Mobilities of Criticalities & Pathhacking into STEM: Learning from minoritized youth

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Over the past 15 years, we have followed youth across the spaces of home, school, and after school across the middle grades, following some of the youth into college. One goal of this work has been to make sense of youths' pathways into/out of/through/in STEM, and use to our understandings to co-design (with youth) for pathways that are equitably consequential. By equitably consequential we suggest that learning and becoming are forward directed and transformative for both the self and the community, such that acts of learning and becoming contribute productively to, and help to legitimize, an ever expanding range of ideas, tools, resources and ways of being in STEM.

For this workshop we are focusing on our data from youth we have gotten to know over the past three years in community-based makerspaces, and their middle school classrooms.

From a connected learning standpoint, we have 4 key ideas that we think contribute to equitably consequential pathways into/within STEM:

- Importance of "contact zones" for space making as an act of brokering
- Importance of critical STEM identity artifacts in brokering
- Viewing brokers as navigating political terrain as interest driven takes political dimensions as youth fight systemic racism, classism and sexism in their efforts
- Youths' engagement in Making as how they "pathhack" into/through STEM

1. Space-making for brokering/bending/expanding social networks and possibilities for becoming in STEM.

Mobilities of learning studies remind us that learning always takes place *somewhere,* both in "relation to history (time) and context (place/space)" (Bright, Manchester, Allendyke, 2013, p. 749). One thread of work that is particularly salient to our own work is that which examines space-making as a part of more expansive views of learning. We use the term space-making in ways similar to that of place-making (e.g., Cresswell, 1996; Massey, 2005; Lombard, 2014). An individual's opportunities to be and to become are shaped by place. At the same time, who one is also gives meaning to place: "Places do not have intrinsic meanings and essences . . . the meanings of place are created through practice" (Creswell, 1996, p. 17).

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

For example, we look at how the playing field *in after school making clubs* (*one area of space-making*) transform for the youth as they refine the problems and designs they worked on in both technical and social ways, expanding their connectedness to others, and the access they have to ideas, tools, and resources for advancing their expertise (Vossoughi, et al, 2013). We explore how youth's making also transform the playing field *among peers, family, and community* (*another area of space-making*). The youths' design work impacts being in community with how their making artifacts impact life there, at the same time they make doing engineering an insider practice, something owned by the community. We also look at how the *playing fields of STEM, both real and imagined* (a 3rd area of space-making) transform. The youths' practices serve as new tools to expand the purposes and goals for engaging in STEM.

We consider the importance of designing for maximal zones of contact (across stakeholders and salient issues across youths' everyday lives in different spaces –home, community, school, informal Maker program) in supporting such space making. Previous studies on makerspaces primarily viewed them as closed learning environments or bounded communities of practice in which individuals participate in core practices regarding making and become a legitimate member of the communities (Halverson & Sheridan, 2014; Sheridan et al., 2014). However, the youth in our projects show us that their makerspace work is much more flexible, and positioned "in a nexus of relations" to various physical and virtual locales, such as home, school, pinterest, playgrounds, and transportation routes. The juxtaposition of these locales, "and the contact zones between them, become an expanded terrain of examination and evidence" concerning both making and place (Leander, Phillips, & Taylor, 2010, p. 336).

We are concerned with mechanisms (youth-driven, broker-driven) that promote, legitimize, and expand zones of contact, with particular attention on the following three:

- Youth create contact zones between places created by the funds of knowledge they leverage towards technical design starting points. For example, Samuel knew how a football spirals and this led him to investigate how to weight the batteries in a light up ball he made. Jennifer knew how her Dad insulated a fireplace as a starting point for thinking about non-bulky ways to heat a jacket.
- Youth also created contact zones by the tools they appropriated for new purposes. For example, Pinterest served both as a tool for Emily & Jennifer to position themselves with authority, given their expert status with computers, and giving them time to think through the fashion side of their design, while seeking safe inroads to the tech side of the task. Emily developed new tests for assessing the quality of the heating system in her heated jacket when the standard quantitative thermometer test proved too limiting, such as the skin test, and the timed test.
- Youth also created contact zones by leveraging their insider social networks. They strategically brought new and different people into the design conversation, such as their friends, parents/grandparents, teachers, engineers, and little kids, entangling technical and social concerns in their designs in ways that advanced the technical

quality while deeply ensconcing themselves and their networks as an integral *parts* of their design.

This blurring of spaces – zones of contact – helped to "deterritorialize" the making space and the broader space of doing STEM (Fendler, 2013). Who can make and whose knowledge matters is surfaced and challenged as the histories and geographies of youth makers shape the ways in which they bound the problems they sought to solve and the solutions they developed.

2. Critical STEM identity artifacts as brokers.

Much of the writing looks at how people broker, and that of course is important. But we have also noticed that critical STEM artifacts (CSIA) that youth produce also play key brokering roles. We define CSIA as significant STEM artifacts or experiences youth produced while engaging in STEM activities. For example, Quentin produced a CSIA when he made a short video highlighting a malfunctioning heater in the stairwell of a local University in the summer, with temperatures peaking over 130 degrees fairenheit. Quentin documented this phenomenon by measuring the temperature in the hallway and asking an adult mentor running his summer program to send the video to the university facilities department. After watching Quentin's video, the energy engineer at the local university took his movie seriously, and wrote a memo to describe the needed repairs based initially on his investigation. Such recognition by the University engineer confirmed that Quentin's efforts were scientifically powerful and important. When post-its were placed on the broken vents by facilities to indicate that repairs were in progress, Quentin's actions were further made public to the broader community. When Quentin referenced these accomplishments in his application to another summer program held at a Technical University, he further leveraged his CSIA towards brokering for new STEM opportunities.

A similar movement of CSIA as brokering tools can be seen with Jana, Caitlyn and Chantelle's example. Concerned that their community club was cutting some youth programs due to budgeting issues, they embarked on an investigation on how their community club could save money by becoming more energy efficient. The girls "imported" a broader community club issue (budget crisis and impact on youth programming) into the learning space of their Maker club. The girls performed an energy audit at the club and presented the results to the club administrators, with suggestions on cost-cutting measures. They later sought for permission in their middle school to conduct, and document, a similar energy audit investigation, which resulted in a short documentary and school workshop for student leaders. The creation and movement of these CSIAs all played a role in a 10-month process of expanding their opportunities to learn and become in STEM, across space and time.

These artifacts, as they become reified within and across communities can expand views of success, such as reifying youth as hard workers, committed citizens, or innovators. As CSIAs move with the youth across settings and overtime, they become layered with new meanings which shift how the youth (and others) envision their futures and make sense of their past experiences. These artifacts also offer youth and their community, imaginary views of possible futures.

3. We are also concerned with the deeply political nature of connected learning and social network building, in pushing past Making interest as neutral "hobbyist" concerns to highlighting nodes of criticalities in youths' lives

We see youths' efforts to author pathways into STEM as more than interest-driven or about bridging worlds. Interest does matter, but so do the ways in which such interests are forged within historical geographies where issues of power, privilege, and location deeply shape opportunities to learn and become. While bridging is important, it is in how this bridging makes possible new and more expansive ***spaces*** for learning and becoming transformative ways that matters most; in ways that may have significant impact on broadening participation.

For example, Kairee and Mirabel invoked and risked new narratives for Making when they prototyped a "rape alarm jacket" for teen girls in their community. While neither girl identified as a "science person," both identified with the community survey results they had collected, where many community members stated that "walking home alone in the dark" as a major safety concern. Kairee and Mirabel connected this last survey response to a local news story they had seen earlier that year about a young Black girl who had been sexually assaulted in their area. An anti-rape jacket positioned the girls with agency and voice over an act meant to silence and dominate. This focus provided direction to the girls in how they might move from a sketched out idea to a workable prototype, and who they needed help from in the process. The new idea drove the girls to conduct research that neither they, nor their mentors, had thought of before. Instead of searching for a jacket that yells for help on the internet as their first step, they began by searching rape statistics of African American girls. They wanted to know who was most at risk for rape. They felt that this data was necessary because it might impact the color, size, and style of the jacket. When they presented their prototype for feedback to members of their community during a more formal feedback cycle day involving community members, local engineers and scientists, and educators, they framed the problem space personally: That girls *their* age "made up 44% of the rapes" in their community.

In stressing criticality, we push on the notion of "interest-powered," one of the hallmarks of connected learning. Interest powered learning are always connected to politics, and place a high value on activity that is tied to both civic and political outcomes (Ito et al, 2013, p. 60). This is certainly true of the youth's interests, with whom we work. However, when considering equitably-consequential making for youth, the kinds of experiences, relationships, and identities that youth are allowed to connect with their making, have often been trenchant, imbued with the perilous nature of their peripheral positioning in society. The risk-taking here for youth is quite high, and puts a different spin on what it means to work towards political outcomes. The youth are driven by critical interests grounded in unequal power-dynamics in their everyday lives and that fundamentally impact their survival. The anti-rape alarm jacket exposes the limits of interest-driven framing for young women. The need to outfit a jacket with a rape-alarm reflects the girls' experiences in the world, and how they have learned to navigate and respond to those experiences through the power dynamics that play out there, both in-the-moment, and

historically. The youth's focus on the jacket was not as much interest-driven as it was an attempt to make in ways that positioned them with agency over the dangers in their lives.

4. Pathhacking their way into/through STEM

STEM is not an easy world to navigate for the young people with whom we have worked. A fun activity, a personal connection, or a scientific understanding is often not enough for youth to see themselves a part of that world, although these are the solutions often offered in classrooms or reform documents. That is, as the young people we work with engage in moments of identity work, over time and space, they are continually confronted with a myriad of challenges, built into the social and institutional structures in which their activities take place, that seek to silence or diminish their contributions and ways of being (Collins, 2009). These youth have had to author new routes that demand re-organizing worlds and/or creating new worlds for their identity work to be recognized and valued.

In reflecting on the first 3 key ideas, we consider the question of how minoritized youth imagine and *hack* paths into STEM across the spaces of their lives. It appears that a salient feature of this path hacking relates to how these young people try on new ways of being through their varied forms of engagement and actions in response to particular norms or sanctions of the worlds they inhabit. As the youth determine to locate their STEM experiences within the nexus of intersecting spaces in their everyday lives (maximizing zones of contact), as they seek to mobilize resources (e.g. critical STEM identity artifacts) to augment and advocate for ways of engaging in STEM that matter to them, they are "pathhacking" a route into STEM. We use the term *hacking* because it refers to the need to wield creative force and agency to imagine a way forward, most of the time through unclear territory, with unknown outcomes or stopping points along the way. We also use *hacking* to convey the characteristics inherent in authentic, hacker subculture; that of playfulness, excellence, and boundary pushing, all undergirded in egalitarian principles (Himanen, Linus & Castells, 2001). We see these youths' identity work in STEM reflect these similar characteristics, as they seek for more elbow room at the STEM table, and opportunities to transform that table. There is force in our view of hacking because there is resistance. Our point on resistance is salient, given that the traditional pathway laid out for minoritized youth is AWAY from STEM **(**Gándara, 2006; Triana & Rodriguez, 1993; West-Olatunji, Shure, Pringle, Adams, Lewis & Cholewa, 2010). However, their hacking is often seen in the contemporary sense of hacking, that of *trespassing*.

Conclusion

Youth need (and we must design for) the zones of contact (funds of knowledge, tools, and networked connections) that allow for the design/movement/re-purposing of identity artifacts and the access to new allies/brokers for hacking new pathways in many different kinds of spaces and over time. In this workshop we would like to be able to share our framework for thinking about this more politically entrenched brokering work in STEM as well as the youth participatory methods we employ to do so. At the same time, we hope to learn more about others' approaches and to have others help us to see the holes in our work. We have not participated in a DML workshop before and are open to suggestions for

how to engage the workshop so that it is most productive for us and the rest of the attendees.

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