

Learning and Becoming in Movement at the Intersection of Formal and Informal Science

Attending to Wayfaring, Intersectionality, Emotions, and Epistemologies

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Abstract

This paper builds on the policy statement of the Informal Science Education “Ad Hoc” Committee (Dierking et al., 2003), and unpacks what a convincing story of real world and lifelong learning in science might entail, as called for in the policy document. The paper takes that policy statement a step further by bringing a critical lens to current research on informal science education, resulting in calls for action in future research, that are illustrated through vignettes from three collaborative research projects. Throughout, we pay attention to the emotional work youth participants in afterschool and community programs are engaged in, marked by intersectionality. We argue that it is this kind of emotional work entangled with assigned positions and the authoring of new selves, that informal science practices can support. One vignette focuses on a girls-only afterschool space in which science is refigured through joint-work, another vignette explores a youths’ educational ecology and brings a space-time reading to learning and becoming in movement, while the last case focuses on navigations among epistemologies in the context of a water stewardship project led by Inuit. The three vignettes and subsequent discussions make possible the proposition of some new tools to think with for design studies and future joint projects committed to equity, deeply seated in and leading to expansive forms of participation, transformations and agency in and of science. In doing so, the paper aims to shift the performance range and positionality of learners and becoming in science and push us to attend more tightly to what happens outside the pipeline vision of science, and the manner science is entangled with learning lives.

Key words: learning in movement; identity; informal science; wayfaring; emotion; intersectionality; epistemology

This paper builds on the policy statement of the Informal Science Education “Ad Hoc” Committee (Dierking et al., 2003), and unpacks what a convincing story of real world and lifelong learning in science might entail, as called for in the policy

document. The paper takes that policy statement a step further by bringing a critical lens to current research on informal science education, resulting in calls for action in future research, that are illustrated through vignettes from three collaborative research projects.

The first vignette makes evident the dialectic between learning and becoming *in* movement and intersectionality. We do so through the study of a dialogue that emerged among high school girls within an afterschool program as they edited streeters. The latter implied asking other youth in the program about how science figured into their lives and then editing the answers into a clip responding to that question. We attend to the contradictions raised as they aimed to weave together stories of their lives as youth and as youth of color, living in an underserved community with normative science. The second vignette offers another view of learning and becoming in movement by expanding the space-time lens. It tells the story of Burak and his wayfaring and making of trails within an educational infrastructure that was accessible to him as a first-generation immigrant from Haïti. The third vignette engages with current epistemological assumptions in science by de-settling the taken for granted, calling for engagement with multiple epistemologies at the intersection of formal and informal science. The vignette offers a story of an Inuit-led water stewardship project in Mittimatalik (Pond Inlet, Nunavut), making evident in what ways on-going epistemological wayfaring constitutes learning and becoming in science. Members in the community of Pond Inlet sought a partnership with a community organization that offers support and resources for Inuit-led projects. That partnership translated into a three-year project, implying the monitoring of water quality in local streams, with results then guiding local and regional decision-making and the planning and protection of community sourced water.

Throughout, we pay attention to the emotional work youth participants in afterschool and community programs are engaged in, marked by intersectionality. We argue that it is this kind of emotional work entangled with assigned positions and the authoring of new selves, that informal science practices can support given their unique role and potential for becoming safe spaces, marked by the development of deep relations and solidarity that result in bonding capital (Nasir & McKinney de Royston, 2013). Afterschool or community science practices essentially can become “thick places” within which it is safe for minoritized youth to push boundaries of science and disrupt and challenge who can be a science person (Duff, 2010). The three vignettes and subsequent discussions make possible the proposition of some new tools to think with for design studies and future joint projects committed to equity, deeply seated in and leading to expansive forms of participation, transformations and agency in and of science. In doing so, the paper aims to shift the performance range and positionality of learners and becoming in science.

Theoretical Grounding: A Mobility Lens

Working in the traditions of sociocultural theory, anthropology and the learning sciences, we understand learning and identity in science as “embedded in our lives over time” (Sefton-Green & Erstad, 2013, p. 2). A focus on learning lives in science essentially pushes us to focus on learners’ navigations of opportunities, for-

mal and informal, that then become the building blocks of their lives and the kind of science literacy and kind of identity work in science learners engage in and aspire to. It assumes that we are all in contact with science in a multitude of spaces and at many different moments in time. Learning is understood as implying shifts in terms of children's and youths' thinking and understanding of science and its key concepts, next to shifts in forms of participation in practice (Lave & Wenger, 1991; Nasir, 2012). Learning is also tied to identity and about becoming a certain kind of person (Holland et al., 1998). Identity is understood as dynamic, grounded in the individual's history and complex trajectory and perception of who one has been, is, and can become, given ascribed social categories by cultural groups and settings, that are then negotiated, picked up or rejected by individuals as they author their own selves in line with desirable identities in science (Nasir, 2012). As such, an identity in science, like learning, is never accomplished, but instead, dynamic, continuously changing and in the making, and marked by the structure-agency dynamic. It is the dynamic process of learning and identity that has to be understood at multiple levels simultaneously, the macro (structure) and micro (agency in practice), and over time. This led to an interest in the study of learning and identity *in movement*, implying the study of "how moment-to-moment interactions related to, and could be made to relate to, broader contexts in which they could become consequential for learners" (Juwon & Shea, 2015, p. 2). It calls for a focus on the accrual of practice. In line with this argument, Barron (2010) documented the manner engagement with and an interest in science or other subject matter develop over time, while Wortham (2006), for instance, focused more tightly on how learning and identity as a certain kind of person takes hold over time in practice. These studies attend to different timescales of objects and artefacts and their role in mediating connections among practices and the becoming of a science person. What unifies these studies is the assumption that learners are agents who "disrupt flows of ideas, practices and people across spatial and temporal orders" (Juwon & Shea, 2015, p. 288).

At the same time, Leander and Hollett (2017) critique studies that focus solely on "connecting the dots" of activities and representational reading of lifelong learning and propose a change in focus, from understanding "learning across settings to learners crossing settings" (p. 1). They suggest a focus on embodied experience of space-time, and ask how understanding this experience, as it moves, might yield insights into the broader theoretical and methodological challenges of understanding learning across settings" (p. 2). Essentially, they call for a focus on "emergence (wayfaring)," and "pushing away from static representationalism" (p.2). In light of this argument, the notion of wayfaring is useful "to describe the embodied experience of this perambulatory movement" (Ingold, 2011, p. 148) and to show in what ways becoming in science unfolds along paths as *one is in movement*. The wayfarer is entangled and embodied in that movement as the wayfarer "threads his way *through* this world" (p. 151), suggesting that "wayfaring is our most fundamental mode of being in the world" (p. 152). Wayfaring implies the making of trails, and the leaving behind of trails, with the crossing of trails then leading to the emergence of knots. Yet, Ingold warns us to not think of knots as a place or point one travels to, but instead, calls for imagining knots as a "tangled mesh of interwoven and complexly knotted strands" or the "binding together of lines" (p. 152). He essentially argues that "knots, and the threads from which they

are tied are lines of wayfaring” (p. 149).

Building on the idea of mobility through the lens of wayfaring in this paper, we assume that coming to know and be in science happens through living, moving and sensing the world of science, implying embodied forms of learning and becoming in movement. In line with Ingold’s argument, we argue that we need to attend to “the entire meshwork of intertwined trails along which people carry on their lives” (p. 149). It naturally calls for enlarging the unit of analysis by attending to the manner learning and identity in science are entangled with other disciplines and developmental tasks, and marked by social, racial, gendered, economic, and political conditions that constitute those relations (Nasir & Royston, 2013). To understand “the complexity and hybridity” of science learning and identity as wayfaring naturally implies attending to the “complex, polycontextual, emotional and intersectional self” (Avraamidou, 2020). Hence, wayfaring is never neutral but marked by emotions and intersectionality that do something to our lives. As noted by Avraamidou (2020), “we live in and through emotions” in different ways, but we also live our complex political relations through emotions, expressing feelings tied to oppression or inclusion, or the joy of doing science or frustrations about being excluded from science, given its hegemonic nature. It led to the two questions this paper addresses:

1. How does learning and becoming in movement and by sensing the world of science and self in relation to science take form and constitute learning lives, at the intersection of formal and informal science?
2. How is such learning and becoming entangled with and marked by emotions and intersectionality?

Methods

We draw from qualitative case studies of three different out-of-school science programs. The first vignette was crafted from conversations that emerged in Convo-Club, a girls’ group run by a community organization (CO), reaching out to ethnically diverse youth in an urban center. We ran science activities within that club for sixteen weeks in 2016, leading up to the co-creation of a video documentary that we refer to, a story about science in the lives of the youth from the CO (Gonçalves et al., 2013). The club had six regulars, including Shanice who is of Black Caribbean descent and volunteers in the club. Sharon, Kelly and Caileigh, ranging in age from 17 to 18 years of age, and Sarah, 13 years of age, are all of Irish Canadian heritage, and finally, Karen who was 14 years old at the time, and is biracial (Irish-Canadian and Jamaican-Canadian background). We focus on a discussion that emerged as the girls were editing the streeters and aimed to co-construct a coherent story from the data they had.

The second vignette focuses on one youth whom we got to know as he participated in a four-week summer gardening and entrepreneurship program in 2018 that we refer to as ‘Vegetable Lane’, offered through a community organization we refer to here as ‘ruelle’, that reaches out to schools, youth, and families in underserved communities. We tell a partial story of Burak, a youth participant who immigrated to Canada from Haïti with his family in 2010, following the earthquake that devastated the island. We relied on fieldnotes, transcriptions of interactions from

video data, arrived at through interaction analysis among the research team (Jordan & Henderson, 1995) and interview data, to develop the story shared here.

The third vignette emerged from an ethnographic collaborative project that implied the joint documentation of a water stewardship project together with its project director and an involved community organization. The latter offered research tools and other supports given its commitment to promoting Inuit youth leadership and stewardship in Inuit Nunangat. In the vignette we rely on conversations and written documents gathered in the context of a qualitative case study of that project which implied observational notes from visits to the community and the water monitoring activities and collection of videotaped interviews of its participants and instructors from 2015 to 2017 (Spring 2015: 3 youth participants; 2 instructors; Fall 2015: 2 youth participants; 2 instructors; 2016: 2 instructors). For this paper, we center the voice of the project director and the manner he described the project and its benefits to the community.

The crafting of the vignettes for this paper was guided by our positioning as bricoleurs in ways described by Kincheloe and Berry (2004). Most important, we selected data sets to craft a story that would “fit the phenomena under study” (p. 101), while making “use of perspectives of multiple individuals coming from diverse social locations” (p. 102). In doing so, and through further iterative processes of re-reading the larger data sets, we were able to craft vignettes that are brief yet do offer rich insights and suggest new possibilities by centering voices of youth and adults still too often silenced in research in science education. We do recognize, however, that these stories are partial, and that many others could be told. Taken together, however, they offer rich insights in light of the research questions which guided the selection and crafting of the narratives.

RESULTS

Vignette 1. Sensing the Worlds of Science in a GirlsClub

The participants in the ConvoClub were busy figuring out what interview clips to use of their peers in their video documentary about how science figures in their lives. They had interviewed four male peers and regular participants in ConvoClub about how they think about science and how science figures in their lives to then inform others about how science is all around them. As a group, they tried to identify common themes among the streeters (video-recorded on-the-spot interviews) they had collected. The facilitator of the group tried to guide them through that challenging process:

Facilitator: Most people [interviewed by the girls] think science is boring, most people... don't know that they do science in their everyday lives. So, did you wanna keep all those little clips, where people say “I don't know”, “I really have no idea”...

Sharon: I think so.

Shanice: I think it's a bit true

Sharon: Yeah.

Sarah: The truth

Shanice: I don't think people actually think about using science every day. Like you go to school 'cuz they're supposed to teach you that there's science all the time, and blah blah blah

Shanice: But nobody remembers science at school.

Sharon: Unless you have to sit and think about it. 'Cuz even when you asked us, we were like "oh..."

Facilitator: Yeah. I know. It is kind of a difficult question to just bring on people.

Sharon: That's why [Bear] said he felt stupid.

The brief exchange above is telling of the hegemonic power of school science. To define science as boring can be read as a manner to save face in light of being positioned at its margin. That vision and positioning also silenced the youth when it came to name how they engage in science in their everyday live. The girls who interviewed the boys, had previously deconstructed that narrow vision of science through dialogue sessions and activities in the girls-group. Those activities helped them develop a vision of science as deeply grounded in and related to their everyday experiences of romance and relationships. It resulted in a new framing of science and authoring of selves as science savvy. Both were experienced by the girls as empowering, resulting in the observation that "there is science all the time" yet "people do not "actually think about using science every day" as further made evident in the ensuing dialogue, following the shared viewing of another streeter they had collected:

Facilitator: So... he [boy interviewed] said he's not interested in science outside of school.

Sarah: And then he does photography, so then that's science...

Kelly: And at the end-

Sarah: And then at the end he loves science.

Kelly: He's in love with science.

Facilitator: Yeah.

Sarah: Because he couldn't realize that photography was science. Yeah!

In this case, photography was a passion for Pedro, yet he did not see it as a form of engagement with science. Yet once it was identified as such by Kelly, it supported Pedro's authoring of self as somebody who "loves science" or as Kelly put it, "he's

in love with science.” Interestingly, and as noted by the facilitator, “the only person who knew something about how science figured into everyday life was David, who said “yeah, moving and walking.” The conversations that day ended with a focus on the take-away message from the streeters as follows:

Facilitator: What does listening to all of these interviews tell you about what people think about science?”

Sarah: That’s boring and that they don’t know very much.

Facilitator: Ok. So...

Sarah: I know, eh. Yeah. Yeah.

Facilitator: Boring [writing it down on a poster board]

Shannon: That there’s no single definition of science. It kinda proves the point.

Facilitator: Proves what point?

Sharon: That there’s no single definition of science. And like what science means to one person is not what science means to the other. Because he couldn’t realize that photography was science. Yeah!

Facilitator: ...ok, so we know that people think that science is boring and they don’t know very much about it. Ah, there’s no single definition of science, it means different things to different people...

The girls explained well the manner science was lived through emotions, noting how a science perceived as boring, naturally results in a disconnect with science. They craved a science that was interesting and somehow entangled with who they were and were becoming. While the video documentary led to many conversations about science and their own identity in science, it became clear over time that talking about science and connecting science to their everyday lives was a tool to refigure science in ways relevant to their lives, which they experienced as empowering, as the following dialogue also makes evident:

Facilitator: Do you think that most girls are interested in science?

Caleigh: Probably not.

Facilitator: Why not, do you think?

Caleigh: ‘Cuz they’re more interested in like their hair, and like their makeup, and like being popular, ‘cuz like science doesn’t necessarily go with being popular, being like in the cool clique, so girls like being in the cool clique.

Facilitator: Do you think that’s more normal for boys to do science than girls?

Caleigh: Ah. Probably. I think maybe yeah. ‘Cuz girls are more like I think we’re more like: We don’t wanna like get our nails ruined, or we don’t wanna like get something on our clothes, or like we don’t want this chemical doing something with my hair, or like if it’s humid and you don’t iron them, they’ll be puffy, like guys are just “I don’t care”, do whatever you do.

Given this exchange, we wondered about the value of our conversations in ConvoClub. They had given the girls an opportunity to deconstruct such gendered discourses, at times also marked by race, about who can be in science or a science person. Yet, such gendered and hegemonic images and practices did continue to define who they could become in science outside ConvoClub. Outside ConvoClub, to be interested in science was about becoming somebody else, somebody who did not value girly things like “getting nails ruined” or “getting something on our clothes”. To be an insider to science meant they had to reject who they really were and wanted to be – proud girls and for some, proud girls of color despite growing up in one of the most underserved communities in the city and lacking access to rich and engaging science in their schools. The dialogue hints at the emotional work such identity work implies and the manner intersectionality marked their positioning in science. We talked multiple times about differences between school science and the science in ConvoClub and how the latter had no currency in school yet was a form of science they enjoyed engaging with and could see themselves identify with.

Implications

The vignette makes evident how emotions are entangled with positionings and authoring of selves in science. On the one hand, the club became a safe space for the girls to engage with and deconstruct science and who can be in science in ways they never had an opportunity to do elsewhere. The study confirms that informal educational settings can become particularly important spaces to engage in such a deconstruction, to voice concerns about the manner science positions and disempowers, to share felt emotions and struggles, and to reposition selves within that complex landscape of meanings and relations with science. ConvoClub supported the girls’ engagement with multiple possible selves that were co-constructed through dialogue and practice. In that sense, the activities in the girls’ group encouraged new forms of wayfaring and the leaving of new trails and learning and becoming in movement. While the activity in ConvoClub was short-lived, it became a safe space to raise personal struggles, share emotions tied to a disconnect with elite science without getting in trouble. It was a place where some foundational work could get done among the girls “for continual science work” (Katz, 2017). The club supported an exploration of science identity as emergent from and tied to a complex “landscape of becoming” (Avraamidou, 2020), making evident how this kind of identity work in science is part of a lifelong ongoing process of wayfaring.

Vignette 2. A Learner Crossing Settings

The Rooftop Garden. Today was the first day of the camp which implied work in the

rooftop garden. Jane, the instructor, engaged the youth in a plant identification activity. One of the boys who had participated in the activity before took the lead in writing down the names of identified plants on a piece of paper, while the others helped out. They all stopped by the nettle plant given a sign “dangerous”. Jane explained that the plant burns the skin upon touch. As they moved on with Jane, she gave them clues that facilitated plant identification. She also encouraged them to touch, smell, and taste, especially the herbs. Youth wanted to know more about what makes the skin burn when in touch with the sap of a nettle plant. Jane explained the liquid in the stem that results in a burning sensation upon touch. The youth then explored the many types of mint they grew, which made one youth think about ‘curcumen’ and ask if they could grow it here. Jane explained that it is a root and that she had never seen it grow in Québec. Another youth offered to bring a book from home, that explains all about it. They then talked about factors that make for a healthy rooftop garden. Jane talked about the mistake of planting just one specimen, as it may result in the contamination of other plants and loss of harvest. After their break, they were asked to water the garden. Burak and other youth filled up the watering cans, while others took hold of the hoses, watering each other and the plants, given how hot it was. [Journal Notes, July, 2017]

The vignette makes evident some of the forms of participation gardening supported. Youth learned more about some plants by “dwelling” in the rooftop garden and identifying crop by touching, smelling, and eating, while learning more about what makes for sustainable gardening, and the kind of care gardening implies, like watering. After one week of gardening, the team transitioned into the kitchen where in smaller teams, they baked different goods with the vegetables and herbs from the garden, for sale at the market. In this vignette we center Burak’s forms of participations and positionings in the program by his peers. It was Burak’s second year of participation in Vegetable Lane. Burak’s Carribean background and history of immigration from Haiti to Montreal positioned him initially at the margin of the local school system given struggles to follow along in French, making him repeat a grade level. At the same time, he remembered the activities offered by ruelle in his elementary school as engaging, which then led him to continue his participation in Vegetable Lane. Burak’s team made brownies with mint from the garden. The following exchange emerged as Burak was cutting mint:

Theo: Wow, you are too good at it! You got experience.

Burak: Ha, ha, ha, yes, I can say, they taught me, kind of. The other one who was here before (referring to the instructor)

Theo: Oh really?

Burak: Yes, there was somebody else here before, not her. [July 11, 2017]

Burak’s embodied expertise in gardening and preparing produce for cooking was recognized by his peers, which led to his sense of empowerment. He referred to his peers and instructors as his friends, “they are my friends and I appreciate them a lot, they are the kind of people who are very nice and it is a pleasure and special treat for me to work with them.” Burak’s emergent expertise and recognition by

his peers as “somebody who can do all these things”, led to pride and positive emotions. Burak developed a positive disposition towards the program which led to full engagement, something Burak noted in the interview and which was not the case the previous year, when his form of participation implied in his words, “just hanging out with friends”.

The team also spent one week in the science laboratory, making soap and bath balls for sale at the market. Burak was again recognized by one of his peers as an expert, a positioning the instructor also approved of, tapping Burak on his shoulder. That embodied recognition followed after they struggled measuring the ingredients for the bath balls. Burak knew that the scale they used was inaccurate, giving often different readings. The instructor was quick to blame Burak, “you must have read the weight wrong.” Yet, in the end, she realized that the scale was broken. His peer, Elias, positioned Burak as knowledgeable by emphasizing, “well, you see, it was Burak who was right.” While the instructor nodded, Elias added “so let’s show some respect for Burak” to which the instructor responded by tapping Burak’s shoulder, noting, “hey congratulations, that’s great!”

The group was also coached by professionals in marketing strategies tied to the start-up of an enterprise. In the brief exchange below, a group of youth was preparing a slogan for a poster to attract customers to their market. Interestingly, their initial focus on a catchy slogan turned into an exercise in French grammar:

Theo: point, it’s your goal

Burak: No, no, no, ... it’s about helping the future generation

[Aider les generations futures]

Theo: It’s your mission to help future generations

[C’est notre mission d’aider des générations futures]

Burak: No, actually, it’s the opposite

Nassan: The future generation [La generation future...]

Burak: It’s your mission [C’est notre mission]

Theo: Yes, help (aider) with a (« ez ») [suggesting the verb needs to be conjugated = aidez des generations futures. [July 25, 2017]As they were creating a slogan for the poster board, they got caught up in a disagreement about the tense of a verb. Burak was right again here too, making the group write the slogan in ways he proposed, positioning him as an expert in yet other ways.

The team took part in the sale of everything at the local farmers market at the end of that week. Burak claimed to have “participated for real only now” in his second year in the program. He shared his feelings with us as he was arranging flowers for the upcoming sale at the local farmers market. He came to the program to socialize, whereas this year, he valued the program for the many things he learned,

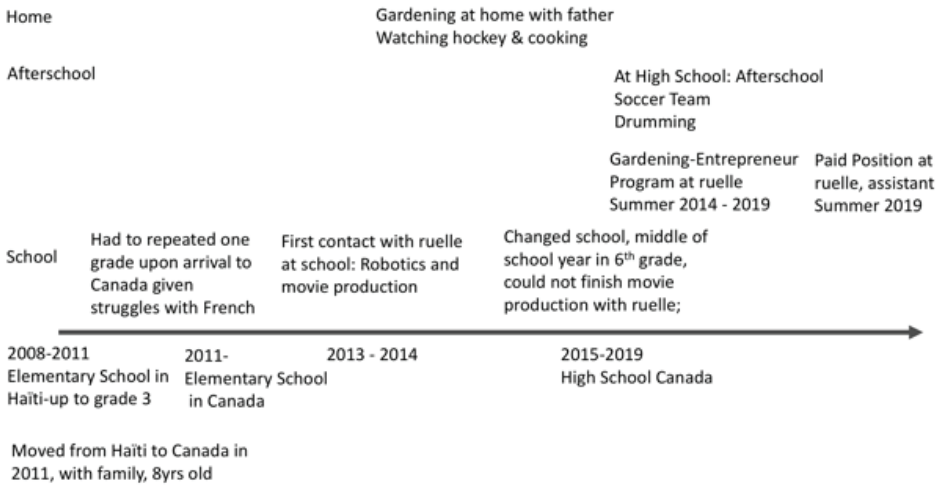
especially about marketing. He saw the latter as crucial for his future, permitting him one day to run his own business. Program participation also “helped me to get to know myself better”... “I realized that I like to eat, I like to create new recipes” and when in school, “some would ask me for advice or some information, and I could share things I learned about in this program.” He also talked about making soap and bath balls with his father, who noted how valuable such ways of knowing are for running a soap business one day.

In the end, Burak participated in the program for four consecutive years. The analysis above suggests that instructors and peers in the program positioned him as somebody who is knowledgeable and has important contributions to make. This was not how he was positioned in school, at least not always, as we found out when doing a timeline of his educational pathway during an interview in 2019. Burak vividly remembered his family moving to Quebec in Canada, and him having to repeat a year of schooling at the beginning, as he could not follow, according to his teacher at the time. It was emotionally challenging for him to be held back. Another emotionally charged memory was his report card and the losing of points which then obligated him to stay inside during recess or stay on after school. It was something that made his mother very upset. At the same time, Burak also remembered teachers who encouraged him. For instance, he struggled with English in high school, as languages did not seem his strength, yet his English teacher went out of the way to help him pass the course. In contrast to school, the aim to socialize with peers initially attracted him to the gardening program. Yet, as Burak explained, over time, “the program helped me to understand myself in new ways, what I am good at, what I am not as good at, what I like to do with my future and what I would prefer not to pursue later on. I also developed a real team spirit this year.” His dispositions towards the program and himself changed. He felt empowered within the program and experienced agency in ways he valued.

Taking on the lens of wayfaring, the analysis makes apparent the manner Burak lived the program through interactions with others who treated him with respect and dignity. Burak was recognized as a youth who can succeed and who brings strengths to the program. That positioning made him live the program in positive ways and did something to him. The program became a “thick place” for him, as his reference to it as a second family suggests (Duff, 2010). In 2019, Burak was employed by Vegetable Lane and helped out in the family gardening program. As summarized in Figure 1, wayfaring became marked by his time at Vegetable Lane in important ways.

Learning and Becoming in Movement

Figure 1. Burak's timeline of activities that were important to him



Burak's timeline also makes evident moments he came in contact with science through ruelle. With his class, Burak participated in a robotics project with ruelle, and later, also pursued a project in movie making, in addition to participating in Vegetable Lane during the summer. Yet, none of these activities gave him a sense that he could become a science person. Instead, he was eager to use science as a tool – like making soap – to one day run his own business.

Implications

The vignette makes evident how important community based educational spaces (CBES) can be in supporting youth development and well-being which we understand as essential to learning and wayfaring in and beyond science. Quality CBES resist deficit views of youth and offer youth opportunities for embodied learning and becoming that are emotionally engaging and empowering (Baldrige et al., 2017). Burak's story makes evident how being treated with dignity is key to his well-being and educational achievement, but also sustained his engagement with ruelle over time, even when he moved away from that neighborhood with his family, which distanced him physically from its location. Engagement over time led to many empowering learning experiences. Most important maybe was the opportunity for Burak to give back, as a youth mentor and employee of the organization. In that sense, my research team understood ruelle as a key "resource, helping youth connect with each other, their community, and adult allies" (p. 388). That is, Burak's positioning as lacking, as needing to repeat a grade, as being a problem

in terms of his behavior by some educators, led to frustrations and exclusion. Yet, through his ongoing presence at ruelle, he built a system of relationships that sustained him and positioned him as somebody who *can* become educated. Burak's wayfaring also shows that ruelle offered opportunities to engage with science, initially through an activity in robotics, and later through gardening. These were opportunities for Burak to engage in "continued science learning" for his own sake (Katz, 2017). That learning was also embedded within a rich set of other learning opportunities, over time, as Figure 1 makes evident. The vignette suggests that Burak was "banking the learning for perceived future need" (ibid, p. 14) and was imagining himself as a future entrepreneur. He was becoming the kind of "competent outsider" to science that will have the skills to one day engage with science in locally relevant and adaptive ways (Feinstein, Allen, & Jenkins, 2013).

Vignette 3: Stewardship of Water and Land in Nunavut

The third vignette speaks to the manner water supply in Nunavut is tied up in complex ways with issues of climate change such as "receding sea ice and glaciers, decreased stream flow and dryness, increased temperatures and rain events." It led to concerns, in many communities, about the quantity of drinking water that is available, but also its quality. In Pond Inlet, Nunavut, the site of the stewardship project we focus on here, the water lake serving the community was created during the settlement period in the 1970's, and still serves the community today, a community that has increased substantially in terms of its population and water needs. To rely on one water source only is risky. Threats to water quality are multiple, some tied to a long history of contamination of the land, others to challenges tied to disposal (Johnson, 2018). The community relies on trucked water delivery and sewage collection, another challenge in terms of water quality. To ensure health safety measures, Chlorine and/or Javex are added to trucked drinking water, a practice that started in the 1970's, according to the elders. Others referred to the addition of fluoride, and still others recalled the frequent "boil water advisories." Those forms of water management stand in stark contrast with the traditional water gathering practices of Inuit prior to settlement and still pursued today. As the youth in this project found out and shared in conversations with us, "elders prefer iceberg and multi-year ice for drinking water as well as water from fresh streams" given its taste. These concerns led to the project in the following ways, as described by its director:

We wanted to develop a project that would provide us with the opportunity to conduct serious research and answer the preoccupations of our community in a way that would build our skills and knowledge for the benefit of our community. We found out that the best way to achieve these goals was by taking the lead in research and manage it ourselves and when needed, request the help of researchers in universities and community organizations. I started this project given encouragement by community members and Elders, and wanted to respond to the concerns of community residents who complained of stomach illness. Our community had no equipment, no capacity back then to research water.

The project was deeply grounded in Inuit Knowledge Systems (IKS) yet open to the integration of and blending with Western Science and scientific methods,

as long as the program remained locally grounded, relevant, and empowering, contributing to the common good (Lipe, 2019). It implied a conscious move away from the domination of Western Science over Indigenous Knowledges or an add-on approach, as is still often the case. The project was deeply seated and committed to an indigenous ontology.

The project director also presented at numerous scientific meetings and had much experience navigating the Western World and Knowledge Systems. When attending a meeting in 2016, he was happy about a change he noticed towards more community-based and community-led research presented by Inuit. Yet, he still saw the need for “more community-based researchers to come and present their work and with their emotion, tell the audience how they feel. This is how it should be in the communities, no more colonial forms” of research.

The water monitoring project emerged from local needs and always stayed in the community. The director of the project was taught by scientists that he sought out for training through a collaboration with a community organization. That organization offered scientific and technical resources and support. The director describes it as “unique... to have been trained by researchers, and everything I’ve been trained at” which implied some training in laboratories at partner institutions and Universities. While not always trivial, it left the project director and his community with new tools and skills to pass on, to “now train youth in my way, because I can speak their language, and I can make them understand without losing them ... just living, being a part of a community, we understand how we can learn and work together. So everything I’ve been trained at I’ve trained my young Inuit assistants in a different way or in our language” deeply grounded in Inuit ways and guided by *avatimmik kamattiarniq* or the collective responsibility for all Inuit to act as environmental stewards and respectful guardians of wildlife and the natural world.

The project director would “like to see more programs and more opportunities” like this one, a reason that motivates him to continue, “that is one reason why I do this, so that there are more opportunities for youth, more money going in, whatever little money it is, it helps the little economy. I’d like to see more programs, and more opportunities when they grow up, so like there can be a path.” The project director was referring to his own path of moving back to Pond Inlet after having spent his childhood in an urban center and Western Educational System. Once back in his community, he could reconnect with his language and culture through work with elders and other community members. Thinking back about his youth, he notes how the youth he works with in the project have the opportunity to be part of an all Inuit Team, something that makes them proud, is unique, and not something he experienced growing up:

It’s a community driven project, community concerns, and it’s run by Inuit. And having an Inuit leader, just gives them pride, and they’ve said it time and time again. It’ll empower them, they can maybe do their own someday.

Pride makes all of us better. When you have something to be proud of, you have something to work for, everything’s easier to work. When you’re happy, you look forward to something. Being proud of what you’re doing, you’re happy, you’re your own boss, you can... like if a boss is proud, it will show with his workers, his assis-

tants and it will catch on. And being looked up to, having the assistants be proud of an Inuit project leader just helps, we're all happy, we're all proud of the work we're doing. It's for something, it's for community. I think it makes it so much easier and better. We can do a good job. It's very nice to get great feedback from elders who believe this is for one common goal and it's not run by southerners anymore.

The project director's ability in navigating epistemologies was put to use but also so much more, as he describes further:

The driving force to what I'm doing is the learning, taking what I've learned and helping and training others so they can understand. For example science has fancy words, I can take it, transcribe, translate it to something that regular community members can understand and if they can understand it, they'll be more..., the better they understand it, the more they'll get involved. And if we can get more and more involvement it's just gonna blow up and... they'll do their own thing. It won't be old fashion anymore - having southerners coming up to our arctic communities doing what they want - it's gonna be Inuit doing what they want. They can take the lead. They can do it [See Figure 2 showing some of the monitoring work].

Figure 2. Sampling at water lake (left); water flow observations and sampling in river (right)



Implications

The water stewardship project speaks to learning and becoming in movement tied to navigations among epistemologies and worlds of science. The project is about rebuilding relations that have been broken due to ongoing colonisation, relations to land, water, language, culture, elders and other knowledge holders, ways of knowing Inuit have always known to be true, while striving for the common good. The project also hints at ways of building research relationships that have to be re-established, implying some of the following kinds of respect: “respect your land; respect your laws; respect your Elders, respect your culture, respect your community, respect your families, and respect your futures” (Wilson & Hughes, 2019, p. 15). Research and joint work can then put in action those responsibilities to relations. The project described here took this to heart. The project director worked with elders to ensure the resurgence of Inuit ways of knowing, doing and being and build a solid foundation of the water stewardship project in this manner. By bringing youth together with elders, bringing youth on the land and in contact with water, the project worked towards rebuilding broken relations. The project led to a relational accountability that set it apart from Western Science and its underlying ideology which too often resulted in researchers flying in and out of the community to conduct their own research with no contributions to the common good of the community.

The project director also refers to the manner the Inuit-led monitoring project was driven by and contributed to “‘messages in our body’ and the feelings in our ‘heart and our soul’” (Wilson & Hughes, 2019, p. 11), which also set it apart from Western driven water research. That dimension became most evident to the project director when he attended presentations by Inuit about their own stewardship work. The vignette makes evident how science figures into our learning lives and how learning and becoming in movement imply navigations among epistemologies with the indigenous worldview being deeply seated in emotions, and entangled with community wellness and a wholistic framing of the world, and of science. That is also why indigenous knowledge systems in this case captures best what the project director describes, and is, as some suggest, “the missing link in scientific worldviews” (Lipe, 2019, P. 453). Learning and becoming in science in this instance is about rebuilding relations in and through movement among epistemologies and world systems, resulting in the rebuilding of respectful relations.

Discussion

Gutiérrez (2020) notes that “learning as movement was intended to unsettle how we see what counts as learning, where we see learning, and especially to imagine what new perspectives and epistemological footings are called for in attending to new sets of relations and spatial configurations.” The three vignettes offer a beginning to re-imagine learning and becoming in movement and at the intersection of formal and informal science. The first vignette looks at a practice committed to re-mediating girls’ interest in science through co-creations and engage in conversations that naturally emerge yet are telling of lived emotions entangled with different positionalities in science. The second vignette focused on wayfaring and knotting, documenting how learning ecologies emerge yet are also tainted by po-

sionalities, emotions and histories in person. The third vignette explored navigations among epistemologies and how those position but also support new possible selves. We call for more work that carefully attends to mobilities, intersectionality and power, emotions, emergence, agency, and embodied learning and becoming in and through science in the real world, through joint-work and attention to mobilities, resulting in new imaginations of what could be. The vignettes offer important methodological insights into the kind of timescales we may need to strive for in future studies of learning and becoming in movement, in science, as well as the “attunement needed to illuminate and document the complexity of human learning activity” (Gutiérrez, 2020, p. 430).

What are some other new tools to think with for design studies and future joint projects in the field? What clearly stands out is the need for a more holistic vision of learning and becoming in science, entangled with subject positions that are political and continuously shifting, marked by intersectionality and lived emotions. A spatial reading of educational venues for deep engagement with and embodied science, also suggests that the co-creation of “safe spaces” to engage with science takes time, yet is highly valuable. Through engagement in the co-creation of such spaces researchers’ take on new positions that can then result in the joint documentation of a practice and its key components in ways that make evident what matters to youth participants. That kind of work challenges our own positionings and relations as researchers with the individuals, practices, communities and epistemologies that we work with, resulting in new possible imaginations of practices that are co-constructed, and that are at the cross-roads of formal and informal science (Gutiérrez, 2020). By expanding the scales of time, we can document deep and durable involvement with science in ways the cases hint at. But we also have to attend to different practices and to the manner learners are entangled with and deeply engaged with a science that is far removed from the pipeline vision (Feinstein et al., 2013). By attending to learning and becoming in movement through a focus on wayfaring, intersectionality, emotions and epistemologies across the three vignettes, the paper begins to unpack what this might imply, encouraging more work that looks more critically at “living and learning” which are “complex and cumulative” (Katz, 2017, p. 23), embodied, emotional, and political, while also deeply entangled with science, all of which constitutes learning lives.

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References

- Avraamidou, L. (2020). Science identity as a landscape of becoming: Rethinking recognition and emotions through an intersectional lens. *Cultural Studies of Science Education*, 15, 323-345. <https://doi.org/10.1007/s11422-019-09954-7>
- Baldrige, B. J., Beck, N., Medina, J. C., & Reeves, M. A. (2017). Toward an understanding of community-based educational spaces in disrupting inequality for minoritized youth. *Review of Research in Education*, 41, 381-402. <https://doi.org/10.3102/0091732X16688622>

- Barron, B. (2010). Conceptualizing and tracing learning pathways over time and setting. *Yearbook of the National Society for the Study of Education*, 109(1), 113-127. <https://doi.org/10.1177/016146811011201308>
- Dierking, L.D., Falk, J.H., Rennie, L., Anderson, D., & Ellenbogen, K. (2003). Policy statement of the “informal science education” ad hoc committee. *Journal of Research in Science Teaching*, 40, 108-111. <https://doi.org/10.1002/tea.10066>
- Duff, C. (2010). On the role of affect and practice in the production of place. *Environment and Planning D: Society and Space*, 28, 881-895. <https://doi.org/10.1068/d16209>
- Feinstein, N. W., Allen, S., & Jenkins, E. (2013). Outside the pipeline: Reimagining science education for non-scientists. *Science*, 340 (6130), 314-317. DOI: 10.1126/science.1230855
- Gonsalves, A., Rahm, J., and Carvalho, A. (2013). “We could think of things that could be science”: Girls’ refiguring of science and self in an out-of-school-time club. *Journal of Research in Science Teaching*, 50 (9), 1068-1097 DOI: 10.1002/tea.21105
- Gutiérrez, K. D. (2020). When learning as movement meets learning on the move. *Cognition and Instruction*, 38(3), 427-433. <https://doi.org/10.1080/07370008.2020.1774770>
- Ingold, T. (2011). *Being alive*. Routledge.
- Johnson, K. (2018). Nunavut communities struggle with shortage and supply issues. *Environmental Science and Engineering Magazine*, April, 10-13.
- Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *The Journal of the Learning Sciences*, 4(1), 39-103. https://doi.org/10.1207/s15327809jls0401_2
- Jurrow, S., A., & Shea, M. (2015). Learning in equity-oriented scale making projects. *Journal of the Learning Sciences*, 24(2), 286-307. <https://doi.org/10.1080/10508406.2015.1004677>
- Katz P. (2017). Formerly ISE: Preparation for Continual Science Learning. In P. Patrick (Ed.), *Preparing informal science educators* (pp. 13-38). Springer.
- Kincheloe, J. L., & Berry, K. S. (2004). *Rigour and complexity in educational research. Conceptualizing the bricolage*. Open University Press.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.
- Leander, K. M., & Hollett, T. (2017). The embodied rhythms of learning: From learning across settings to learners crossing settings. *International Journal of Education Research*, 84, 100-110. <https://doi.org/10.1016/j.ijer.2016.11.007>
- Leander, K. M., Phillips, N. C., & Taylor, K. H. (2010). The changing social spaces of learning: Mapping new modalities. *Review of Research in Education*, 34, 329-394. <https://doi.org/10.3102/0091732X09358129>
- Lipe, D. (2019). Indigenous knowledge systems as the missing link in scientific worldviews. In H. Tomlins-Jahnke, S. Styers, S. Lilley, & D. Zinga (Eds.), *Indigenous education: New Directions in Theory and Practice* (pp. 453-481). University of Alberta Press.
- Nasir, N. (2012). *Racialized identities: Race and achievement for African-American youth*. Stanford University Press.
- Nasir, N., & McKinney de Royston, M. (2013). Power, Identity, and Mathematical Practices Outside and Inside School. *Journal for Research in Mathematics Education*, 44(1), 264–287. <https://doi.org/10.5951/jresmetheduc.44.1.0264>
- Sefton-Green, J. & Erstad, J. (2013). Identity, community, and learning lives in the digital age. In O. Erstad & J. Sefton-Green (Eds.), *Identity, community and learning lives in the digital age* (pp. 1-19). Cambridge University Press.
- Wilson, S., & Hughes, M. (2019). Why research is reconciliation. In S. Wilson, A. V. Breen, & L. Dupré (Eds.), *Research and reconciliation: Unsettling ways of knowing through indigenous relationships* (pp. 5-19). Canadian Scholars.
- Wortham, S. (2006). *Learning identity: The joint emergence of social identification and academic learning*. Cambridge University Press.