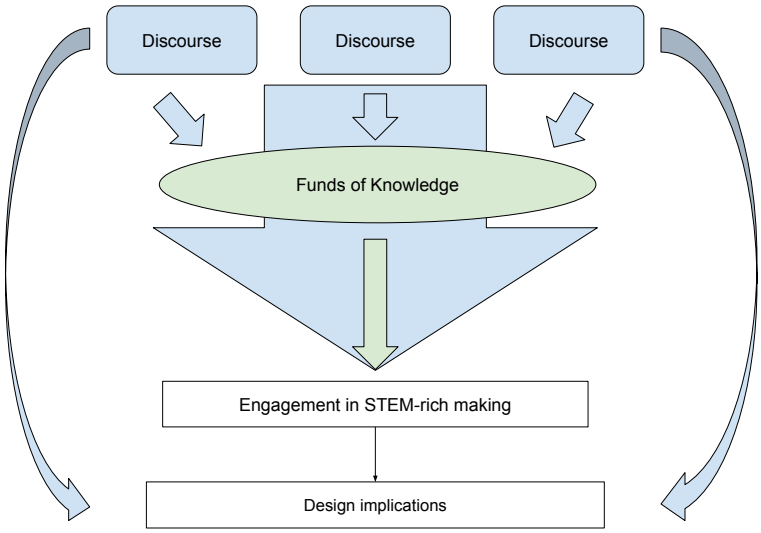

Figure 7.1, Model of factors influencing design implications. *Youth co-researchers experiences in the makerspace and their Discourses inform design implications.*

In the sections that follow I first present Onie's co-planned making activity and the design implications that arose from our conversations together. I then present Jazmin's co-planned making activity and her design implications. I conclude by sharing implications I drew

from conversations with RaeRae. While RaeRae and I did not get to finish this portion of the project together, she shared some strong suggestions for educators looking to create spaces of learning that welcomed all students. With the discussion of each design implication I share how it offers strategies to correct the intersectional debts owed to students who have been marginalized by traditional approaches to STEM. I conclude with a cross-cutting look at how these design implications offer various paths to equity and justice in STEM-rich making.

Onie's Making Activity: Lighting Up Things

The premise of Onie's making lesson was inspired during a conversation about lighting up a cake with a series circuit instead of candles. Thinking about fun and creative ways that circuits can be built into different objects she began to consider some practical items that might be useful to illuminate:

> What if someone brung in a bike and we, like, put lights on the tires somehow. Or maybe we could do it on my old skateboard! Me and José still haven't made the solar power skateboard so it could be solar powered lights - so instead of it being solar powered to move like José was saying, we can make it be solar powered for the lights to light up.

Onie and José had been talking about how to enhance her skateboard for some time; however, their designs had fallen to the wayside in the winter months. Onie took a more serious approach to this design premise as she thought about why it would be important for her skateboard to light up in the dark:

> 'Cause if someone is riding a skateboard at night, what if it's a street where one of the lights are off or something. Like one of those lights [pointed outside] street lights, that's what it's called, yeah. But if one of them are broken or something. Like, I remember one time I was walking at night to the store - it wasn't by myself because my mom would NOT let me do that, but um - it was with my brother's girlfriend and my sister. So, we walked to the store by their house and while we were walking back it was this light that had turned off for a second, they screamed. They thought someone was going to kidnap them or something.

Living in an area that is home to low income communities of Color, where infrastructure has been systematically ignored by those in power, Onie knows that walking (or skateboarding) in the dark requires protection. She cannot drive, she does not have a cell phone with active service, and as a Black girl she is uniquely vulnerable to the unprotection of institutional agencies and organizations (Morris, 2016). She calls upon these experiences with inequity as a motivation to make – recognizing her ability to illuminate objects as a partial solution to the injustices she faces.

Onie suggested that when enacting this making activity, educators should "… tell them [youth makers] to think of something they'd like lit up - but have them have at least two or three reasons, so they're not just - like - what if a little kid just says 'butt.'" Onie was less concerned about the logistics of achieving this hypothetical request of rear lighting and more attentive to how we might refocus youth to critically think about what need their STEM-rich making could be responding to. We discussed various reasons that youth might want to illuminate objects and how we could support their thinking. Onie suggested that better transportation, safety, and style were three ways that circuitry could support important ends in youths' lives. In suggesting these threads, Onie was calling attention to the need to center topics that reflect both her lived experiences and identity. She was specific as she discussed why she would want to light up the hood of her sweatshirt or her drawstring backpack, reiterating the importance and care with which she dresses in a way that reflects her identity as a Black girl. Taking an expansive stance on how STEM-rich making can correct everyday injustices that youth experience, Onie married her STEM knowledge to enhance and amplify her identity.

Onie recognized that if this making activity was going to support youth in illuminating objects in meaningful ways, circuitry skills were needed. She recalled paper circuit maps were a

helpful scaffold when she was first learning about circuits in GET City. These maps involved figuring out the right way to lay a LED bulb over a traced circuit, making sure that copper tape was set up to complete all parts of the circuit, and experimenting with different ways to make a "switch" for the circuit. Onie used these maps to explore simple, series, and parallel circuits. She suggested that after the paper maps help convey the basics of circuitry "they [youth makers] will try to figure out new ways they can do it - can they do it like this and then turn it, like I did when I did the heart! I made a heart out of copper tape." (See Figure 7.2). Onie was able to take the basic circuitry maps and turn it into a design she found personally meaningful, an experience she wanted youth makers new to circuits to share.

Onie also decided to make a video that discussed the basics of paper circuits, the kinds of circuits youth could make, and offer tips. As Onie knew from her heart switch, encouraging creative designs begets a need to support creative trouble shooting. Her hope is the video would support youth makers who are new to the content and practices by showing them the end product, sharing tips and troubleshooting advice.

Onie's commitment to using green energy expanded the content she wanted to share in this making activity. She is familiar with the solar panels in GET City that are placed in the window and immediately provide energy to circuits. As she thought about how she could use this activity to achieve the ends she had set for her own skateboard vision, Onie realized she would want her skateboard to light up at night – when there is no sun to power the circuit. She recalled setting up solar lights for her Grandma's garden, explaining, "… in the day time it took the sunlight and stored it and then at night they lit up from the sunlight they had stored." To better understand how solar batteries work, Onie decided that taking apart the kind of lights she had put up for her Grandma would be a fun and helpful experiment. Building on this idea, Onie then

suggested that youth makers be taught how to use power tools so they could take apart other electronics to examine their circuits and wiring.

Recognizing that a number of moving parts were at play in this making activity, Onie wanted to make sure that youth would not feel left behind or lost. She suggested that we write all of the big ideas out and ensure this list is visible and available to everyone. Onie then suggested we give each youth maker an area on the white board to write down any questions they might have, list their planned steps, and identify materials they needed. Onie's care and attention for the youth participating in this activity reflects a historicized understanding of being overlooked or problematized in larger student settings (Morris, 2007). Often punished in school for moving around while trying to avoid being bored, her proposal offers youth space on the often-coveted whiteboard to think through problems and stay engaged with the task in generative ways.

Figure 7.2, Photograph of Onie holding her heart circuit. *Above the copper tape reads "No Bullying" and below reads "My love."*

Onie's Design Implications

Implication 1: "Go down" to where youth are, teach from there. Onie's Discourse around respectful scaffolding is foregrounded as she explains how and why maker educators should be thoughtful about how they teach youth makers about circuits. Recalling the maps that helped her learn about paper circuits, she continued to think about how educators could support

youth makers new to circuits. She pushed maker educators to further scaffold the activity by developing a youth-centered video that offers additional tips and insights which could be overlooked by someone experienced in circuit making.

Central to Onie's conceptualization of supporting youth involves having empathy and respect for the newer, younger members. As she stated:

> If you're an eighth grader … I feel like you shouldn't act like you're very much older than the sixth and seventh graders ... Like, I feel like you should think about how you were when you first got into GET City. Like, I would think about how I was and try to go down to how I was and help them how I needed help.

By trying "to go down to how I was" and think about how she needed help, Onie suggests maker educators take the time to get to youth makers' prior knowledge and experience and build from there. She is being clear about the need for youth to feel as though they belong in this space and their knowledge is valued. Rather than forcing engagement on terms decided on by adults, Onie recognizes the need for engagement based on mutual respect and trust where the community reflects its participants – a key element of belonging that Herzig (2010) identifies as contributing to the success of Black girls in STEM.

Often this design implication is violated by adult educators who assume that youth are familiar with certain references, know how to use materials, or have specific background knowledge. By beginning with conversations geared to surface what youth already know, educators can shift from positioning themselves as more knowledgeable to needing to learn from youth. This approach to working with youth – with care and attention toward scaffolds that start where youth makers' knowledge, interest, and abilities are – offers space for these scaffolds to be personalized and incorporate youths' funds of knowledge.

This idea of starting where youth are to ensure they feel as though they belong is in part why Onie thought it important that *GET City for Real* featured youth discussing STEM-rich

making. She explained how youth understand things differently than adults, “Because you guys are more mature. And you guys understand more than us… So, we break it down to our satisfaction, I guess I'll use that word. And they [viewers] will understand it more.” The idea that youth are better able to serve and educate their peers because their experiences are more similar than anything adults could offer nuances ideas articulated by others in the makerspace community. Ryoo, Kali and Bevan (2016) identify peer-to-peer learning as a key pedagogical move that encourages expansive and equity-oriented participation. Similarly, Fields, Kafai, Nakajima, Goode, and Margolis (2018) also write about the importance of peer pedagogy both formally (youth teaching youth) and informally (through casual assistance and feedback). Neither of these studies, however, addresses Onie’s concern that peer teachers need support in thinking about how to “break it down” to the satisfaction of others without acting superior.

Implication 2: The importance of engaging in STEM-rich making toward consequential ends. Onie’s Discourse of care-taking is highlighted as she declared that “… it’s important that they [youth makers] pick what they’re gonna help”. Demanding that her peers critically think about how their making work can help address local problems that matter to them, Onie highlights the social side of STEM-rich making while providing space for her peers to draw upon their own experiences and expertise in selecting an issue. She pushes for youth to have a platform upon which their perspective is not only valued, but the catalyst for their making and change. In doing so, Onie is pushing against historicized locus of power in STEM that supports innovation on behalf of the wealth, white, male perspective. She pushes against deficit narratives about the power by celebrating the community cultural wealth (Yosso, 2005) that she and her peers are a part of.

This approach to making weaves together several approaches to equity in making: it begins with the premise that youth are not only interested in STEM but ready to engage with it and use it as a tool toward ends they identify as important; it positions youth as experts; and the focus is not on a final product but rather on the process.

Pedagogically this design implication requires allowing youth to take the lead in naming how they want their work to matter and supporting them in that vision. It also requires allowing socio-political concerns to be an important part of the conversation in makerspaces, which is rarely the case (Vossoughi et al., 2016). Onie lives in a city where poverty levels are high, and infrastructure has been neglected – her suggestion that youth might choose to focus on safety and transportation reflect the ways in which these local injustices shape the problems which matter to her. She does so in ways that value the strengths of her community, in a way that honors approaches she has seen successfully circumvent these hurdles.

To support youth in making that matters, adults in makerspaces need to be able to balance allowing youth to name goals while supporting them with content and practices as needed, rather than leading with content. This aligns with recommendations from Tan and Calabrese Barton (2018) who refer to having "just in time" lessons ready to support youth in expanding their STEM knowledge toward their own ends. Similarly, DiGiacomo and Gutiérrez (2016) recommend that facilitators "follow-support" youth makers rather than "lead-support" the making process. Each of these recommendations give space for youth makers to identify personally meaningful ends for their work and draw upon their funds of knowledge around a making project while placing educators in positions of support. Educators also need to learn to be attuned to how youth name the problems they wish to address and how they (and the educators themselves) are positioned as insiders and/or outsiders to these problem spaces.

Implication 3: Share power tools and privileges. In almost all of our conversations, Onie mentioned her love of power tools. She was excited to find an opportunity to use them in her making activity as a way of exploring larger electronics and solar panels. Earlier I had asked Onie what she would recommend for a dream makerspace that welcomed everyone and her immediate response was, “Power tools. In my dream there would be a lot of power tools”. When I asked Onie why power tools were so cool and something she wanted to share with youth makers, she explained that it is not just about the tool itself, but the feeling of being trusted and treated as a capable person.

> I think, like, it [using tools] makes me feel like I'm not very young. When I was, like, if a teacher doesn't let you do something just because of the age - like I felt like I was old enough when I was in third grade. But I wasn't. But about fourth or fifth grade is the age you should start doing that. You don't - teachers don't really understand that. They think it's eighth and ninth grade and stuff. But it's really not. I was really happy to get that privilege. So, I really like it [using power tools] and I started using it [the jigsaw] A LOT.

Onie positions herself and her fellow youth makers as capable of things that teachers “don’t really understand” and points to feelings of empowerment when she is trusted to use these tools. Onie’s explanation of appreciating this “privilege” points to pedagogical moves of inclusion that have contributed to her feeling self-efficacious and confident in this STEM-focused place. These feelings are markedly different from what much of the literature on Black girls in STEM reports on seeing – rather than reproducing narrow ideas about what STEM is and dictating how youth engage with that, Onie is able to connect her emerging sense of self with STEM practices. Her affiliation with STEM is built on her own interests and capabilities which she is encouraged to explore.

While the importance of trust has occasionally been discussed in relation to more formal educational settings (e.g., Cook-Sather, 2002) it has not appeared in discussions of makerspace culture. Though reasonable to expect that trust is part of an environment that seeks to center

youths' funds of knowledge, Onie's design implication demonstrates the multidimensional nature of that trust. Trust can manifest in a variety of ways – including in access to tools. This is not to suggest an unsafe environment – all power tool usage is carefully supported in GET City. Rather, the crux of Onie's suggestion is that youth are treated as equal partners in the making process.

Thinking about the broader sense of this recommendation -- allowing tools to be widely accessed -- helps us see how Onie's Discourse of collaboration informs this design implication and how it can be applied to a variety of scenarios beyond jigsaws. Onie's preference for equitable collaboration can be seen as she suggests that "privileged" tools – such a camera, an iPad, or time and space on the whiteboard – should not only be used by adults but shared with youth. This sends a message that acknowledges the ability of youth and positions them as equal members in a makerspace. Although some scholarship highlights the importance of having tools and resources transparently available (e.g., Bevan, 2017), that discussion has not been extended to explore the importance of having a partnership culture that also welcomes the physical take up of these tools, through re-distributing power in this way. Onie's ability to use the jigsaw while calling upon her funds of knowledge around random building has helped position her as an expert in GET City and made an indelible impression on how she considers equitably designed makerspaces share their resources.

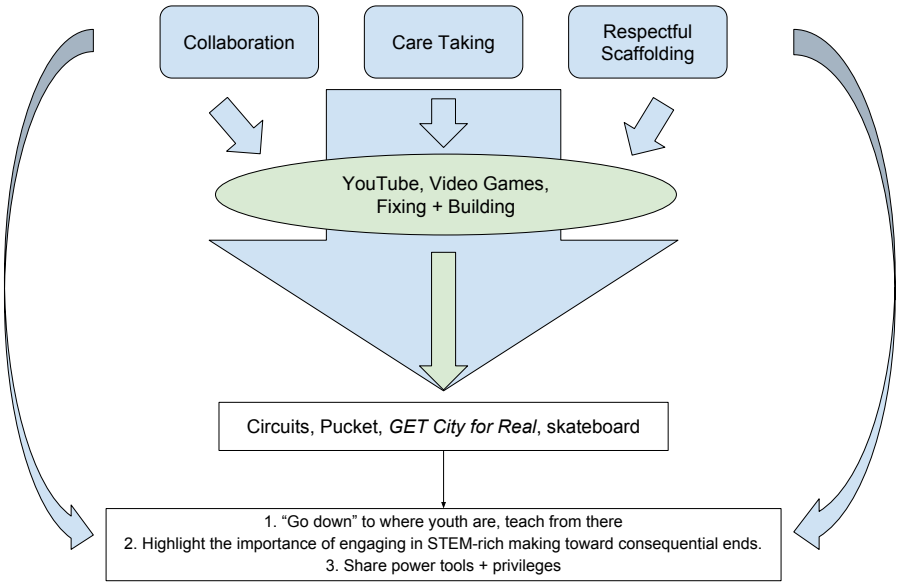

Figure 7.3, Model of Onie's design implications

Jazmin's Making Activity: "Everyday Things = Science"

Jazmin decided to structure an activity around uncovering the STEM practices that go into creating objects that youth use every day. We started by talking about slime – a popular middle school creation. Jazmin explained:

> I think it's because it's such a common thing and no one's told them [youth] the science behind it…. So they're just like, "Oh I thought it was a toy." And you're like "Yeah, it's science!" They're like, "Well, I don't think so – I don't see how it's science." So that's what I mean when I say, like, "Explain the science behind it" because it's a lot of stuff that's like, everyday things that's science that no one would know about.

Above, Jazmin articulates what she sees as the goal of this lesson – supporting youth in seeing how STEM concepts and practices exist in their everyday lives. She identified the disconnect between science as it is taught in school and students' out-of-school lives as the fundamentally inequitable inspiration for this activity, echoing calls from scholars focused on cultivating STEM counterspaces that honor and reflect the needs and everyday lives of Black girls (Ashford et al., 2017).

To help youth better see the science in their every day, Jazmin decided youth should bring in something they use all the time. This everyday item could be anything: lip balm, soap, a paper plate, etc. We would then support youth in researching both the technical and social history of these objects. In this way, youth would be supported in understanding the engineering and design decisions that go into creating the objects that are connected to their social needs. Jazmin thought that youth who have not done this kind of research before should be supported through guiding questions, such as: "What use does this object serve / problem does it solve? What is it made of? Why? What other designs exist to address this purpose?" She also decided that we should provide videos connected to the kinds of objects brought in by youth, such as the *How it's Made* series.

Jazmin, concerned that youth may find research alone unsatisfying, felt that this activity would be made "more fun" by recreating (or, re "making") the object they had brought in. For example, we talked about making soap from bacon grease. This would help not only unpack the STEM practices and knowledge that went into making that item as they have it but would help name historically grounded practices as scientific – contributing to additional and alternative perspectives about what science can look like and how community members successfully engage in STEM practices every day. Jazmin's hope was that this fosters a better understanding of how many activities that youth engage in every day are, indeed, scientific.

Jazmin also considered the role of feedback in the re-making process. She recommended we ask youth to keep track of their "design drafts" so they could track how their thinking and products changed and improved over multiple iterations. She also wanted to make sure that the maker educators ensured that all youth were able to receive multiple perspectives on their work. In this way youth could continue to think about more expansive ways to improve their everyday

object. Jazmin suggested that surveys could help collecting information and feedback, as could having a showcase where youth present their research and re-made objects.

Jazmin's Design Implications

Implication 1: Educators must trust youth, let them be in control. Jazmin's Discourse of independence is highlighted as she explains that makerspace educators need to be willing to say "Here's the idea. You figure out what else to do and we'll bring you the materials so you can do it." This statement highlights the importance of trust; trust that youth are capable of knowing what they need and are welcome to take up resources toward productive ends. It offers one perspective about what it can mean and look like for youth to *belong* in STEM spaces (King, 2017). Rather than feeling like intellectual and cultural outsiders as Black girls often report in traditional STEM spaces, Jazmin emphasizes access to resources and mentor/youth trusting relationships as contributing to a space where she is in control and confidently understands her place as an important contributor.

Jazmin recalled her own experiences as a youth maker, observing, "I like a lot of the activities where they have us put our own little spin on it … it makes everyone a lot more excited. I can tell because everyone gets a lot more creative and stuff like that." As Jazmin notes in this quote, this design implication impacts more than the task at hand – it expands the potential outcomes of making as youth feel more excited and creative. She speaks to the need to call upon STEM practices to ends that reflect to her own interests and lived experiences, rather than the white, masculine norms that inform most STEM activities in traditional educational settings (Charleston, Adserias, Lang & Jackson, 2014).

Trusting youth and letting them be in control creates powerful spaces for them to call upon their funds of knowledge and to feel safe in doing so. Pedagogically, this asks that maker

educators are open with materials and engaged in youths' making work without dictating it – asking questions and supporting youth led explorations. Similar to Onie, Jazmin points to the empowering nature of being supported in these ways (rather than supervised). Knowing she has access to materials in the room enables Jazmin to call upon her interests and abilities around "boredom building" to engage in iterative and thoughtful making work without feeling like other adults are in charge of her work. This is one reason her fan project has come to be such a staple in her work at GET City – she recognizes she has access to makerspace resources and has persistently developed several different blade designs using a wide variety of materials.

This design implication is a push against restrictive pedagogical practices that too often accompany Black girls into STEM spaces (Archer, Dewitt, & Osborne, 2015). Trusting youth to lead with their vision and process of making is grounded in a respect that recognizes youth as experts in their own right. As adults move further away from being the only knowers of "important" information about making, expertise is distributed more equitably across members in the makerspace. This is an important and strong push against historic power differentials that fall along lines of age, race, and gender. DiGiacomo and Gutiérrez (2016) underscore the possibilities inherent in pushing against traditional asymmetrical power relations in traditional learning spaces – explaining that relational equity between adults and youth is more likely to result in the kinds of partnerships that result in transformative learning for all parties.

Implication 2: Ensuring quality by getting feedback from multiple perspectives. While Jazmin understands the importance of allowing youth to take control, she does not absolve maker educators from constructive involvement. Jazmin has high expectations about the support educators give and anticipates that they hold youth makers to high standards. She lamented that some adults miss this opportunity – being kind at the expense of authentically supporting youth's

work, saying, "… don't lie to them. Don't be mean, but just don't lie to them." She projects her own high standards on the making work of others, reflecting some of the values and expectations that undergird her "good influence" Discourse. Just as she is intentional about presenting herself as a capable and trustworthy individual and maker, she believes it is important for other youth to work to be their best making self, too.

Jazmin made the point that feedback from multiple points of view is important to ensuring the quality of a making project. She suggested several ways this could be achieved in her making activity: "When they do make their first draft, ask everyone for feedback or ask a few people for feedback and survey what everyone thinks about their product." When she refers to "everyone" Jazmin is moving beyond GET City to include other youth at the Boys and Girls Club, staff, and parents. She is expanding our perspective of whose knowledge counts and is valuable in the making process. By ensuring there is space for community feedback Jazmin is underscoring the importance of ensuring Black girls are able to see their community members as role models in STEM practices, building affinity and identification with her own intersectional identities and seeing those identities reflected as important in the work she is doing (Ashford et al., 2017).

Jazmin's Discourse of being a "good influence" helps nuance this design implication as she suggests that consequential making can, and should, involve audiences with different life experiences so that makers will be trusted by the community for whom they are making. Jazmin recalled her own lack of perspective while creating the Donator app and how important it was to have expansive circles of feedback:

> … Because, like, we had some GET City members who have said that they've experienced, like, being in a homeless shelter or in a foster home and stuff like that. So, like if we, if there are club members who are outside of GET City who experienced that, with the Donator app that really would help because they'd be able to give us feedback on

> what we're doing right, what we're doing wrong. They can be able to give us input on what is actually true in most cases and what isn't and what we should actually write down, what we should not write down, what we should believe, what we shouldn't. Because then like you can see both sides of it. Like from my point of view plus theirs.

This quote illustrates the importance of being able to call upon distributed expertise in making. Indeed it is an example of a youth-led push to extend beyond what equity scholars recognize as important: Jazmin is not just asking that her experiences as a Black girl interested in STEM are valued and recognized as strengths (Ashford et al., 2017), she is asking that community members are also recognized as important and treated with respect in this process. Jazmin recognizes the importance of requesting feedback from people whose lived experiences offer a perspective she does not have. She elaborated, "… because if I was to just design something for everyone, but it was only my point of view, not everyone was going to like it. So, I mean getting different point of view helps for more people like -- 'cause you know, everybody got different ideas." Jazmin places great importance on being a trusted maker and recognizes that she would be hard pressed to achieve this without input and support from others. She values not only the technical skills needed to develop the app but the community wisdom that helps her capture desire and possibility instead of damage (Tuck, 2009).

Implication 3: Keep "everybody's every day" at the front of planning. Jazmin's Discourse of advocacy is prominent in the way she worked to center the everyday experiences of youth in this making activity. She looks to validate and celebrate the lives of youth in ways that not many educators do. When I pointed out the amount of quick preparation that maker educators would have to do when youth decided what objects they wanted to explore, Jazmin presented a solution and then immediately walked it back as an unfair approach, saying, "What about if we … we just had, I want to say a list of everyday objects, but then at the same time, that's not EVERYBODY'S every day." The tension between wanting to be prepared and wanting to give

youth space to authentically call upon their funds of knowledge is a dilemma many educators wanting to develop equitable making cultures could experience. Jazmin walked into the thick of this conundrum and emerged having decided that youth should bring objects from home with no input from their maker educators. Ensuring these projects are genuine representations of youths' every day was more important to Jazmin than being a step ahead of the design process. In expressing this, she reaffirms work of social justice STEM programs that work to center culturally relevant approaches to engaging youth in scientific endeavors that respect and reaffirm their everyday lived experiences.

Another moment where Jazmin worked to ensure that the everyday experience of youth makers stayed at the fore of our planning came as she explained that having youth re-create objects was important because it would give a concrete purpose to the research youth were going to undertake. She elaborated, "…We gotta have them recreate it because I sometimes probably would've been like, 'Well, why do I need to know this?'" Jazmin calls upon her own experiences with research that did not take into account her every day, understanding that content with connections to her context is more valuable and "more fun". This particular example highlights the importance of moving away from teaching STEM content and practices detached from youth's context. A more equitable and engaged approach is to *lead* by getting to know context that matters to youth, and then presenting STEM content as a way of supporting what youth already know and are interested in. This work helps youth claim STEM as their own as they take up these practices to ends grounded in their everyday life. It attends the historicized injustices in the way STEM has traditionally been presented in narrow ways that that do not attend to the social condition of Black youth, nor the needs of women (Mutegi, 2011). Jazmin is committed to

forging connections between STEM and youth that are grounded in cultural competence (Ladson-Billings, 1995).

Implication 4: Support multiple ways of finding and demonstrating knowledge.

Jazmin wanted to ensure that youth would be able to successfully meet the challenges of this making activity. Recognizing that seeking information and understanding through online research is a very specific way of learning that privileges certain skill sets, Jazmin drew on her Discourse of advocacy to suggest that "we should probably set, like, questions that they should look for that -- to figure out what they need." Her efforts extend an additional hand to those who might need support in engaging with this part of the activity.

Jazmin, like Onie, identified the importance of having videos about making available as another form of support. Jazmin recognized that youth makers may not like, or may be challenged by having to find information online. She mused,

> What about, like, having them look at videos? I'm pretty sure there's a lot of YouTube videos that could help with that. Okay! There's a show called *How It's Made*… it depends on what it is, but they could possibly look at that.

Recognizing that they are multiple ways of communicating and engaging with information, Jazmin calls upon her own experience and knowledge of youth practices to suggest YouTube and *How It's Made* as helpful making resources.

The importance of being able to represent knowledge in multiple ways arose again as Jazmin reflected on how a "final product" is not always the best reflection of what people learned or cared about. Although she wants to hold youth to high standards, she does want to dictate those standards. She recognizes that successful making can look different to each person. Jazmin suggested that the re-made products youth create should reflect an openness for them to "… put your own little spin on it. They won't have to it exactly like most things. They can make

a funky little cup as long as it holds liquid and you can drink from it, it's fine!" Jazmin recognizes that important learning and idea generation can take place in ways that might be considered "funky" but should not be considered incorrect. In doing so she underscores calls from Ashford and colleagues (2017) to provide "opportunities for Black girls and women to be creative in how they communicate their ideas and their understanding of scientific concepts" (p. 23). Working to cultivate a space that is personable and welcomes multiple ways of engaging with content toward transformative ends is critical in shifting what opportunities in STEM look like and who can take advantage of them.

Honoring those contributions as valuable also requires recognizing that there is no one "right" way of finding and demonstrating knowledge. Creating such a hybrid place of learning and conversation can then expand successful engagement in STEM beyond narrow, prescribed performances. Accountability measures in school increasingly push STEM-based classes toward test-preparation – making frequent use of textbook-based participation, vocabulary memorization, and worksheets (Blanchard et al., 2010). There is little-to-no opportunity to be welcome "funky" demonstrations of understanding across these assessments.

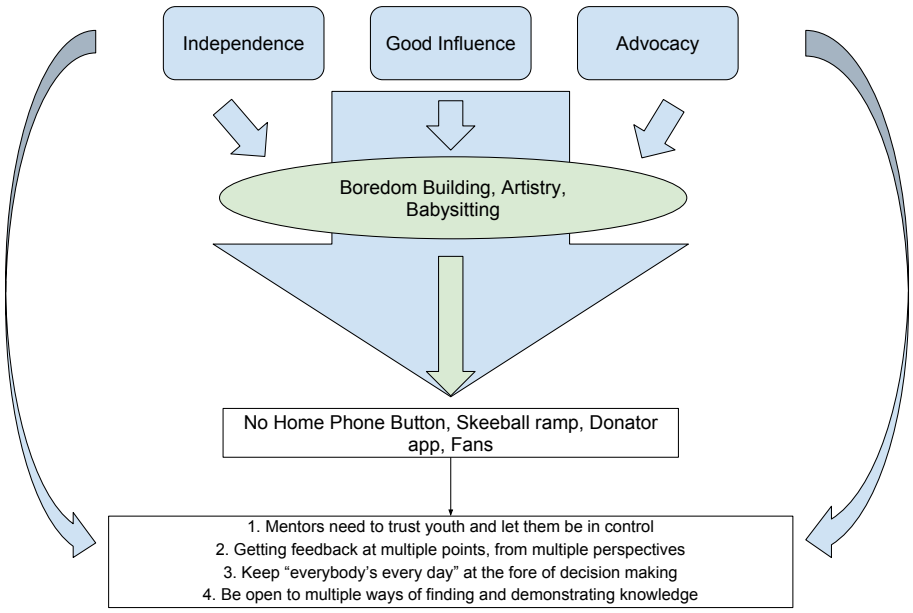

Figure 7.4, Model of Jazmin's design implications

Implied Implications from RaeRae

RaeRae and I were unable to finish our research together. We did not discuss how she envisioned equitably centering youths' funds of knowledge and Discourses in making work, nor did we co-plan a making activity to see how these design implications might be enacted. I am therefore only able to present RaeRae's design implications as I understand them from our conversation groups and GET City interviews. These implied principles are broader than what I presented in both Onie and Jazmin's chapters as I was unable to categorize and member check with RaeRae and cannot say how she would nuance and implement them.

Implication 1: Educator Actions Must Reflect Asset-based Assumptions

RaeRae's Discourse of justice often came to the surface when she felt the actions of adults around her were unfair and overly disciplinary. For example, RaeRae felt unfairly scrutinized by some of her teachers, like Mr. E, who she emphatically declared was "aggravating," "Because every time I touch a boy or hug a boy he yellin' at me… And every time I go to the bathroom, he watch me - like - he's a stalker." This troubling complaint demonstrates

the pervasive nature of the racialized and gendered stereotypes RaeRae was experiencing by age twelve. While this particular incident took place at RaeRae's charter school, it is representative of the power hierarchies within which she was routinely positioned that policed her Black body (Morris, 2016). This design implication, then, points to an urgent need for adult perspectives to reflect an anti-racist, asset orientation. It is a call to engage the depth of work that must be done to recognize and work against the educational debt (Ladson-Billings, 2006).

This design implication is also informed by conversations RaeRae and I had about the transformative possibility that can arise when interactions between educators and youth are based in assumptions of value and trust. Below I share an excerpt of a conversation we had about science that underscores the importance of these assumptions:

> Sarah: What do you think it takes to be good in science?
> RaeRae: Your brain. Bein' smart.
> Sarah: Huh! What do you think it takes to be smart in science?
> RaeRae: Trusting yourself.
> Sarah: How come?
> RaeRae: Cause if you don't believe yourself, you can't do nothing. Or, like, you be like – oh you always… just wasting your time and breath.

As RaeRae explains that "trusting" and believing in oneself is key to being good at science, the importance of this design implication is put into concrete terms. Her statement implicates adult educators and those who are in positions of power to either foster or shut down that trust and belief. RaeRae points to a fundamental truth undergirding studies about Black girls and science identities: socialized ideologies about Black girls and Black women (e.g., Stephens & Phillips, 2003) as well as scientists must be deconstructed in spaces that want to nurture interest and persistence. Educators who demonstrate their belief in youth support youth trusting themselves. This cannot authentically be done with a deficit view of youths' Discourses and funds of knowledge.

If educator actions reflect a dedication to asset-based frameworks, a fundamental shift in both power and attitudes occurs. By learning from RaeRae's stories we see the need to push against hierarchies that position youth as "less than" – along the axis of age, race, or gender – and instead recognize these identities and social experiences as the source of knowledge and expertise that should be celebrated and centered.

Implication 2: Relationships Contribute to Belongingness in STEM

The conversations RaeRae and I had for this study took place after her regular involvement in GET City. As a result, she was able to reflect on her participation in GET City and our relationship across the years. This design implication draws on RaeRae's reflections and include some of my own. It discusses the role that sustained relationships can play in contributing to feelings of belongingness in STEM-rich making. Belongingness in STEM suggests a push toward decolonizing ideas about who can do STEM, belongs in STEM places, and contributes to STEM knowledge.

If youth are to feel as though they belong in STEM spaces, they need to be welcomed as their entire selves. This is a fundamentally humanizing stance that places primary importance on relationships between educators (and researchers) and youth, built on "care and dignity" (Paris, 2011, p. 140). This is a right which Black girls are rarely afforded in traditional STEM spaces. Too often Black women and girls in STEM experience microaggressions, perceived inferiority and inadequate support (Ireland et al., 2018). Welcoming Black girls into STEM in a way that celebrates their intersectional identity requires the intentional creation of spaces dedicated to their interests, *counterspaces* of the kind Ashford and colleagues (2017) discuss.

This design implication is a reminder that relationships with youth cannot be built on adults' interests or demands. Middle schoolers have full lives: they have homework, drama, and

many different relationships; they are developing understandings of their bodies, personalities, and identities. These moving parts that make up being a pre-teen mean that their attention can be in other spaces even when the clock says these ninety minutes should be dedicated making time. RaeRae's social enthusiasm often precluded her full attention or attendance in GET City. Although it was one of her favorite things to do and an activity she took pride in, she reflected that it was hard to be present at times because, "I was just so focused on friends and paying attention to friends." Despite these distractions, she was consistently welcomed in GET City because educators welcomed her entire being, not just her making dedications.

Long-term relationships with educators helped maintain RaeRae's identification with GET City and its activities despite long absences, underscoring the importance of having caring mentors to help youth – especially Black girls – navigate their ways in and through STEM pathways (Ferreira & Patterson, 2011). RaeRae demonstrated the power of how relations maintained her identification as one who belongs in a GET City through both her contributions to this dissertation work and her continued work to improve the dog rescue kit. By making space for the full personhood who might otherwise perceive STEM-based areas as the domain of only students who are good at school, this design implication pushes against a psychological byproduct of the education debt owed to youth.

Implication 3: Provide Opportunities for Youth to Showcase Their Work and Position Themselves as Experts

When RaeRae and I spoke about times she felt most seen and proud in GET City she highlighted moments where she was able to show other youth and adults her work and was offered an opportunity to demonstrate her expertise around making and related STEM practices. These moments aligned with RaeRae's Discourse around "feelin' myself," where she was given

the opportunity to position herself as a confident and capable STEM-maker on her own terms. This was at distinct odds with what she experienced at school, where she was either disciplined or worked to be invisible. Instead, she was able to declare herself an academic success while making clear her cultural competence – all of this juxtaposed as a critique and comparison point to her schooling experiences (Ladson-Billings, 1995).

RaeRae identified multiple ways in which she was able to position herself as an expert in meaningful ways. Her appreciation of social status meant that she enjoyed public opportunities to showcase her work in front of peers. Indeed, during the arcade showcase that featured RaeRae's track, RaeRae was very excited to show off her work. She recalled, "My big brother was there and then I was really happy about that – for him to see my stuff… They were sayin' 'Oh that's cold' and stuff like that – like, all the cool words and stuff." Pleased that her track was getting the "cool words", RaeRae reflected on the full day saying, "… it was really fun. And I liked to show mines off... And I liked to show off and be like, 'I made this!'" Being able to take space and to claim herself as a STEM-rich making expert in front of her peers was an important moment of both confidence and identification with those practices. RaeRae was able to support her identification as both a scientist and a proud Black girl.

In both grand demonstrations and smaller more every day opportunities, RaeRae enjoyed being able to showcase her abilities and knowledge. This opened up space for her to identify as someone who engages with STEM practices while having fun and being proud of her ability to create cool things. By ensuring these kinds of opportunities are made available, a platform is given to youth to own their skills, abilities, and expertise – shifting away from dominant narratives about who should be identified as a STEM expert.

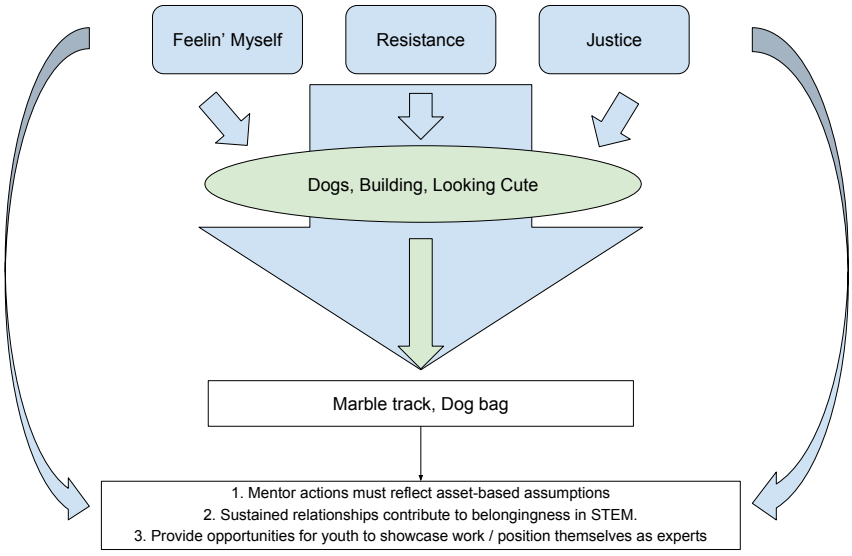

Figure 7.5, Model of RaeRae's design implications

A Look Across Design Implications

Onie, Jazmin and RaeRae offer important insight as to where they see STEM-rich making as offering opportunities to push against inequities. These opportunities exist across multiple points of engagement and implicate the culture of the makerspace: the practices, activities, and attitudes that inform the making process. Below I discuss how my youth co-researcher's design implications point to three cross-cutting aspects of the culture of making that shape their concerns around equitable engagement : 1) ensuring that the making work youth do matters, 2) disrupting the "culture of power" that informs traditional interactions between educators and youth, and 3) humanizing / culturally relevant approaches. The design implications informing these themes are italicized, and Table 7.1 synthesizes this section.

Ensuring Making Matters

Both Onie and Jazmin suggest design implications that draw attention to ensuring that the making work they engage in matters. They understand the meaningfulness of their STEM-rich making work to arise from serving their community. They work to solve problems that impact others and feel strongly that this work is grounded in sincerity. For Onie that means youth are

supported in the ideation phase of making, as they consider *how and why their making work is important*. She works to highlight the connection between youth makers and causes larger than themselves in thinking about how making work can matter. This can be seen in her approach to developing a YouTube channel that addresses the historicized injustices of an education system that does not meet her needs, nor the needs of other youth.

Jazmin is focused on the process of how youth make their work matter by working to ensure that youth are receiving *feedback from multiple sources in the community*. For her making becomes consequential when stakeholders are consulted and agree that the making work in question is being completed by someone who is trustworthy and has considered all perspectives. She pushes makerspaces to push beyond technical considerations of whether a making project "works" to consider the extent that a project represents the needs of those for whom it was made. For example, Jazmin considered her Donator app most meaningful after it received careful consideration from relevant community members.

Both of these design implications call attention to STEM-rich making as mattering as a response to community needs. They trouble dominant narratives of makerspaces which focus on individual interest and attainment of youth makers. Jazmin and Onie's design implications suggest that if makerspaces want to be hailed as places of transformational learning, they must re-ground themselves as a place where youth can engage in transformational work. Each of these examples and design principles calls for makerspaces to honor youth's perceptions of need throughout the process of considering what it means to engage in making.

Disrupting a Culture of Power

All youth co-researchers offer ways to break the "codes and rules for participating in power" that are based in middle-class, white, masculine values (Delpit, 1988, p. 282). They

suggest educators trust the abilities of youth who fall outside of these norms, giving them space be equal partners in making. Onie's suggestion that educators *share power tools and privileges* and Jazmin's thought that educators should *trust youth and let them be in control* both name the need to empower youth by recognizing them as worthy of respect and capable of directing their own work. Each of these design implications helps explain how makerspaces can better position youth as the ones with the knowledge and ability to engage in decision making.

From RaeRae's experiences we see how it is important to reverse assumptions derived from the culture of power that position youth as deficit or "disadvantaged" by providing *opportunities for youth to showcase work / position themselves as experts*. RaeRae underscores the importance of opening space for youth to be able to call upon their funds of knowledge and to have those funds of knowledge be recognized and celebrated. This design implication shows the depth of framework shift that is needed: it is not about being granted participation within the culture of power, it is about breaking the culture of power – refusing to conform by changing the narrative about what skills and abilities should be recognized and how.

Humanizing Approaches to Relationships

All three youth co-researchers discuss ways in which educators can reflect a more humanizing culture in makerspaces. RaeRae speaks broadly to developing a culture of promise within makerspaces while Jazmin and Onie suggest practices that reflect the culture that RaeRae describes.

RaeRae, more so than Onie or Jazmin, experienced the injustice of having her Discourses dismissed and being positioned in deficit ways. The stories that inform her design implications are a reminder of how deep the educational debt owed to students is. RaeRae encourages educators to see and celebrate the promise of youth. Her suggestions that *educator actions*

reflect asset-based assumptions and that educators work to have *sustained relationships* with youth offer fundamental ways that educators can support youth who bear the brunt of multiple systems of oppression. Ladson-Billings (2006) suggested that a "debt service" accompanies the education debt in the form of distrust and suspicion of educational institutions. RaeRae offers two ways that educators can begin repairing that trust.

Onie's suggestion that educators *"go down" to where youth are* and Jazmin's recommendation that educators are *open to multiple ways of finding and demonstrating knowledge* are two pedagogical strategies that can support educators engage with youth in ways that work to cultivate and honor "insider trust" (Paris, 2011, p. 139). They each point to the need for educators to engage with students in culturally relevant and humanizing ways – approaches that are hard to cultivate if educators do not appreciate their own positionality and the intersectional injustices that youth experience every day.

Table 7.1
Summary of Design Implications and Cross Cutting Themes

Cross cutting theme	Analytic claim	Design implications informing this theme
Making that matters	• Outcomes contribute to the community • Respond to local injustices • Involve input from community stakeholders	Highlight the importance of engaging in STEM-rich making toward consequential ends (O) Getting feedback at multiple points, from multiple perspectives (J) Keep "everybody's every day" at the fore of decision making (J)
Disrupting culture of power	• Trust and respect youth • Treat as partners • Expand perspectives on whose knowledge counts	Share power tools + privileges (O) Educators need to trust youth and let them be in control (J) Provide opportunities for youth to showcase work / position themselves as experts (R)

Table 7.1 (con't)

Humanizing approaches to relationship building	• Intentional in positioning youth • Build trust • Recognize personal positionality within systems of oppression	"Go down" to where youth are, teach from there (O) Be open to multiple ways of finding and demonstrating knowledge (J) Educators actions must reflect asset-based assumptions (R) Sustained relationships contribute to belongingness in STEM (R)

CHAPTER 8

LEARNING ACROSS ALL STORIES: IMPLICATIONS + DISRUPTIONS

This chapter is divided into three sections. The first considers how the findings presented in Chapters Four through Seven hold conceptual implications for sociocultural researchers considering critical stances on learning, and practical implications for makerspace educators. The second section is a reflection on my two roles as a researcher and participant practitioner. The final section concludes with future lines of work that could extend the findings of this study.

Implications

Discourses in Equity Work

Recognizing the need to welcome youths' Discourses as a key component of equitably centering funds of knowledge informed the shape of this study. Discourses helped explain the development and leveraging of youths' funds of knowledge and were called upon in how youth co-researchers conceptualized equitable making activities. The prominence of Discourses reaffirmed the need for sociocultural researchers to take a critical stance on surfacing issues of power and context in learning environments.

Gee (2008) explained Discourses as a reflection of socially situated identities – ways of being that inform the world what "type of person" you are. The Discourses that Onie, Jazmin, and RaeRae hold reflect their intersectional identities. They are taken up in a world where white supremacy is so "hegemonically woven into the fabric of our US society they [racisms] operate almost invisibly, like the air we breathe" (Matias and Newlove, 2017, p. 920). The prevalence of other "invisible" Discourses presents a conceptual and analytic challenge – we must understand how these dominant Discourses operate to observe the barriers they present to other Discourses.

The extent to which youths' Discourses are embraced, then, depends on where they are and with whom they are engaging.

The premise of this study – that equitable STEM learning requires an expansive stance on valued knowledge – must also be applied to Discourses. Looking at the experiences each youth co-researcher had in GET City helps highlight the practical implications of this conceptual premise: If Discourses are contested (e.g., Jazmin's Discourse of independence was not honored in her forced group work with others) moments of alienation and frustration can occur. Discourses that are welcomed and engaged with by the makerspace community and educators lead to a greater sense of identification with the makerspace and making work. For example, Onie was able to call upon her Discourse of respectful scaffolding to enhance her jigsaw skills.

Each youth co-researcher offered concrete ways in which normative systems of power could be resisted based on her own experiences in GET City. The co-researchers' visions of equity, of "designing a makerspace where everyone can feel good bringing their out-of-school knowledge" (the language used during this project) aligned strongly with their Discourses. Who they are is reflected in how they suggest spaces are structured. It tells us that opening space to work against the educational debt owed to students of Color necessitates recognizing a full person — their ways of being and their funds of knowledge.

This focus on Discourses has expanded my view of equity and helps us theorize the myriad ways in which we can work to push against the interaction of power hierarchies that erase the ways of being, talking, valuing, thinking that matter to youth. Matias and Newlove (2017) point to the epistemic hegemony of whiteness in the United States; Evans-Winters (2017) names disciplinary processes in schools that silence Black girls; Barajas-López and Bang (2018) challenge western epistemological frames as part of their validation and celebration of

Indigenous knowledge systems in STEM-rich making. Each these examples demonstrate how people in those systems of power can work to give space to those silenced Discourses.

An Expansive Perspective on Seeking Funds of Knowledge

This study helps identify the powerful ways funds of knowledge can stretch across social networks. For example, Onie's fund of knowledge around video games was first cultivated as an important way to spend time with her family. Being able to engage in this activity also offered her social clout with peers and has expanded the communities she can claim membership in and engage with online. Similarly, RaeRae's ability to engage with her funds of knowledge around "looking cute" is mediated and influenced by her mom and is part of an ongoing conversation with her peers and popular culture about what is fashionable and important messages that can be sent with clothing and make up. This expansive perspective on how funds of knowledge draw from multiple networks offers a better insight as to how youth think about the knowledge and practices that contribute to their success and well-being.

Looking at how a wide range of experiences can contribute to different funds of knowledge allowed me to better understand the multidimensional ways in which youth engaged with their funds of knowledge. For example, Jazmin's fund of knowledge around artistry goes beyond simply her technical skill across various art forms — she explains that she can call upon her knowledge about art and related skills to calm her down when she is stressed. The personally meaningful ways in which she calls upon her funds of knowledge around artistry helps demonstrate how her skills and abilities are used to multiple ends. Recognizing the multi-layered nature of funds of knowledge can help widen the approach researchers take to better understanding how and where funds of knowledge are developed and called upon.

Appreciating this level of nuance within each youth co-researcher's funds of knowledge helped clarify the ways in which the youth co-researchers were calling upon their funds of knowledge in ways we had not previously appreciated. For example, RaeRae's funds of knowledge around dogs were so involved that she was able to engage in a critical questioning of the Ingham County Animal Control Director during a meeting where we expected she would be receiving information rather than directing the tone of the conversation. Similarly, Onie's fund of knowledge around random building was not just important because she had the patience to figure out how to make a pucket board — her experience with making her own projects at home inspired her to find pieces of wood that were far larger than she needed and to make many cuts. These additional steps could be perceived as time consuming or not considerate of resources by educators who did not know her; however, they were an important part of her bringing in her funds of knowledge, applying and expanding them with the use of this new tool.

As educators think about how to engage with and center youths' funds of knowledge to learn about STEM practices and concepts, appreciating this depth is helpful. For example, Jazmin's boredom building is more multifaceted than simply being able to build; it includes an eagerness to plan and consider constructions. If we had recognized this earlier we could have built from this, encouraging her to use planning as an intentional research step, sketching out objects that were similar to her desired goal.

Getting to know the depth of youths' funds of knowledge requires an authentic interest in and conversation with young people. Funds of knowledge work has traditionally called upon teachers and researchers to speak with parents about their children's areas of out-of-school expertise (Fraser-Abder, Doria, Yang & De Jesus, 2010; Gonzalez et al., 1993). It is not clear to me that a parent could share the richness and meaning of these funds of knowledge on their

child's behalf. Acknowledging the importance of including youth in this conversation has implications for how we seek to better understand funds of knowledge. As mentioned in the previous section, a fundamental building block for establishing relationships that are grounded in trust has to do with having authentic conversations with youths' Discourses. Before considering youths' funds of knowledge, there must be some mutual respect of Discourses.

Implications for Makerspace Education

The stories told by each youth co-researcher demonstrate how youths' Discourses can open space for them to leverage their funds of knowledge toward their STEM-rich making. To support opening this space, educators must be aware of how dominant Discourses in STEM and making work to silence youths' Discourses. The positionality of educators is also implicated in this reflection, though rarely discussed in makerspace literature. The focus of much makerspace literature foregrounds youths' interests which appears to invite the assumption that by being backgrounded, educators are exempt from setting the tone of practices and Discourses in the makerspace (e.g., Martin & Dixon, 2016; Peppler, 2013). Not explicitly inviting educators into the critical questioning of makerspace practices and culture ignores the historicized power dynamics that individuals exist within, muting the hard work that adults must do to push against those dynamics. It also does not do justice to the effort and relationship building educators must engage in understand the depth of youths' funds of knowledge.

The stories shared across Chapters Four through Seven offer suggestions about how pedagogical practices grounded in youths' Discourses can open space for equitable approaches to maker education. The design implications shared by the youth co-researchers help us understand how educators can better support youth in a subject area that can be traditionally alienating. For example, Onie's design implications highlight her concern for careful scaffolding and

collaboration. Her description of each recommendation is grounded in an empathetic thoughtfulness that makes it clear she cares about the experience of future young makers. This is a stark contrast to the ways in which STEM subjects are typically taught in a "gatekeeping" manner, focused on maintaining standards to ensure exclusive access to college courses (Aikenhead, 2011). Even current reform efforts like the NGSS, which purports to work against exclusive access to STEM, does not work to engage students with this degree of care about their experience and values – rather, the focus continues to be on how to bring youth in to participate in a dominant vision of STEM, with no disruptions. Jazmin's design implications also build from her desire to support those around her – thinking about how everyone can share their most meaningful work. This again shifts away from the pedagogical approaches that position STEM as a finished body of knowledge and of assessment practices that maintain a narrow range of what constitutes acceptable evidence of STEM knowledge (Vossoughi, Hooper & Escudé, 2016).

Both Onie and Jazmin present design implications for makerspaces that are focused on helping educators realize they need to shift power in distinct ways: by trusting youth and by expanding conceptions of whose knowledge counts and for whom STEM-rich making should be produced. These recommendations shape opportunities for youth to engage with STEM-rich making by re-balancing assumptions around what is regarded as valuable in STEM-learning spaces. Jazmin's recommendation that makerspaces recognize multiple ways of demonstrating knowledge is a clear push against positivistic and rigid ideas about engaging in scientific and engineering processes. Her recommendation that youth makers receive feedback on the social aspects of their project by people involved with the problem being addressed shifts power to the voices of those who have been left out of mainstream conversations about their own experiences

(Evans-Winters, 2017). It affirms the need for what critical race scholars have consistently called for – letting those most impacted by systems name their own reality (Ladson-Billings, 1998).

RaeRae's Discourses and design implications remind us of that experiences of Black girls in STEM are neither heterogenous nor generalizable. Positioned within dominant norms in more deficit ways than either Onie or Jazmin, RaeRae's Discourses represent self-preservation on grander scales than Jazmin or Onie have needed to cultivate. The design implications I inferred from our conversations are, accordingly, large pushes against oppressive systems of power. They are fundamentally humanizing – asking first that mentors assume capability and possibility, and secondly that trusting relationships are foregrounded in the making process. Her third design implication represents a call for maker educators to embrace the many ways in which we can understand youth as capable and belonging in STEM. It also encourages both educators and youth makers to engage in a more expansive understanding about the work of scientists, engineers, and mathematicians.

As Onie and Jazmin were able to make their recommendations concrete in the co-planning activity, their work served to extend the limited literature around what designing an equity-oriented makerspace can look like. The few research-based articles that do discuss the design of a makerspace do so largely in terms of ideal outcomes without offering more concrete pedagogical suggestions that speak to the opportunities and challenges inherent in the ideals they aim to meet.

Concluding Contributions

Participatory Disruptions of Power in Research

Participatory research can be shaped in many ways – and in doing so can attend to power dynamics differently. Bang and Vossoughi (2016) list no fewer than ten different approaches and

methodologies that exist within and grow from the epistemological and ontological sensibilities of participatory research. This study was not led by youth (I came to them with specific questions), but it did work to disrupt the normative power dynamics of doing research on participants, instead working with youth. The methods of this study demonstrate the capability and thoughtfulness of youth, capacities that many adults neither presume nor respect (Kohfeldt, Bowen & Langhout, 2016). My hope is that this study contributes to methodological considerations that promote a more democratic inquiry into issues around equity in education.

There are many ways in which youth co-researchers can contribute to the direction of a study and meaningfully take action in the study in ways that are both interesting, meaningful, and age appropriate. As I worked with Onie, Jazmin, and RaeRae I found that our most meaningful conversations happened in moments where they took control of our time together and began pursuing their own agendas: talking about camping, making hot glue gun cases, snap chatting friends, and many other tangential activities I did not anticipate. None of these activities were part of my proposed methods; indeed, several approaches I suggested (developing a 'Me Map' and interviewing important family members) did not come to bear on the study in successful or helpful ways. O'Donoghue, Kirshner, and McLaughlin (2003) ask that adult researchers continually reflect on how they are defining "participation" for their youth co-researchers, reminding adults that if they want youth voice, youth must be able express themselves on their terms and be empowered to engage in decision making about a study. Methodological flexibility was key in this study, encouraging youth to participate in ways they were comfortable with and contributing in ways that were authentic representations of their interests. By letting youth lead I was able to see and appreciate their skills and abilities in much

more multidimensional and personal ways than if this had been an interviewer – interviewee relationship.

Another methodological contribution I hope this study offers has to do with discussing the challenges that can accompany partnerships and the fruitful ways of navigating those challenges. Asking youth to join a study as co-researchers requires re-defining roles. Doing so involved a re-conceptualization of power dynamics and boundaries in ways that were far more fundamental than simply the research space where I had explicitly recognized the need for their voices to be elevated. Asking the youth to join me for this project required that I served as shuttle for both Onie and Jazmin, picking them up and dropping them off at various family members' houses. These trips resulted in great car conversations and meeting grandparents, neighbors, and pet geckos. Another hurdle that highlighted other boundaries and expectations I did not realize I had happened when I lost contact with RaeRae over the summer of 2018 and with Onie over winter break. Phones broke, parents' phone numbers were disconnected, and schools changed. RaeRae and I were able to reconnect over Facebook messenger, Onie and I over email. This reiterated to me the importance of maintaining relationships with parents and guardians, regular contact, and ensuring that I was available on based on the schedule of the youth co-researchers. Youth are in control of only small parts of their time, so it was important that I respect the free time they were able to offer myself and this project.

This study points the value of surfacing issues of intersectional injustices and interrogating those injustices in partnership with those intimately affected by them. This interrogation requires a willingness of researchers to examine their complicity with systems of oppression as we work to push against them. The tensions that arise from participatory research are important and should make those in positions of relative power uncomfortable. The efforts of

participant co-researchers should inform the ways in which we work to disrupt systems of oppression and injustices – in research, in education, and in everyday assumptions we make of others. To this end I hope the knowledge and experiences that Onie, Jazmin, and RaeRae shared expand the perspectives of those who read their stories. Their messages of power and possibility should inspire researchers and practitioners alike to approach their work from more humanizing and asset-based perspectives.

Disrupting Power as a Practitioner

Co-planning a making activity with Jazmin and Onie was a personally transformative experience, as was discussing their design implications. The practical and hands-on complication of power was an opportunity for me to reflect on how my whiteness as property (Harris, 1995) led me to understand myself as capable of developing making activities and conceptualizing equity for Black youth. I found myself particularly humbled and appreciative of their guidance and openness in the articulation of the design implications. Moments that I had not thought twice about were pivotal to their understanding of equity, and moments that I identified as a struggle they empathized with and pointed to the power and possibility that could arise in the future. For example, I had not appreciated the depth to which Onie appreciated being able to consistently use the jigsaw, nor did I understand the attention that Jazmin paid our openness with resources. In these instances, the youth co-researchers and I had shared interactions, but we each perceived the experience differently. This helped highlight the extent to which we pay attention to different things and value them in different ways. While developing their making activity they each displayed care and attention to the experiences of youth in a way I was unable to.

I did not know what it would look like to cede the focus, direction, and content of these activities to Onie and Jazmin — none of us had co-planned a lesson before. The approaches Onie

and Jazmin took to developing a making activity were uniquely theirs and reflected their personal Discourses and experiences; each approached the task in a different way. In doing this together they shared with me expansive ways of re-imagining what STEM-rich making could be.

Ryoo and Calabrese Barton (2018) point out that the "pedagogical approaches and designs of many makerspaces have not systematically taken up the educational needs and rights of students from non-dominant communities" (p. 4). Involving and supporting youth in the take-up of their rights and needs is an important way to ensure the construction of making activities begins to speak to their lived realities – the counternarratives that I cannot know. Engaging in this process helped me realize the extent to which the experiences of the youth co-researchers make them more qualified than I to offer critiques and suggestions for how equitable making could be shaped.

Limitations

Although I believe this study holds important implications for the field of educational research and makerspaces seeking to more equitably welcome all youth, my findings are limited by several factors. This was a study done with only three youth, and of those three youth only two were able to complete the entire project. It is worth noting that RaeRae, who could not complete the project, had different experiences in both the Boys and Girls Club and GET City as a result of how she was positioned within dominant Discourses of discipline. Her perspective is valuable where she was able to offer it, and the study would have been richer had she been able to co-plan a making activity. This leads to another important limitation — the experiences of three Black girls cannot and do not represent the experiences of all Black girls engaging in STEM-rich making work. This study offers a small stage for three youth makers to share their experiences from one context. Although they all had different experiences, GET City itself is

focused on being embedded in the community and is not representative of mainstream makerspaces. The recommendations that youth from other makerspaces might develop could focus on a wide range of other problems.

Futures Lines of Research

Completing this study helped me think about how the findings that have come from it could be expanded and provide the basis for future work. Firstly, I think there could be value in repeating this study in different contexts. I mean this both in terms of the literal makerspace context (e.g., a makerspace not already considering issues of equity and community-based making) and the different experiences of youth who have different lived experiences (in terms of race, gender, socioeconomic status). Examining the utility of the figure relating Discourses, funds of knowledge, and experiences in STEM-rich making environments in different contexts could provide some interesting additional reflections on how different structures of power manifest and mediate youths' engagement with STEM-rich making. I would want to ensure that this larger conversation still contributed to the overall goal of understanding equitable engagement in makerspaces. I do not want to lose the voice of Black girls in this expanded consideration.

A final way I see this study as contributing to future research revolves around supporting educators in engaging with the process of understanding and centering youths' Discourses and funds of knowledge. There has been a fair amount of work done for practitioners about the need to approach funds of knowledge work with deference and respect while talking to families; however, this literature does not address working directly with youth to these ends. I believe this work could work to connect other bodies of literature (e.g., developing culturally sustaining and relevant pedagogies, humanizing research) and offer productive new ways to consider how to

support makerspace educators in creating a space where youth makers are able to engage in meaningful, equitable making.

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