

Becoming in STEM: Developing a Culture of Criticality in the Space between Person and Institution

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Introduction

No one ever really thought I could do much and so I don't think people care whether I become a hairdresser or not. But, I'm good at it. I do my friends' hair all of the time. I can do white hair and Black hair. I have been in GET City longer than anyone! I have been in it since 5th grade. That is like six years. I could do things there. I made a PSA [public service announcement] about water efficiency with my friends. I showed it at school, and people saw what I knew. I taught them something. . . It got me thinking more about how I want to be a "green" hairdresser. Autumn, High School Sophomore

Autumn, a young white woman growing up in multi-generational poverty in an economically challenged midwestern city, has authored a STEM-empowered life against the dominant sociohistorical narrative in American society. She has attended public schools that served significant populations living in high poverty – overcrowded classrooms, high teacher turnovers, out-of-field teaching, and limited STEM resources. Yet, she has authored herself into STEM despite these mitigating circumstances.

Autumn is currently a high school senior with aspirations to become an engineer or a hairdresser working in an eco-salon. She spends part of her time after school in a makerspace housed in her local community center, building things to solve other people's problems. She reminds us that her out-of-school efforts to participate in STEM exist worlds away from schooling. However, she takes the optimistic view that if she could tell teachers about her out-of-school STEM experiences, her teachers might be better able to help her and her peers serve the interests and needs of her community, as well as see Autumn's potential in STEM.

Now a rising 12th grader, we have followed Autumn since 5th grade through school and afterschool. As she grew older, she became more interested in helping us to document and tell her story. She is an author on this paper. Also during this time, Autumn has shifted from wanting to be a hair designer (5th grade) to wanting to own a "green" (environmentally friendly) hair salon (8th grade), to considering engineering as a possible career (10th grade). Autumn has struggled with being labeled "a girl in the background" and someone whom her mother described in 7th grade as "if she would just get Ds, I would be happy." However, over the past 6 years, Autumn has engaged in an ever-increasing range of STEM-rich actions and relationships, including building a Little Free STEM Library, leading workshops on energy efficiency, making educational movies for her community to teach about green energy, and writing for her afterschool STEM club blog. We are interested in Autumn's engagement with others in these activities over time and space, and how they shape her own *and* her community's engagement in STEM.

The overarching question that guides this manuscript is: What are the interactional forces that operating across space and time that influence Autumn's *becoming* in STEM, as a white girl, growing up in multi-generational poverty in a Midwestern city.

Using Holland & Lave's (2009) two forms of history –“history in person” and “history in institutionalized struggles”–we examined several pivotal events, and the micro-dynamics at play, identified by Autumn with respect to becoming in STEM. We sought to make sense of the ways in which Autumn's STEM experiences were carried out in local practice but also enacted against the broader background of cultural/historical narratives. In this process we traced Autumn's **core commitments-in-practice** in STEM & Community. We also examined how these core commitments-in-practice led, at times, to **conflict** and new forms of “contentious local practice” (LCP) as these commitments-in-practice pushed back against particular local, historical and sociocultural contexts.

Background and Framing

The underrepresentation of youth-of-color, including girls of color in STEM has been well documented (e.g. May & Chubin, 2003; Grossman & Porche, 2014). Recent work on studies of girls identities and learning in STEM in low-income communities has pointed to the importance of the intersecting role of structural and curricular inequalities in spaces intended to increase access and opportunities such as STEM schools (e.g., Weis et al, 2015; Eisenhart et al 2015). Studies specifically on white girls from low-income communities are, however, few and far between, especially those which focus on communities of multi-generational poverty. Catsambis (1995) found that white girls are the ones who lag behind white boys the most in terms of their beliefs on the usefulness of science or science as a career choice, inspite of higher levels of achievement.

Our study is grounded in a critical justice view of equity and social practice view of learning. Critical justice focuses attention on recognizing diversity and addressing structural inequalities perpetuated through, for example, systemic racism and classism (Balibar, Mezzadra, & Samaddar, 2012; Conklin 2016) . A central focus of this work is in re-shifting relations of power and position within multiple scales of activity in education, and their intersections with historicized injustice that play out in life in classrooms.

Social practice theory provides a lens to examine the ongoing struggle between personal and historical narratives influencing participation with science by integrating “the study of persons, local practice and long term historically institutionalized struggles” (Holland & Lave, 2009, p. 1). We chose this theory due to our interest in not only “understanding and explaining real, everyday, situated activity in its concrete, material detail” (Roth, 2006, p. 22), but also the formation of identities influenced by the historical cultural practices situated in these everyday practices. Thus, social practice theory expands on cultural historical activity theory (CHAT) by foregrounding identity formation, or as Holland and Lave (2009) argue, by “emphasizing historical production of person in practice, and pay(ing) particular attention to differences among participants, and to the ongoing struggles that develop across activities around those differences” (p. 1). The identities youth and those they interact with take on are influenced both by how they are positioned and ways in which they position themselves in the valued cultural practices of their communities (Allen & Eisenhart, 2017).

Juxtaposing social practice theory on critical justice we can make sense of how two forms of history –“history in person” and “history in institutionalized struggles” (Holland & Lave, 2009) – yield pivotal interactional practices, and the micro-dynamics at play, create (and foreclose) opportunities for critical science agency. Personal experiences carried out in local practice are

enacted against the broader background of cultural and historical narratives. We want to dig into the kinds of contestations that make up LCP in order to unpack how commitments-in-practice take shape over time, maintaining and transforming both person-in-history and enduring struggle. This approach “demands relentless attention to how material economic practices, power relations, and the production of meaning and difference constantly play upon one another” (Hart, 2002).

We see this in Autumn’s story as she encounters societal narratives about what it means to learn and do science as young, female, from a low-income background juxtaposed with her personal narratives of doing science in and for their local communities. This often plays out in the struggle between the ways in which school positions science and values certain ways of knowing and doing science and the cultural meaning making practices youth bring with them from personal experiences (e.g., Birmingham et al 2017). The intersection of these histories impacts conceptions of what it means to be scientific, who can do science and where science is meaningful.

The struggle between the two forms of history also influences individuals actions in local practices. The institutional and personal narratives experienced or brought into the classroom hold specific meanings for the actors in this space. Holland and Lave (2001) argue “cultural genres” that “rule in social life” are:

associated with particular persons or groups of people identified in social space and historical time. Practices and discourses become markers of their owners and evoke their social image. They carry with them the aura or, to use more sensuous metaphors, the images and the odors of particular others, particular professions, particular social groups, particular individuals with which they are associated. (p. 16)

In our work presented herein we sought to make sense of the ways in which Autumn’s developing STEM knowledge and practice were carried out in local practice but also enacted against the broader background of cultural/historical narratives. We traced how Autumn sought to take action with their developing science knowledge, and how they bridged or positioned it alongside or against community knowledge and practice. We also examined how these differing epistemological groundings, at times, gave way to conflict (“contentious local practice”) as they pushed back against particular local, historical/sociocultural context.

Methods

Critical, longitudinal, participatory ethnography was our selected methodology because of its explicit focus on participatory critique, transformation, empowerment, and social justice, as well as the focus placed on privileging cultural places and dedicated time invested in these spaces by youth. This hybrid form of ethnography is grounded in the idea that researchers and participants can use the tools of ethnography (embedding ourselves in context), to conduct empirical research in an unjust world in ways that examine and transform inequalities from multiple perspectives, leveraging both emic and etic perspectives (Trueba, 1999; Madison, 2012). The work is critical in the sense that we pay attention to and seek to challenge through this work the powered interaction between actors and the social structures through which they act, given that these relationships are never neutral. This was important as we attempted to make sense with youth and of how youth, who are positioned in particular ways due to race, gender and class, engage in STEM-related activities and pathways longitudinally, across time and settings. Lastly this work is participatory in the sense that the youth in our study were active contributors to the questions we asked, to the data we generated – in its forms and in the roles such data played – as well in the construction of the narratives we tell about the data.

In this particular paper we tell Autumn's story (first author). To collaboratively tell her story, we draw from three data sets. First, Autumn co-constructed a portfolio of her learning and participation in STEM across the spaces of home, school and community, pulling in events and experiences from the 5th through the 12th grade. During a 10 week period though spring/summer 2017, Autumn worked primarily with Day (4th author) to create a collection of artifacts together representing her pathway through life with and in STEM learning and practice. This collection included a multimodal slideshow presentation featuring photos, videos, screenshots of blog posts she had authored, and text she produced to introduce a chronological storytelling of her life's work so far to various stakeholders of interest (e.g., her current teachers, professors at her local state university, science education researchers at national conferences where she presented, and future employers). It also included a written complementary artifact, a co-constructed narrative of her efforts to be and become in STEM prominently featuring a transcribed "Q and A" style narrative interview between Autumn and Day.

Second, the researchers have kept ethnographic data files on Autumn's experiences over the same time period, which include her participation in weekly conversation groups, videos of after school and community participation in STEM, twice yearly interviews, and artifacts she produced. These data are comprehensive and reflect Autumn's experiences in STEM as she progressed from elementary to middle and through high school. Autumn also culled through these to help with her portfolio construction.

Third, we conducted extensive portfolio dialogues with Autumn to make sense of her portfolio and why constructed it as she did (e.g., what the different events, people, resources, power dynamics named mean to her), as well as how she describes the importance and impact of these events. For example, in preparation for this paper, Autumn worked primarily with Angie (second author) to describe the commitments and practices she felt made up the pivotal moments in her portfolio. They also worked together to describe the conflicts Autumn experienced as she enacted her commitments in and through STEM.

Data were collaboratively analyzed in the grounded theory tradition, using a constant comparative approach (Straus & Corbin, 1998). The first phase of analysis involved open coding by thoroughly perusing all generated data (e.g. transcribed interviews, observation fieldnotes) to surface a) critical episodes of STEM engagement that youth leveraged in some way for STEM engagement (e.g., group activities in science class or informal science spaces that featured particularly salient performances, in talk and actions) especially vis-a-vis the commitments named by Autumn; b) how Autumn positioned herself during critical episodes; c) how she responded to how others positioned her within these episodes; and d) the artifacts Autumn chose as most representative of herself in STEM, and why. Weekly conversations were held between the authors as a way to work towards a more "expansive consensus": differences in view were debated until new meaning was generated. A detailed list of emergent open codes were kept with analytic memos which we then brought to bear on the second pass at axial coding.

Our second phase involved examining/identifying how Autumn enacted her named commitments in practice, to create new opportunities and spaces for becoming in STEM (especially when these were previously denied). With the help of our theoretical framework, we then worked to make sense of what it meant for Autumn to enact her commitments-in-practice through history-in-person and history-in-institutionalized struggle. This axial phase of coding was used to uncover relationships and connections between the Autumn's STEM engagement and the tensions/conflicts that emerged. We took these data points as markers of new local

contentious practices and sought to connect these back to Autumn's commitments-in-practice. Embedding ourselves longitudinally in contexts with Autumn helped us make sense of the relationships and relevant background happenings that shed crucial light on these "snapshots" across time that we share below.

Findings

Below we trace Autumn's **core commitments-in-practice** in STEM & Community as she sought to take action with her developing science knowledge. We use the phrase commitments-in-practice to indicate that these commitments take form through social interaction, where people and contexts exert significant influence, both supportive and otherwise, on how Autumn adopts or authors such commitments. We also examined how these core commitments-in-practice led, at times, to **conflict** ("contentious local practice" or LCP) as these commitments pushed back against particular local, historical/sociocultural context.

In what follows below, we outline four core commitments-in-practice, and how they took shape over time, what they meant to Autumn, and the practices and knowledge she brought to enacting these commitments-in-practice. In elaborating on how Autumn enacted these commitments in practice (history-in-person) we describe key events, which Autumn indicated reflected these embodied commitments. In describing the events that Autumn has selected, we draw attention to how Autumn's commitments-in-practice emerge, in part, from her having a space or platform for her to try out and refine these commitments with and against the enduring struggles she experiences in STEM and schooling.

Then, in the second part of these findings we trace these events longitudinally, as they intersect and build with each other, and in different contexts. By telling Autumn's narrative this way, we hope to draw attention to how Autumn's enacting her commitments-in-practice clash with history in institutionalized struggle, leading Autumn to engage in forms of local contentious practice that become re-enactments/revisions/refinements of her commitments over time (either individually or in combination).

Commitments-in-Practice

Commitment-in-practice #1: "Teaching others. . . kids, teachers, my family, people in the community"

What this commitment in practice means to Autumn: The first commitment-in-practice is "teaching others . . . kids, teachers, my family and people in the community". Here, Autumn is attuned to leveraging her developing knowledge of "community STEM expertise" to teach others - across settings - a) science content in accessible ways, b) what one can do with science other than science class, which include investigations to save money and the environment, c) how to use science to make a difference at school, and at home, d) how teachers can do more to attend to their students' diverse learning needs and interests, through her active efforts to model more equitable and youth-centered teaching practices ("Because, you know, nobody wants to just sit down and read paragraphs from a book and write down the questions and answer them"). This commitment-in-practices matters to Autumn because "in school we don't really do real science" . . . "we just learn things," "we don't do anything with it."

She cites her experiences in GET City, Girl Scouts, and at home, as places where she has "done things" with science that carry meaning to her or to her friends and family. Teaching, for Autumn, means offering practice-based access to STEM in ways that integrate her desires for and agency to make a difference. Importantly, she distinguishes her definition of teaching from a more lecture-based, authoritative repertoire of practices she has observed and experienced in

formal education. Autumn is an advocate for project-based learning and “hands-on activities” as opportunities for providing learners with multiple entry-points into content engagement, explaining: “It doesn’t feel real when they’re just having us read out of a book and writing down questions and answers. But when you do hands-on stuff, it feels real because you actually have to figure out stuff. When you have to figure it out yourself.”

Initial episode illustrating “teaching others”: In her STEM pathways portfolio, Autumn indicated that the most powerful project she did was when she taught her 6th grade science class about water and energy efficiency based on a video and investigations she designed in her after school club. She includes in her portfolio a 5 minute and 42 sec video clip from this moment in her classroom, and that we had recorded. As she stated about this portfolio entry: “teaching my classmate about the projects that i did because some of them like it was helpful to my classmates and teacher and so they would know there are other things besides science class that you can do with science.”

In this episode, Autumn along with two other middle grades girls, took what they had learned about energy efficient technologies and behaviors to younger students at her school to teach the science classroom at school. Autumn wished to do this because she wanted her peers to be able to “know what I know.” Autumn’s after school teachers (author 2 and others) helped them to organize and practice their lesson, and worked with the classroom teacher to create the space for them to do this. They prepared a Powerpoint and then led the class through a hands-on, interactive experiment looking at the difference between CFL and incandescent light bulbs.

The lesson began by Autumn and her two friends surveying the students in her class about what types of light bulbs they use at home before asking them to predict the efficiency of three different kinds of light bulbs presented (incandescent, CFL, LED). Autumn began the lesson by saying, “Let’s compare light bulbs to see if CFL light bulbs and LED light bulbs can save energy. Like, this is the CFL and that is the incandescent.” After her partner lets the students know that they will be measuring energy using a watt meter, Autumn asks for volunteers to predict how many watts each bulb will use. Autumn calls on students as her friend makes note of their predictions by repeating each students’ guess. But then her friend, who is a “star student” and was supposed to lead the next part of the lesson freezes. After a pause, Autumn jumps in and takes over the rest of the lesson. She Autumn focuses the class on collecting data by saying, “OK, let’s measure how much energy each light bulb uses.” Next she calls on a student to come to the front of the room and helps them read the watt meter, which she then repeats for the other two bulbs. Autumn then asks, “What did you notice about the amount of energy used between a CFL, LED and incandescent light bulb?” The 5 minute 42 second video clip (a selected portion of the entire lesson) ends with students discussing what they noticed and what that means for the amount of energy they use at home.

In this particular classroom, the teacher had previously described Autumn as a student who is just “lost in the background.” He says

There are no expectations on Autumn at all. Mom and Dad don't even like to talk about Autumn at school. They just say that she has problems. She is in the special ed room and she has problems. If she could just get D's we would be very happy with that. So, she doesn't have a whole lot of expectation on her as far as school goes which is sad. When you talk about Peter [her brother], their whole world lights up. So that is just who she is at home, she is that kid. So that is a little background on our friend Autumn here, but really nice kid.

Autumn is also becoming through doing –as she unexpectedly stepped up to the plate and taught the lesson because a peer froze, the teaching act makes Autumn a teacher, and starts to draw from her a deeper commitment to teach.

Autumn noted that teaching this lesson helped her classmates become “more active in science class” and “learn more science” in ways that were “fun.” Autumn also noted that by “teaching my class I am also helping my community because, well like, when we were doing the CFL lightbulbs that was teaching my community that if you are using incandescent you are using more energy and spending more money than if were using CFLs. That is important because the community uses alot of energy.”

Commitment-in-practice #2: “Helping people.”

What this commitment-in-practice means to Autumn: While related to the first commitment of teaching others, Autumn separates this commitment-in-practice out because helping others also involves using what she has learned and done with science to address issues, questions and concerns that others have. She notes that “lots of kids don’t have things” and “have alot of unfair things happen.” She reflects on her own situation where she felt she did not get the experiences at home or at school she needed to help her learn to read or write better at an earlier age, even though she had an Individual Education Plan. She reflected on the time she worked on a water efficiency video with two friends - “they are smarter than me” - but who made a welcoming space for her in their group project. She described how they helped her with the “hard parts” of the video such as describing water efficiency and calculating how efficient devices translate into money and carbon savings. She also said she helped them because she helped to choreograph the “water dance” and ideas for how the movie could go. She also said she was a good collaborator.

For Autumn, the commitment-in-practice of helping people involves a) figuring out what other people’s concerns are and how to address their concerns, and b) being patient and open to what people need or care about. Helping can involve working on large and/or long-term projects, such as the Little Free STEM Library (LFSL). But it also involves smaller actions, like being a mentor in her maker club. As she noted, “Instead of me doing my own project I wanted to help other people with their projects.”

Initial episode illustrating “helping others”: Autumn says that the best example of helping others is her work on the Little Free STEM Library. In the 10th grade, Autumn conceptualized, designed and built a Little Free STEM Library at her local community club. She felt that access to STEM books would help others learn to read and engage with science, aspects she felt were limited in her schooling. She included mini-maker kits so that others could “make the things that [she] had a chance to make [at the club].” She added an eye-catching LED lighting system powered by a handcrank generator, which would be “good for the environment,” and “get [kids] curious”. She describes the project one she “worked on the hardest ever.”

Autumn was concerned that children in her community have time to read while also having the chance to “make things” -- concerns she felt were not adequately addressed at school, concerns also central in her own life.

Over 6 months, with help from her after school teachers, she researched the need for a library, the possible styles and wood types, drew up blue prints by hand, then in a 3-d sketching program, cut and assembled the wood. With feedback from peers, she added a door and a lighting system powered initially by a hand crank generator. She continued to work on the

project the following year making it more accessible, changing the lighting system, and expanding the materials shared inside.

She notes of the LFSF:

“The Little Free Library shows that i want younger kids to learn to read and learn different science books and stuff”

“Some teachers make you feel that you can’t be accomplished in life. With the Little Free STEM Library I felt accomplished. The Library helps kids practice reading and learn more about science. If kids live in a library desert like us it really matters more. If we were over in the south side where I live, people would be like ‘that is cool!’ If we go to the east side and they could learn too and make a difference too! Then they would reach out to other communities, and it would just keep growing and growing...”

When reflecting on this commitment-in-practice Autumn selected the following blogpost (January 2016) to help illustrate these points. She said that this post showed how hard she has worked with the help of her mentors and peers, and how important the library will be for other kids to learn to read. She said that she knows how hard it is to learn how to read, given that she has been in special education and labeled a “struggling reader” but she always felt that she never had a chance to just practice with books at home or school.

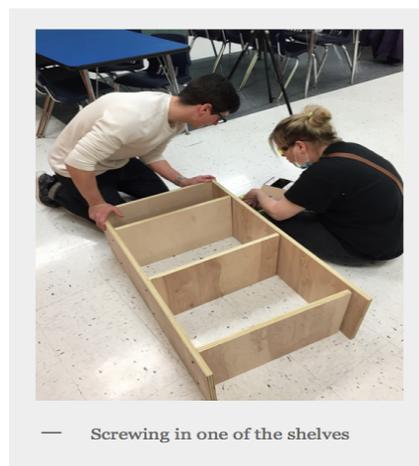
Autumn also liked it showed her working with a GET City mentor because that “was a big part of it”. She also uses the photo from this blogpost as the screen saver on her laptop she earned for being a mentor in her maker space. She also said that she thought the blog comment she had gotten was “A good one” because that person know how important that “lots of books” would be.

Getting it done!

Posted on **January 27, 2016** by **autumn**

Today I worked on the little free library that we are putting in the Boys & Girls Club. I got A LOT done so far. It looks amazing! Just like our blueprints! I wouldn't of gotten as far as I did if Danny and K wasn't helping me put it all together. We still have A LOT of work to do, but once we get it done. It's gonna be the first thing I have done in a while! I can't wait to see what it turns out to look like. I can't wait for the kids to get books to read. Thanks so much for helping me work on it Danny, and thanks for getting all of the materials for me Angie, Y'all are the best!

Also, other kids were working on their projects. C & J are making heated leggings. That is such a good idea- it is so cold outside! They also figured out how to get electricity from the piezo generators (for another group's project, but C & J figured it out!).





Edna on **January 28, 2016 at 3:09 pm** said:

Edit

Wow that is very impressive progress! I am glad to see that your "little library" is more a medium library, so there will be space for many books. Very exciting, can't wait to see more pictures of continued progress!

She points to the importance of STEM knowledge in imagining the library, constructing it with an alternative energy source, and designing the paper circuit kits. She points to knowledge of community as crucial in knowing what to put in the library to help kids to "get to where I've gotten."

Her actions to continually expand the library point to her desire to become in STEM and to make a difference in her world. For example, she points to a FB post of a friend who delights in learning about paper circuits. She invited her classroom science teachers to come to the club to see what she made.

Commitment-in-Practice #3 and #4: "Learning more for myself and working hard at it" and "Fcience" or "Doing science that matters"

What these two commitments-in-practice mean to Autumn: We discuss the next two commitments-in-practice together. First, Autumn wishes to continue to learn more science so that she can help and teach others. As she states, "I need to learn more for myself" "I'm interested in science." "It helps me figure things, and I'm curious." "I need to learn more anyway if I'm gonna help people." In referencing her portfolio, one of message that she wrote to her teachers in the 6th grade, in an artifact she included in her portfolio, was that "She is willing to work hard. In reference to a video she made she said she wanted teachers to know "That I got it done." At the same time, she says that to learn more you have to find ways to make it worth learning. In her words you have to figure out how the science "matters."

Initial episode illustrating "learning more for myself" and "Fcience": In the first earlier commitment we noted that Autumn felt that she wanted to teach others science in ways that were not taught at schools. This, in part, points to how Autumn wants to experience science. Autumn experienced science in different contexts led her and her peers to create a new word, "fscience" (pronounced fy-ence), to describe the type of science they participate with outside of school. Autumn was a driving force in coming up with the word, defining it and later appearing in a short video describing the term that was included in here case.

- Isa: Our word of the day is ...
- Autumn: Fcience
- Isa: Fcience is what describes GET City, its science that's fun
- Autumn: GET City knows how to make science fun without getting bored
- Both: Instead of a bored face, you will have a happy face



When we unpacked the term *Fcience* with Autumn and her peers, they explained that *Fcience* is a contraction of the terms “Fun” and “Science.” But fun here had deeper meanings than enjoyment. Fun meant engaging with science in ways that were worthwhile or made a difference. Enjoyment came from being yourself, doing real world science, and making a difference. The term *Fcience* challenges how we think about the accessibility of science for Autumn and others like her in school settings. It points toward Autumn’s insistence that she is capable and interested in developing expertise in science, but those understandings cannot be separated from who she is, what she cares about and the types of impact she would like to make on her community. For Autumn, *Fcience* is not simply a desire to have fun devoid of learning. Instead, *Fcience* is something these youth want to engage with when it is made accessible, contextualized and geared toward action that aligns with their commitments to community.

Tracing *Fcience* through Autumn’s blog posts further illustrates how these ideals matter to her in particular ways, given the projects and contexts in which she has engaged with STEM. For example, as we see in the blog post from February 2015 (note that she co-invented the term in 2012 and continues to use it), she writes about two peers in her maker club who are working on their projects, which will be helpful and interesting to youth in their community:

Two Great GET City Projects!

E has been working on how to make a solar powered shoes. She has been working on this for the past couple of months. J and E have been working on a heated jacket and their heated by solar and re-chargeable batteries. To me I think they have had fun making this. Also for E’s project her shoes are gonna be heated by solar panels. For the other groups they have been working so hard on their projects, but these projects were the most interesting to me. These are ones that kids will really want. Now that is *Fcience*! ~A, GET City blogger extraordinaire



Conflicts & Local Contentious Practice

Each of these above-described commitments-in-practice, and how they were enacted and developed/transformed over time by Autumn, speak to the ways in which local conflicts implicate “broader historical forces at work, locally, in multiple ways” (Holland & Lave p. 12). For example, as Autumn argues, school science is not usually fun, accessible, or connected to action and/or consequence that brings deeper meaning and urgency to the learning process. So her commitment-in-practice of *doing Fcience* opened up spaces to explore, question, and critique systems of power that have zapped the life force out of science learning in formal spaces and places of education.

At the same time, we also think that the specific kinds of conflicts which arose shaped how Autumn responded in practice, giving new forms of depth and texture to her commitment-in-practice over time. How she has recognized, understood, navigated, and negotiated/rejected/re-worked multiple levels of the situations that have populated her pathway over time has helped to frame and influence how she thought about herself, her actions, and her abilities to make an

impact in the world. Thus, her experiences of being and becoming have acted on her as she has acted in and with the systems of power that affect her life, her community, and others.

We note at least three interrelated forms of conflicts and local contentious practices.

First, there is conflict and local contentious practice over the *authority to name what counts as doing science*, for whom, where, when and why, e.g., Whose knowledge? Whose agenda? For what reasons? (“Authority to Name”)

A second form of conflict and local contentious practice relates to *awareness* around how inequalities operate and how responses to such inequalities can challenge or maintain inequality. Embedded within this contentious practices are both differences in discourses/narratives that relate to people, context, science and power/oppression in how science-related problems/solutions are named/framed. (“Awareness/Discourses”)

A third form of local contentious practices around the very distribution of *access, participation and resources* in science. Who has access to science knowledge and practice and how so, to the tools to learn and do science for oneself or one’s community, or to the financial and social resources to do science? (“Access/Participation”)

We discuss how these three interrelated forms of conflicts and local contentious practices together take shape across Autumn’s experiences in STEM through expanding upon a series of events related to the initial examples described above. To do so, we trace the above described events & commitments-in-practice longitudinally, as they intersect and build with each other, and in different contexts. By telling Autumn’s narrative this way, we hope to draw attention to how Autumn’s enacting her commitments-in-practice clash with history in institutionalized struggle, leading Autumn to engage in forms of local contentious practice that become re-enactments/revisions/refinements of her commitments over time (either individually or in combination).

Local Contentious Practice: An Argument for Actuality with Engineering Design (“Authority to Name”)

“I want to help kids learn to read cuz lots of kids might not get it at school or at home [like me].”

In January of 2016, Autumn and Samuel decided they wanted to enter their LFSL project in a local entrepreneurial faire for teens. Their afterschool teachers told (authors 2 and 4) about the event, and many other groups of youth from their afterschool club were planning to go. None of us had ever been to the faire before, but the organizations had personally reached out to us to suggest that this would be a good even for GET City youth.

The Great Lakes Entrepreneurial Faire [GEF] is an annual event in mid-Michigan for middle and high school aged youth to showcase their entrepreneurial projects, with the possibility of winning monetary awards to help them advance their work. To enter the annual faire, youth are required to submit a two-page business plan, which addressed categories such as the problem & solution, target audience, financial summary, and competition. Autumn and her friend Samuel worked on their business plan over about two weeks, with help from two different mentors. They found the categories (e.g., marketing, competition) of the required plan difficult because they did not match their vision of their “LFSL business”. They decided to enter their LFSL project in 2016 under the guise of a not-for-profit business, with the encouragement of their mentors even

though no such category existed in the submission process. As they explained in their business plan,

Our project is meant to be “non profit.” We do not want to make money from it. What we want to do is provide opportunities to the kids in our community, where there are no other opportunities. We know what it is like to not be able to get to the library and not be able to make the kind of inventions that we think up in our heads. Some of us are lucky to have GET City where we can get these materials to do these things. But not everyone can get to GET City either. We want to bring GET City and other STEM experiences home to kids, who, like us, know that they can use STEM to make a difference in their communities.

Autumn was excited for this event because she felt that she and her friend had developed a business model that would “actually make a real difference” in her city.

Her argument for actuality was a reaction to what she perceived as business ideas that had been supported in her city traditionally, judging by what businesses she saw in town and what ideas she believed were glaringly missing. It was equally a reaction to what she and her peers perceived upon entering the building of the GEF event. Walking past table after table of food and glamour-based business proposals/prototypes, Autumn arrived at her designated spot in the room with a newly added layer of purpose and urgency to frame her commitments-in-practice with her little free STEM library. Standing among her competition, she remarked in defiance of the overwhelming tide she witnessed around her that her project would actually matter. It had a purpose she could respect, grounded in her commitments-in-practice to do science, to help her community, to work hard, and to teach others. After all, she added, “no one needs another wedding planner or cupcake business.” Her engineering design project had real substance, real consequences, and real impact.

The atmosphere at the GEF event which she decided was standing in contrast to these commitments did not come as a complete surprise to her, however, given that she had understood the world of business to be about profit, not helping. As observed in the quote above, a large part of the language she and her partner Samuel included in their business plan for the GEF showcase was in direct response to what they had observed was wrong with business, where the primary goal was to make profits.

In the plan, Autumn (and Samuel) demonstrated a commitment to expanding the library system to help others in her community, and in procuring donated and re-used materials to lessen the economic and environmental burden of producing their libraries.

On the day of the faire, they brought their fully functioning library with them to the convention center, filled with donated science books and several mini-maker kits they assembled. They felt they had a real chance at winning an award. However, despite her high hopes, her project failed to win anything. Instead, Autumn noted “cupcake” and “wedding” projects won “all the awards.”

Autumn was angry. During a debriefing conversation with all of the GET City youth after the event, she stated, “I was really mad.” “They only cared about projects that made money.” And, “The projects didn’t really help people because they just did things that were already out there.”

“GEF kind of shut me down because they were giving the same groups money for doing things that are done every year anyway. Some of the projects matter but most of the projects are just about making money...”

The GEF clearly favored projects that had for-profit business plans. Awarding top prizes to wedding planning, cupcake decorating, and fashion-related companies. Further, while Autumn and her peers attending from her community-based maker club had digital presentations (e.g., powerpoint slides and videos to share at the Faire), nearly all of the rest of the projects had elaborate materials, posters and table setting that earned the praise of judges.

The event was unsettling in many ways for Autumn. She felt that the judges did not understand or care that her project addressed a “real” need in her community. They completely missed, or at least dismissed, the actuality of her work. She felt that her business plan was dismissed because her goal was not to make money but rather to help others have access to science books and mini-maker kits so that kids in her community have opportunities to “get to where I’ve gotten” by having greater opportunities for reading and doing science. Her commitments came up against dominant narratives and how these narratives are embedded within institutions --the GEF event which Autumn and her fellow youth presenters observed and described as being structured to uphold, reproduce, and honor unjust framings of innovation and engineering design as a purely capitalist and individualistic pursuit, a selfish act of business as opposed to a collaborative, community effort for the collective good.

She was further upset that the detailed efforts that she and Samuel put into ensuring that the LFSL helped others went unrecognized. They had put a hand-crank powered LED light-up system around the library to get kids curious about how it worked and what was inside it. They included mini-maker kits so that kids had access to resources to make, when they likely do not have such resources at home. The books were mainly STEM books, that reflected a range of reading levels, from picture books to high school books, so that anyone could practice their reading and learn some science in the process.

However, despite these frustrations, Autumn was still proud of her project and her efforts. As she wrote in a blog post the day of the GEF event:

Today we all went to the [convention] center for the [GEF] event to show our projects! Samuel and I showed our library. We all did amazing! . . .My group got alot of good comments about our little free library. It was the hardest I ever worked. The library will help the kids read and also make things!

Autumn affirmed her commitments to work hard and to keep doing “Fscience” that mattered in the above quote. She further enacted these commitments-in-practice by deciding to enter the further improved on LFSL in the GEF the following year.

Local Contentious Practice: New discourses towards inclusivity and criticality in science & engineering participation (“Awareness/Discourses”)

“I kept working on the project for another year with Samuel and we improved it”

During the next school year, Autumn and her friend wanted to improve their LFSL project so that it had better reach and accessibility. At the suggestion and help of one of their mentors, they used GIS technology to determine actual locations and times of public libraries, bus routes/time from their homes, schools and afterschool club, requirements for library cards (e.g., proof of residence) and fee structures associated with late books. They determined that they lived in a library desert and needed to create multiple LFSLs to serve their community well. They also added wheels to the bottom so that they could change its location. They switched from hand-

crank to a solar system to light the library as the larger concern was helping people see what was inside the library from a distance.

Autumn insisted in participation in the GEF again that next year. But first she was going to present her LFSL at a smaller “5 minute tops” competition. This smaller event, held across town at the local community college, was a more high-stakes pitching presentation event, in which presenters were nominated from prior events and were each expected to deliver a polished, 5-minutes-long pitch for investment to a panel of judges. It also took place at night, adding a dimension of exclusivity or specialness that was also present, in a different flavor, in the elitism of the event’s unspoken but widely assumed “business” dress code. In the first event, she had been one of the only representatives of a business positioned to help, teach, and do, in comparison to businesses positioned to provide physical consumer products. In this event, she assumed a better chance of belonging together with the group of other “businesses” because she had been invited to attend (based on her group’s performance at a Boys and Girls Club presentation earlier that year).

As she prepared for the event she wrote on her blog that she and Samuel worked on a 5 minute presentation. In this blog post she offers some explanations for the changes they made to how they teach others about how and why their LFSF matters -- clear expressions to her commitments-in-practice. She notes the GIS mapping research she did (science that matters), having fun coming up with new ideas to improve it (learning more science), and how all kids deserve to read (helping others and teaching others). She also makes an explicit argument for having a “social justice business” -- as an important descriptor for why her business is to remain not-for-profit - “it shouldnt cost them any money.”

A social justice business approach to the Little Free Library

Posted on **March 16, 2017** by **getcity**

On Tuesday, Stephen and I worked on our 5 minute slide show that we are presenting on march 22nd 2017. In our presentation we talk about the little free stem library that we are making and what it is for and how we are planning on doing with it. For example, we used Google Maps to determine where all of the libraries are in Lansing and when they are open. We figured out we live in a library desert. We really need to provide this service to our community. It should not cost them any money. Everyone deserves to learn how to read.

Also when we practiced our talk on Tuesday, we did it under 5 minutes. I’m glad that me and stephen are making the little free library because its helping kids around Lansing and around the world and I’m hoping that other people tell kids that don’t have a way to the public library about the free library. Also me and sthphen are having lots of fun making the library and we are having fun coming up with new ideas to put in the library and how we are gonna put them in other places other than the boys and girls club. i hope you enjoyed the blog post -autumn



Autumn also brought her school science teacher to the club to see her library, and her presentation. She felt her teacher would have an opportunity to see a side of her that is “hidden” in school. Autumn did not think that her science did not care – indeed, she felt her teacher was a very caring person, one who would make a visit to the Boys and Girls Club. Rather, she

thought that no one asked science teachers to care about the community and it was “just not a part of school.”

Further, she noted that having had to “deal” with the GEF “made me start to think about how I can get more people to care . . . some people don’t really care.” Dealing with the GEF for Autumn meant that she responded to the historical institutional narrative of profit and elitism business codes by subverting the practices of that institution (the polished business-normed 5 minute speech) towards her local contentious practices for re-naming what counts (caring and serving community beyond profits) and raising awareness on inequities in youth STEM engagement opportunities.

Autumn was successful in enacting her contentious practices. She was recognized by the panel of business judges. As she reflected: “I won \$125 and I think its cuz i really helped people see how it was a social justice business. I also talked about how the library would help kids just like me. It was not supposed to make money. It was supposed to just help.”

The ways in which Autumn worked to improve the LSFL informed by more research were ways in which she further enacted her commitments to teach others, specifically the GEF stakeholders about the value of the LSFL and her commitment to help others (children with no access to reading and making materials related to STEM). Through the process, Autumn had to draw from her commitments to work very hard and do science that matters to her. In this way, her commitments in practice functioned in effect in a positive feedback loop as they were further sharpened and deepened as she engaged in local contentious practices.

Local Contentious Practice: “*Now Im a mentor and the chief blogger*” (“Access/Participation”)

Autumn blogged more than usual during the time she worked on the library. While she presented posts on projects and activities of others, she posted many blog posts about the library itself. Blogging about her work and her peer’s projects was one way in which she is keeping to her commitments-in-practice #3 & #4, to learn more about herself, more about science and to engage in Fcience. Autumn becoming GET City’s chief blogger is also a direct push back on how she had been labeled and judged wanting by teachers in reading and writing, as a D student.

Since she began work on the LFSL in the 10th grade, Autumn penned 42 blog posts (October 2015-present). Of the 41 posts, she mentions the LFSL in 18 posts, and in 10 posts the focus was exclusively the LFSL.

These blog posts, kept across two years, remind the world (open readership) of: a) how hard she has worked, b) how important access to STEM is, c) how important the library is, and d) how much others appreciated her work. She points to the importance of STEM knowledge in imagining the library, constructing it with an alternative energy source, and designing the paper circuit kits. She points to knowledge of community as crucial in knowing what to put in the library to help kids to “get to where I’ve gotten.”

She highlights the following blogpost written by a younger maker club peer, Jasmine, who is now starting to write blog posts and with Autumn’s help fixed the broken wheels on the LFSL. Autumn likes how the LFSL is something that everyone shares and owns, “Our Little Free STEM Library wheels broke...”, suggesting that this is a really good example of how teaching others helps them to develop their own commitments, too.

Getting down to business

Posted on **March 8, 2018** by **angle**



Our Little Free STEM Library wheels broke, so I removed them and now I am adding fabric so that the LFL can move around easily now that we have no wheels on it. Right now I'm cutting up fabric to put at the bottom. I think this will look nice and work. When I'm done with that I am going to fix the solar panel and lighting system. -Z



Discussion

In the findings above we shared how Autumn's commitments-in-practice take shape over time and spaces, as her person-in-history interacts with history-in-institutionalized struggle (Holland & Lave, 2009). The local contentious practices, which take shape as a result, challenge and expand Autumn's commitments-in-practice and her desires for why these commitments matter. They also work to deepen Autumn's commitments-in-practice.

With Autumn's story, we also push on this conceptualization to argue that by examining how local contentious practice takes shape over time, we can better understand how a ***culture of criticality develops in the space between person & institution***. We believe that builds on but advances how we think about the importance of local contentious practice because it stretches how we understand how tensions play out in as individuals participate in cultural activity towards transforming possibilities for new cultural possibilities. A culture of criticality supports Autumn, and those with whom she interacts in activity (e.g., mentors, peers, allies) in collectively forming new and different relationships and navigations with/in social networks, communities, and activities – opening up access to new resources, spaces, and points of entry, and representatives of STEM, making STEM more accessible, visible, and doable in her community.

The particular institutional narratives (which are often limitations) are what shapes Autumn's developing commitments-in-practice and through that process, she develops a criticality lens that she uses to inform how she enacts her commitments-in-practice. For example, with the initial foray into entrepreneurial faire with her Little Free STEM Library, the capitalistic, middle class life-style (i.e. wedding planners, cup cake bakers) institutional narrative produced tensions and her justice-oriented entrepreneurial practices were framed as contentious. This experience informed how Autumn re-evaluated her commitments-in-practice and how she then layered on a critical lens to what she does next: She further displays her commitments to work hard, to do science that matters. Her commitments-in-practice lead to moments/experience that bring those around her into this cultural space. Her mentors engage in new investigations alongside her, and also seek out their own interactions with GEF leaders to question their exclusionary practices. That translated into doing more research on the library desert issue, adding more technical features on the LFL, working harder on another presentation aspect --the 5 minute presentation that allows her to gain more prominence without necessarily having to get more

“stuff” to stand out (like the cupcake winners the previous year) so that she can teach the GEF stakeholders the importance and value of her LFSL, so that she can eventually help the peers the LFSL is intended for.

Further, Autumn positioned helping as a centralizing practice in STEM. This is arguably in opposition to the ways in which powerful adults in her life have positioned helping as secondary to other more individualistic-framed qualities, and have positioned her as “helpful” and a “team player” as a lesser compliment to their descriptions of others as special, smart, and leaders. But over time Autumn has worked to show the world, and the important adults close to her in her life, that her qualities as a helper also make her a leader in her community--and a respected leader in STEM and literacy.

Here we see a culture of criticality developing when the person -- in this case Autumn -- retools the enactment of her commitments-in-practice in savvy ways that foreground criticality, as a result of her shaping her commitments as a response to institutional narratives.

A shift in Autumn’s local contentious practices takes place, reflecting her developing criticality -- She is critiquing the normative view of 1) what counts as helping others; 2) what she needs to do to be able to robustly help others, and 3) to communicate to others, what such helping entails. This developing sense of criticality has impacted how Autumn shifts in her practices as related to discourse, access, awareness and authority. She articulates an increasingly nuanced awareness of how inequality in STEM participation operates through how non-dominant communities are mislabeled as having no value to dominant society. Through her blogging and renaming terms such as “fcience”, Autumn introduces and promotes new ideas and terminology to distinguish her work and commitments, her definitions and actions that constitute helping others in her community, with social-justice oriented business models and “communicating to the world” what fcience kids in her community are doing. Autumn also challenged authority through her practices --she questioned school authority who decides how students learn about science instead of doing science, she critiqued the GEF organizers for their profits-biased criteria towards youth entrepreneurialship, she advocated for her role as a chief blogger with the GET City teachers and club administrator as a key way for her to continue learning science, engage in fcience, and *help, in the ways she has determined to be meaningful*, the younger GET City youth as a mentor. In shifting her practices, Autumn as had to reflect on her own becoming, making a commitment to be more vocal and open with her own story and to be willing to call explicit attention to the equity issues she herself faces, alongside members of her community.

Conclusion and Implications

Autumn’s story is a powerful one. It is a hopeful story of how one girl growing up in multigenerational poverty, who was deemed an unsuccessful student, went against the odds and embarked on a different path towards becoming somebody in STEM. It would, however, be unethical and unjust to frame Autumn’s story as an exemplar of one who “pulled themselves up by their bootstraps and succeeded through sheer determination”, as locating the resources to do so solely in Autumn as a resilient person. While Autumn is indeed admirably resilient, she also had steady allies in her community who helped support her crafting and ensuing development of her core commitments-in-practice that led to her agentic practices. While Autumn and her allies relished the small wins along her becoming in STEM, they nonetheless kept a firm eye towards transforming systemic inequities as an ultimate goal. Autumn’s story points to both the kind and degree of marginalization nondominant youth experience in their STEM engagement and raises questions for how science teachers, researchers, and educators

across formal and informal spaces should consider what empowering, authentic and connected STEM experiences for all students should entail.

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