Hacking a Path In and Through STEM: Unpacking the STEM Identity Work of Historically Underrepresented Youth in STEM

Edna Tan, University of North Carolina at Greensboro, e_tan@uncg.edu
Angela Calabrese Barton, Michigan State University, acb@msu.edu

Abstract: In response to the vast inequities minoritized youth experience in STEM, we investigate how minoritized youth imagine and author pathways towards becoming in STEM. Drawing from social practice theory, identity and mobiliites of learning, we investigate, through critical longitudinal ethnography, how youth hack a pathway in and through STEM as they remix and repurpose tools, practices, relationships and artifact within and across the STEM-related worlds in their lives. We present one case study to articulate how youth engaged in pathhacking identity work to both gain access and transform both the process and outcomes of STEM participation in both informal programs and school science. The process, salient factors and implications of pathhacking identity work are discussed.

Keywords: identity work, minoritized youth, STEM, equity

"When I think of STEM pathways I think of science fairs and stuff. I don't think I was ever that kind of a person... It makes me feel like an imposter to call my pathway a STEM pathway." - Cathy, pre-med university freshman

Introduction

Large gaps in achievement and interest in engineering and the physical sciences persist for youth growing up in poverty, and in particular for African American and Latino youth from low-income communities. These gaps persist across all levels of educational attainment. In the United States the percent of bachelor degrees awarded to African Americans in engineering in the U.S. has hovered around 4% (Yoder, 2014). The research literature documents many reasons for these persistent gaps, including inequitable access to resources, quality instruction or role models, along with cultural barriers and stereotypes (Margolis, et al., 2008; Oakes, 2005).Yet, success in the sciences and engineering is one viable route towards personal and/or community economic advancement for youth growing up in poverty. It also factors into opportunities for informed, meaningful, and empowered democratic participation. That lower-income communities of color experience the greatest levels of environmental injustice in the US, and often have the least voice in STEM-related decisions affecting their communities are further evidence of the impact of persistent inequities in access to the sciences and engineering (National Academy of Engineering, 2010).

Our work is in response to these vast inequities that youth from lower-income communities of color face. We know that institutional and classroom level practices in schooling and society have unfairly positioned lower-income youth and youth of color as non-experts and outsiders to STEM. Even when such youth succeed in science academically, they disproportionately do not view themselves as having a future in science. Take, for example, Cathy, whose quote opens this paper, is an African American female growing up in a lower-income community and attending a majority minority school, Cathy performed well in school and earned a full scholarship to college. Later, Cathy points to the people and out of school experiences that kept her in STEM despite not having access to the more traditional STEM enrichment experiences of the prototypical STEM person. She sees herself as an imposter in STEM, one who does not belong, despite her academic success.

The overarching question that guides this manuscript is: *How do youth imagine and author pathways towards becoming in STEM*? We use the term "imagine" to capture, as Boal (1974/1979) might say, the places where expectations can become desettled, generating new practices grounded in the world as it is, and the world as it could be. In particular, we are interested in the ways in which youth navigate their worlds, and author spaces of learning, doing and becoming in STEM. Tensions arise, however, when the different institutional, social, cultural and political forces push back on youth as they work to author these pathways, as Cathy noted in her comments, causing her to feel like an imposter.

Conceptual framework

We draw from both social practice theory and mobilities of learning studies to frame identity as constructed in social interaction, over time, and across many different spatial (physical and virtual) locations. We take as a

starting point the idea that identity is constructed in practice – practice that requires knowledge, skills, and ways of thinking that characterize the community in which one is engaging (Holland, Lachicotte Jr., Skinner, & Cain, 2001). Identity is also a highly social and dynamic construct and is related to how individuals are recognized by others at any given moment, in ways that support or work against who they are and want to be. However, neither one's agency to act in particular ways or how one is recognized by others for what one does, are constant. Such things can quickly change as individuals move across space and time where their individual and collective actions are differentially enabled and constrained by social structures-in-motion.

We therefore find it more productive to focus on *identity work* rather than identity itself. By identity work we refer to the actions that individuals take and the relationships they form towards becoming particular kinds of people. The reception, or recognition, of these positionings by the community highlights the dialectical nature of identity work. Because identity work happens within and against local norms and expectations and as a part of longer standing sociocultural and historical narratives, its outcomes are always uncertain and gain new meaning as they get traced in time.

Leveraging on a mobilities of learning framework (Engeström & Sannino, 2010; Gutiérrez, 2012) helps us situate identity work across multiple time scales, different spatial (physical and virtual) locations, and both vertical and horizontal dimensions. The real and imagined geographies of learning experienced by youth as they work on, and within, the powered boundaries of science and community, all play into how young people position themselves with and against the normative expectations of becoming in science (Bright, Manchester & Allyndale, 2013). Studies have documented how individuals navigate and bridge the worlds of home, school, and community, including how they move people, practices, tools, and ideas across these settings (e.g. Ehret & Hollet, 2014). These studies remind us that there is continuity between youths' worlds and that of science and that we best understand these worlds as "generative resources in learning new ideas and traditions of inquiry" (Warren, Ogonowski, & Pothier, 2005, p. 121). They have also led to the recognition that youths' mobilities among a vast range of learning arrangements makes learning and identity work always "tangled up" among practices in complex ways (Rahm, 2012).

Identity work across time and space is one way to understand how youth author paths to possible futures in STEM. Possible paths are created and facilitated by power-mediated opportunity structures that some youth can traverse, but others struggle to understand, let alone be welcomed by. Often times, youth-centered actions towards path authoring are not recognized by traditional structures and gatekeeping authorities (Authors, 2013). A focus on how youth author paths through their identity work highlights the forward trajectory of young learners' decisions and opportunities toward promising possible futures in/with science. Seeing such movement allows for nuanced examinations of the twists and turns a possible path takes throughout individual learning landscapes. How youth choose to engage in science, for what purposes, where and when all shape, and are shaped by, the people, places, events, and power structures that constrain or expand activity. This approach also foregrounds the multiple directions one may take with science, the various on/off ramps into/through science, and the agency youth have to author within/across the multiple layers and contexts of learning experiences in science.

Methods

We draw from data spanning 12 years of research (2013-2015), across four studies, including two that are on-going. These studies have all utilized critical, longitudinal ethnography, where we have followed youth across sites (four states), spaces within sites (community-based, home, informal science, school science), and time (focused, youth case studies that are between one year long to 5 years and ongoing). For the two cases presented, we observed Quentin for 6 years in both formal school science and informal science settings, in a Midwestern state. For Melanie, we observed her for 1.5 years in her formal school science setting in a Northeastern state. We purposefully select these two cases to highlight the importance of two different grain-sizes of longitudinal ethnography and the focusing on different spaces. These two cases also allow us to unpack the kinds of pathhacking identity work that can take place across these varying spatial and temporal domains. Data sources (Table 1) include extensive fieldnotes across sites for each case study youth, narrative and artifact interviews with youth, focus group interviews with youth and their peers, interviews with teachers and adult mentors, and STEM artifacts youth produced.

Table 1: Date Types Generation Strategies

Data Form	Specific Data Generation Strategy	Quentin	Melanie
Participant Observation	• Informal science setting (Green Club): Video recordings of twice weekly sessions and field notes	60hrs/yr 20hrs/yr	n/a 130hrs

	• Formal science classroom: Observations and video recordings		
Interviews	• Focus groups & solo interviews	10hrs/yr	5 hrs
Artifact Think Aloud	• Allowing youth opportunities to talk about their engineering design work in detail (mid and end of year)	2hrs/yr	2hrs
Artifact Collection	Youth's science related work collected: examples include school science projects and classwork; for Quentin, also artifacts from Green club, including sketch up notebook, 3D Google SketchUp model of design, worksheets, prototype, movie, etc.		

Analysis

Data was analyzed by our research team in the grounded theory tradition, using a constant comparative approach (Straus & Corbin, 1998). We first engaged in open coding by thoroughly perusing all generated data (e.g. transcribed interviews, observation fieldnotes) to surface a) critical episodes of STEM engagement that youth subsequently leveraged in some way for future STEM engagement; b) how youth positioned themselves during these critical episodes; c) how youth responded to how others positioned them within these episodes; and d) the artifacts youth chose as most representative of them in STEM, and why. We took these codes to be signifiers of the identity work youth were engaging in. Weekly conversations were held between the authors on these insights as a way to work towards a more "expansive consensus"; that is to say that any differences in view were debated until new meaning was generated as a result of our differences. A detailed list of emergent open codes were kept with analytic memos attached to them which we brought to bear on the second pass at axial coding.

With our theoretical framework as a guide, we then looked for evidence of how youth repeated performances of salient identities-in-practice, across space and time. In particular, we looked for what youth did (the actions they took), and how they went about it (the resources they recruited), to create new opportunities and spaces for becoming in STEM that were previously denied. The relationships and connections identified in this second stage of coding, in turn, guided our selective coding, and became categories and themes, from which our example cases were selected for a final round of analysis and presentation

Findings

We purposefully selected two case study youth, Quentin and Melanie, as focal cases. We highlight these two cases because they reflect two highly dynamic cases of identity-in-the making, where youth respond to and push back against the people, contexts, sociocultural histories and normative views and expectations, all of which shape their opportunities to become in STEM. In both cases, the paths authored by youth are non-traditional and non-linear, involving identity work that required creative cross-leveraging and re-mixing of available resources.

Their stories help us to see how identity work, in the moment and over time, make authoring paths into STEM more or less possible. At the same time, we selected these two cases because they reflect a profound difference in how identity work in the moment and over time juxtapose in ways that productively yield possibilities for the future, both real and imagined. Whereas Quentin eventually both narrates and embodies a possible future in STEM, Melanie struggles to connect who she is and what she brings to the STEM table as something that holds potential, despite her moments of success. These differences in their stories help us to describe the complicated process of path authoring through the on-going and high contentious interactions among self, science and social contexts. Finally, these two cases were selected because they help us to interrogate how the matrix of race, class and gender intersect and play an active role in the on-going opportunities youth imagine as possible in path authoring. The differences in timescales between the two cases are further leveraged to shed light on how the simultaneous use of different timescales helps to surface the insight on the role of in-the-moment identity work on imagining and authoring pathways in STEM.

For the purposes of this proposal, we present only Quentin's case.

Quentin

Quentin is a gregarious African American young man growing up as an eldest son in a single parent family. In the six years we have known Quentin, his family has moved three times in search of more affordable living conditions. We first met Quentin when he joined the Green Energy Club [GEC] afterschool program in the fifth grade, at the insistence of the Club's main director. He told us that he did not mind being in GEC because he

could "use the computers to make movies" and "do things" for his community. However, he also indicated that he was not interested in science.

Vignette 1: Quentin's letter to his 5th grade teacher

In January of his 5th grade year (6 months into the school year), Quentin wrote a letter to his science teacher. He entitled his letter, "BRINGING FUN SCIENCE TO YOU! (A.K.A) MR.B!".The text of the letter is as follows:

> Hi Mr. B, this is your student Quentin the first one in the 2nd row. I'm going to tell you about things that we should to in Science. I'm in [GEC] and [GEC] helps me get my grade for science to like a B or a A. I really don't like getting lectures and getting assignments out of those 20 year-old science books, it doesn't have the latest science news and new experiments.
>
> I do things out of school and out of GEC that involve science. I went to door to door and ask adults if they use CFL lights. The majority of the adults did NOT use CFL lights, I will try to decrease the amount of people who use incandescent lights. I did it on Wain Wright Ave. and I did it because people's bills are up because they use just Incandescent lights. In GEC we made a word that is probably not going to be in the dictionary, but anyways the word is called Fcience, it is Fun and Science put together and I want you to make our science class into a Fcience class. Here's the definition of Fcience: Doing things that are interesting that include scientific things.
>
> Its not so much for energy that I get attention in school, but for being a smart alek. I think that should be good. GO FCIENCE!"

Vignette 2: Power-Sucking Pigs, 6th grade & 6th grade science

In the summer leading into 6th grade, Quentin participated in a two week GEC summer program focused on solar energy, which took place at the local university. Quentin investigated solar energy as a viable renewable energy source for the energy challenges his community faces, both economic and environmental. As part of this work, he along with another young man, Cam, produced a 60 second video-based public service announcement – "Power Sucking pigs" – aimed at educating his local community on the importance of these issues (see http://getcity.org/blog/2012/10/06/power-sucking-pigs/).

In the video, the two boys start out acting out the role of business associates in a meeting using their laptop computers. Suddenly, the overhead lights in the room flash and the electrical power goes out. The two business associates look at each other and ask if the laptop lost power. Trying to figure out what caused the power to go out, they scan the room and discover there are "power sucking pigs" draining all the energy from the wall outlets. The pigs are also played by the two boys who have donned pig noses. The boys infuse their sense of humor as we see the business associates chase the pigs set against the sounds of rhythmic drums. The video transitions to a serious tone as the boys narrate and show graphics of energy use in the US compared to the rest of the world. They also add information and images for ideas about how to save energy. The boys included a picture of a home with solar shingles from a field trip taken in the summer program. The video closes with the boys standing in front of a mirror. The boys in unison remove the pig snouts and point to the reflection in the mirror and declare, "It's you!" The video finishes with a link to the group website where viewers can find additional information.

In this PSA, Quentin highlights the need to unplug electrical cords from outlets when they are not in use in order to reduce carbon dioxide emissions and save energy. He provides information about energy consumption in the US and how using solar panels can reduce electric bills and emissions. All of the information provided in the PSA came from his scientific investigation (e.g., investigating how much CO_2 is emitted from burning fossil fuels, testing how solar panels work, and measuring standby power) and field trip experiences (e.g., visiting a solar powered house and a solar research lab). He also provides information about energy consumption in the US and how using solar panels can reduce electric bills and emissions. He wanted their movie to speak to people like his mom – making ideas "real" not distant, and making change something that was possible for lower-income families. Quentin decided to bring his movie later that fall into school to show his science teacher. Of the power sucking pigs movie, he said, "It's the movie that changed how people thought about me…We showed people how they can save electricity, which will help with CO_2. Mainly, I was excited to show my teacher because he saw that I could do it. That I got it done. And that I know a lot. I had to get it done. I'm not really that C and D person."

At the time Quentin shared this video, he was struggle in school, in general. We often found him sitting in the hallway, having been sent out of class for "clowning around." However, Quentin felt that this punishment was unfair, as he felt he was not clowning around. He said he was just a funny person. Because he spent so much time outside of class, sitting in the hallway for his behavior, he missed many assignments, leading to low grades.

He did not seek to make up the work because, as he says, "what is the point?" Quentin says his teachers did not know who he really is or what he is capable of.

Vignette 3: Grand Climate Change (7th grade)

In the 7th grade, Quentin and his peers were studying how the GEC might "get off the power grid". Over the course of 24 weeks, Quentin engaged in activities investigating the electrical production system and its alternatives, with a particular focus on energy transformations in these various pathways. About mid-way through this unit, Quentin learned about a contest for "youth innovators" hosted by a local non-profit organization focused on promoting entrepreneurship. Any youth under the age of 18, could submit to the contest a prototype of an idea that could be brought to market. On his own time Quentin worked on prototyping a game, which he named Grand Climate Change.

Quentin's reason for focusing on a video game was that he wanted to teach young people about the impact of climate change, which he felt was already "in action." As he states, "My idea was a Video Game**.** As kids, we have already seen climate change in action. Hurricane Sandy. Hurricane Katrina. We have seen lots of tornados and big storms all across the country. We have had a warm winter with hardly any snow. This year was Dustbowl 2012." He was concerned, however, that his peers would not be interested in playing science game, even if was a fun computer-based game. His idea for getting kids interested was to model the game after what he knew to be a very popular game among his peers, Grand Auto Theft. As he states:

> I wanted to create a video game that teaches other kids about climate change. One game that I like and that lots of other kids like is Grand Theft Auto. This game is about taking missions from the masters and completing them. It's kinda violent. But, it's fun. It's popular. I like taking missions. So, my climate change game would be like this, but it would not be violent. The missions would be about doing thing to help CO_2 from not building up. Each mission, you have to know more, or learn more about the causes and effects of climate change.

Like Grand Auto Theft, the game would involve main character, Tony, whose job it was to solve the missions and rise through the ranks and take on more difficult and complicated gameplay. Tony would encounter antagonists in his journey, who would attempt to impede his progress. Grand Climate Change not only draws upon the gameplay of Grand Auto Theft, but also draws heavily upon what he had been learning overtime in his after school program, in both in the 6th and 7th grade. As Quentin states,

> My game . . . would have a main character Tony, who goes around the city and does missions. He helps people do stuff to help prevent climate change. You have to have ideas. You have to understand how the things you do contribute to climate change.
>
> I started with three missions. Mission #1 is to go to someone's home and remove all incandescent lightbulbs and replace them with CFLs. So Tony might come to a home of a person who sells incandescent lightbulbs and they refuse to let him in. So, he has to convince him why it is important. How it works. You have to think of all the reasons why someone might care. You need to think about the strategy because the more angles you hit, the better you do.

Quentin was motivated to make his game because of a contest that he learned about from a peer in the GEC program. He was excited by the prospect of winning both a camera and a monetary prize ($250) if he placed in the top three. Winning the contest was also another way that Quentin felt like he would be able to prove to people that he was smart and capable in science. In the end, Quentin won second place in the state-wide contest.

Vignette 4: Summer Engineering Program (7th and 8th grades)

Quentin applied for and received a full scholarship to a summer engineering program at the state's technical university, about 7 hours bus ride from home, and in a part of the state he had never been. He felt that having a chance to take engineering classes on a university campus would help him to be better prepared for a future in STEM. As he stated, "When I finished 7th grade, I decided to apply to Tech University for a summer camp program to learn about engineering. We do not learn about engineering in school, only in GEC. I thought I needed more of chance to see what it is about. I was accepted to the program with a full scholarship. When I was there took civil engineering classes, and we built bridges and things there and learned about it. It was interesting to me." Quentin enjoyed the program so much that the following summer, after completing the 8th grade, he applied again. The eligibility requirements explicitly state that students could only receive the scholarship one time. However, he requested to be able to apply again because engineering is not taught at his school, and that science was also

barely taught at his school. Quentin felt that if he could attend the summer residential program again he would be able to catch up on what other students in other schools probably had the chance to learn. He referenced his accomplishments, such as Grand Climate Change and Unacceptable Heat, as indications of his ability to work hard over time, and as indications of his desire to become an engineer. As he stated, "I knew I had to apply again after 8th grade. No one has ever been able to go twice, but I knew I had no choice but to try. I felt lucky that I got accepted."

Discussion

Quentin's story reminds us how youths' identities are always in-the-making, responding to and pushing back against the people, contexts, sociocultural histories and normative views and expectations which shape their lives. Over time, and across the different spaces of their lives, we have seen these young people grow into particular kinds of STEM people who challenge normative expectations for who can be a STEM person and what it means to be a STEM person. We have seen them author paths into STEM that are nontraditional, and far from linear. They have strategies in re-mixing and re-purposing both traditional and nontraditional resources – material and symbolic – alike, in order to engage in the kinds of STEM work they care about, and to be recognized for who they are and what they can do. Institutions, people, tools, and practices, all imbued with and embedded in histories, have structured the youths' opportunities to become, and have also provided points of resistance as youth refuse marginalization.

Rather than a STEM identity "pathway", which suggests a pre-laid out route with helpful and visible signposts or at least an obvious track for one to walk on, we have come to see minoritized youths' identity work, over time, as a form of path*hacking*. We use the term 'hacking' because it refers to the need to wield creative force (or 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 minoritized 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. The traditional pathway laid out for minority youth is AWAY from STEM **(**Berry, 2005; Gándara, 2006, Triana & Rodriguez, 1993)

For example, if we return to Quentin's letter that he wrote in the 5th grade, we can see some of the struggles that he faces as he considers his own pathway into STEM in the 5th grade. He points out which student he is –- "This is your student Quentin, the first one in the second row" – suggesting that he worries he does not know whether his teacher really knows who he is, despite having been in his class for 6 months. He also contrasts his feelings about being a passive recipient of science ("I don't like getting lectures") with his active engagement in community ("I do things outside of school… I went door to door."). He points to the creative ways in which he leverage his community funds of knowledge in order to help make science more accessible and salient to his community. However, he also indicates, in the last paragraph, how important it is for others to recognize and value his efforts for what they contribute to community, not for how they reflect negative stereotypical views.

As we consider the question of how youth imagine and *hack* paths into STEM, it appears that a salient feature of this identity work 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 such, the youth are engaged in an on-going process of negotiating between their individual agency and community response to their efforts, in order to have their identity work legitimized as an important part of becoming in STEM. However, their hacking is often seen in the contemporary sense of hacking, that of *trespassing*. Such judgment lead youth to see themselves, as Cathy does, as an imposter. We present three ideas derived from our case studies that describe the salience of the identity work that youth do across towards their authoring a way into STEM: 1) the nature of pathhacking; 2) the tools of pathhacking, and 3) the pitstops, dangerous intersections and cul-de-sacs of pathhacking.

Trying on new ways of being with/against norms and expectations: The nature of pathhacking

The youth in our study are engaged in the on-going practice of trying out new ways of being in STEM, both with and against the norms of expectations of the worlds they inhabit. These practices are not always fully intentional towards identity building, but they reflect moves to preserve, defend, validate, or call attention to the lived experiences they bring to learning and becoming in STEM. While such practices, over time, can position youth against oppressive norms in a bid to seek new avenues of agency, they also bear potential academic risks.

The youth appear to try out these new ways of being not for the sake of resisting sanctioned norms themselves (e.g. in opposition to the authority figure, often teachers, and sometimes peers, who positioned them on the margins of STEM). Rather, they appear to do so in order to gain recognition for the non-traditional forms

of "STEM capital" they possess, in order to transform the discourse, and what counts as legitimate ways of being and doing in STEM (Archer et al, 2015). In Quentin's case, he authors the letter to his teacher not in antagonism, but to remind his teacher that he is a hard worker and one who cares about science and his community. By introducing the term "Fcience," he suggests, however, that the world of *school* science has not yet offered the same affordances for being in STEM that his community has offered, and suggests changes that could be made to his classroom. He is aware of the constraints his teacher and school face (e.g., having to use 20 year old textbooks), but suggests that it is still possible to do "fcience.".

Another path hacking maneuver youth perform towards productive STEM identity work is to re-organize and/or create new figured worlds more suited to who youth are in-the-moment. Quentin drew on compelling reasons (he has no access to engineering in his public school), his deep personal interest in engineering, and his future career aspirations in order to secure for himself another scholarship to the engineering summer camp, even when he was, being a previous awardee, technically ineligible for another application,. Such hacking acts open up new possibilities for thinking about oneself and one's futures differently (and what one needs to learn and do to get there). Quentin further laminated his STEM identity in the second camp as a result of this hacking move.

Critical STEM identity artifacts and allies: The tools of pathhacking

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. The 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. Pathway hacking requires both tools (what we call "critical STEM identity artifacts") and allies (social relationships) for figuring out these unknown worlds one is working within (and its affordances and constraints) and to work towards reconfiguring these worlds. In particular, we noticed three important roles that hacking tools and allies jointly play.

First, both tools and allies help to break down marginalizing binaries, such as that of novice/expert, insider/outsider, successful/unsuccessful. Second, tools and allies legitimized ways of being that are more inherently germane to youths' sense of selves instead of the privileged "other". Third, they broker connections across potentially deep chasms. Quentin's Grand Climate Change game (tool) reflects his desire to engage others in broad environmental issues related to everyday practices such as lighting and driving. He is deeply aware of the precarious nature of these practices for the people in his community. In authoring the game, he had to draw from, and synthesize information from various domains: peer culture, video gaming culture amongst teens, video gaming infrastructure, nuanced content understanding about the different issues salient to Climate Change and translating content into a gaming format. Indeed, this suite of expertise that Quentin demonstrated was recognized when he won for the $250 prize. His GC adult mentors (allies) supported his game development. When Quentin referenced these accomplishments in his application to Tech U's summer program, he further leveraged these tools towards new inroads into STEM (brokering connections).

The pitstops, dangerous intersections, and cul-de-sacs of pathhacking

We have noted how identity work accrues over time, as small events disrupt oppressive forces in youths' lives. Each disruption becomes a moment where ideas, tools, and bodies can refigure learning and becoming, giving rise to new relationships and opportunities for becoming in STEM. We view these moments of re-grouping and re-building as pitstops, or rest areas where youth and their allies can begin to imagine for themselves what the possibilities of becoming in STEM might be. We also view pit stops as safe place to rest or get some help, but also as a place to regroup and to figure out how to tackle the terrain ahead. For Quentin, pit stops included various Green Club experiences and consecutive summer programs at the local technical university.

At the same time, such pathhacking is not always forward moving, and young people can find themselves facing dangerous intersections, crossings or even deadends. As Quentin entered his teenage years, the structures of his afterschool club required him to spend his spare time in the teen room, where the rules for engagement were distinctly different from the younger spaces and the GEC. He eagerly joined the teen room, and relished in his status there. He spent more time hanging out, and less time finishing homework. More energy was put into social relationships, time on his phone, and appearance. It was not that any of these practices were in conflict to his vision of becoming in STEM, but they did not mesh with the club director's view of what it meant to be a teen leader. His participation in GEC and attendance at Tech U was threatened, and he felt that he was forced between worlds he had found ways to marry in the past. That he spent his time in GEC designing a cell phone charger (while being a teen) speaks to one way he sought to push back against dichotomous choices he felt were presented to him, and at least implicitly, sought to re-organize his worlds so that his new teen status mattered in STEM. But Quentin was lucky in many ways. He carried with him a history of relationships through GEC (allies) that made

this identity work as a teen possible in his work on the cell phone charger, and he had a wide repertoire of tools for bridging the chasm between these worlds.

Conclusions and implications

In many ways it is impossible to see how Quentin navigated the pitstops and dangerous intersections without calling into question timescales. We cannot look at any individual act as taking place apart from a history of engagement across the spaces that make up their lives, what they do in those spaces, and how they sought to move ideas, practices, and tools from one space to another. While achievement scores offer a form of evidence for student learning, they reveal only a narrow slice of it --they tell us little about what students understand science to be or the mechanisms by which students come to engage in meaningful science learning, and to see themselves as a part of science. Indeed, *who individuals are and want to be* in science has serious implications for how or why one might engage in science class, enroll in science courses, or use scientific ideas and practices outside of the classroom.

References

Boal, A. (1974/1979). *Teatro del Oprimido*. Urizen Books (translation to English 1979 by C. A. McBride & M. O. Leal McBride).

Berry, R. Q. (2005). Introduction: Building an infrastructure for equity in mathematics education. *The High School Journal*, April/May, 1-5

Engeström, Y., & Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review*, 5(1), 1-24Bright, Manchester & Allyndale, 2013

Ehret, C., & Hollett, T. (2013). (Re)placing school: middle school students' countermobilities while composing with iPods. *Journal of adolescent & adult literacy*, *57*(2).

Gutiérrez, K. (2012). Re-Mediating current activity for the future. *Mind, Culture, and Activity*, 19, 17–21.

Gándara, P. (2006). Strengthening the academic pipeline leading to careers in mathematics, science, and technology for Latino students. *Journal of Hispanic Higher Education*, *5*(3), 222-237.

Holland, D., Lachiotte, D., Skinner, D., & Cain, C. (2001). Identity and agency in cultural worlds. Cambridge,MA:Harvard University Press.

Margolis, M., Estrella, R., Goode, J., Jellison Holme, J., & Nao, K. (2008). *Stuck in the shallow end: Education, race, and computing*. Cambridge, MA: MIT Press.

National Academy of Engineering. (2010). *Engineering, Social Justice, and Sustainable Community Development.* Washington DC: National Academies Press

Oakes, J. (2005). *Keeping track: How schools structure inequality*. New Haven, CT: Yale University Press.

Rahm, J. (2012). Collaborative imaginaries and multi-sited ethnography: Space-time dimensions of engagement in an afterschool science program for girls. *Ethnography and Education, 7*(2), 247-264.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory (2nd Ed).* Thousand Oaks, CA: Sage Publications.

Triana, E. M., & Rodriguez, M. G. (1993). *United-Unidos: Mathematics and science for Hispanics.* Washington, DC: American Association for the Advancement of Science.

Warren, B., Ogonowski, M., and Pothier, S. (2005). "Everyday" and "scientific": Rethinking dichotomies in modes of thinking in science learning. In R. Nemirovsky, A. Rosebery, J. Solomon, and B. Warren (Eds.), *Everyday Matters in Mathematics and Science: Studies of Complex Classroom Events* (pp. 119-148). Mahwah, NJ: Lawrence Erlbaum Associates.

Yoder, B. (2014). *Engineering by the numbers. American Society for Engineering Education*. Available at: http://www.asee.org/papers-and-publications/publications/11-47.pdf. Accessed November 5, 2015.

Acknowledgments

We thank participating youth, community members and teachers. This work was funded by [blinded].