STEM LEARNING AS CARE WORK

Katie Headrick Taylor, Jiyoung Lee, Erin Riesland, & Mack Ikeru

College of Education | University of Washington, Seattle

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Project Description

This research-practice partnership we call STUDIO, designs and studies out-of-school time (OST) STEM programming for Immigrant and/or refugee youth living in a mixed-income housing development in West Seattle. Unlike formalized STEM curricula (in schools), our programming is explicitly anti-racist and anti-sexist, problematizing and re-imagining knowledge production in science, technology, engineering, and mathematics. Importantly, our programmatic and research aims are not only about broadening participation in STEM but changing the *what* and *how* of STEM learning and practice. Participating youth come to STUDIO already brilliant and caring; our aim is to create a brilliant and caring afterschool context worthy of their time and attention.

Our view of STEM learning is informed by Black feminist critiques of technoscience and sociocultural studies of learning in classrooms, homes, and community settings. These models acknowledge and value pluralism, affect, context, aesthetics, and labor/care in STEM learning. As such, our design principles commit to engaging the whole scientist, working across various explanatory frameworks, and de-centering the myth of individual accomplishment. We explore these commitments in the Background Literature, showing how we were informed by extant STEM education research. Looking at our programming through a feminist lens of care, we found STEM learning in STUDIO as *nourishment*, a form of *maintenance*, and supporting *families of choice* for youth and adult facilitators. We provide examples of these findings and also provide implications for STEM educators working in school and OST contexts.

Established in 2013, STUDIO is a collaboration between the University of Washington and Neighborhood House (NH), a countywide, multiservice organization offering health, housing, education, and employment services (to read more about this partnership, see Herrenkohl, et al., 2019). In STUDIO, programming is created at the intersection of youth interest and STEM mentor expertise. STUDIO is located in a vibrant public housing community with 379 middle school and high school aged youth (582 families). Fifty-eight percent of the youth are immigrants and refugees from East Africa (Somali, Ethiopian and Eritrean, 42%), Southeast Asia (Vietnamese and Cambodian, 13%), and Central and South America (3%). The community has one of the highest concentrations of poverty in the county and over half of the residents (51%) did not complete high school. STUDIO serves 40 to 60 middle and high school youth per year. Our design, research, and facilitation team include University of Washington faculty and graduate students, undergraduates pursuing degrees in STEM fields, and NH staff. Youth attend weekly STUDIO sessions but also use NH facilities with their families for other aims throughout the week (e.g., tutoring, family game night).

Over the course of the COVID pandemic, STUDIO programming shifted to online, using the Zoom video conferencing platform to bring youth and adult facilitators and researchers together. We iterated an in-person curriculum called “World through Food” via this online modality. World

through Food invited youth to explore various science concepts and practices through cooking dishes that are both culturally familiar and new. We also include curricular units in our analysis that were delivered in person, before social distancing restrictions. These units focused on place-based technologies and chemistry. Our primary research question guiding this work is as follows:

> Given the commitments and values of this RPP, the youth, and facilitators, what different model of STEM learning is enacted and how does this model inform other OST and in-school STEM contexts?

Background Literature

Models of STEM Learning

People working within science, technology, engineering, and mathematics (STEM) benefit society with countless social, environmental, and healthcare advances. Most recently, we have a COVID vaccine, a blood test for breast cancer, and a space mission that collected asteroid rock and material. Also this past year, people working within STEM advanced racial equity and social justice within specific disciplines (e.g., physics, botany, biology, chemistry) using the hashtag #strike4blacklives. Mobilized by the murders of Tony McDade, Breonna Taylor, Regis Korchinski-Paquet, George Floyd, and Ahmaud Arbery, a multi-racial, mulit-cultural coalition of physicists, under the name Particles for Justice, organized a nationwide day of reckoning with anti-Blackness and white supremacy in STEM. An excerpt from their call to action reads:

> We are calling for every member of the community to commit to taking actions that will change the material circumstances of how Black lives are lived -- to work toward ending the white supremacy that not only snuffs out Black physicist dreams but destroys whole Black lives. In calling for a strike, we call on people who are not Black to spend a day undertaking discussion and action that furthers this work, while providing Black scientists with a day of rest. Every single institution around the world can and should get involved in this work, and the strike marks an opportunity to recommit to the humanist values which should underpin academic work, including the belief that Black Lives Matter.

The benefits and perils of STEM education are not specific to higher education. In the U.S. context, most models of STEM learning and teaching in K-12 are based on, and working toward, economic and military dominance of the nation state (e.g., Leslie, 1993; Vakil & Ayers, 2019). These models can isolate learners whose families are from around the world, have been upended by military force, and/or have been excluded from pathways of economic vitality (e.g., Sengupta-Irving & Vossoughi, 2019). Yet Black and Brown youth from Immigrant and/or refugee families find ways to survive and thrive in STEM learning contexts by “staying with the trouble” (e.g., Haraway, 2018), or acting within and across contradictory frames of learning and being in the world. Their participation in and stories of STEM practice from homes and out-of-school settings provide anti-racist and culturally regenerative models of learning and teaching that oppose the culture of capitalism and militarism pervasive in school curriculum (e.g., Strong et al., 2016; Stromholt & Bell, 2018).

Martin (2009) proposes an analysis of STEM curricula that is either 1) rooted in the hegemony of the nation-state, or 2) rooted in deep moral concern for BIPOC learners and their futures. Taking up that framing, Vossoughi & Vakil (2018) create a heuristic (Table 1.1) for understanding the different ways in which STEM education is discussed as "expanding the workforce," "building-up national defenses," or "closing the achievement gap." Such objectives are rooted in U.S. dominance. They then offer alternative objectives in which "what counts" as STEM education *expands* based upon the knowledge and practices culturally and linguistically diverse learners bring to a classroom or out-of-school time program. In addition, diversifying who gets to participate in STEM promotes a future free of labor and environmental exploitation.

Diversity as rooted in U.S. competitiveness and hegemony	**Diversity as rooted in deep moral concern for students of color**
1. Culturally and linguistically diverse STEM workers as tied to expanding markets	1. Culturally and linguistically diverse knowledge producers as tied to expanding and democratizing the meanings, values, and purposes of STEM education
2. Token representation as tied to perceptions of multicultural democracy	2. Substantive representation as tied to the redistribution of power and the struggle for social, racial, and educational justice
3. Expanding the pool of qualified domestic labor so that U.S. technological innovation can dominate markets and secure military hegemony	3. For some, expanding the pool of qualified domestic labor as tied to economic/social mobility and community development. For others, diversifying STEM education as tied to building a future free of racial hierarchy and economic exploitation.
4. Closing the "achievement gap" as tied to improving international measures of STEM excellence	4. Reimagining and transforming education such that all students (in the United States and around the world) have access to intellectually respectful learning experiences and the resources to fulfill their individual and collective potential

Table 1. From Vossoughi & Vakil (2018) for understanding different orientations to STEM education as either being in service of the nation-state or as rooted in deep moral concern for BIPOC learners.

Re-imagining STEM Learning

There are no doubt more than two models of STEM learning and here, we investigate the literature for how others have put forward possibilities in which learners' cultural and political identities transform STEM. Our search and subsequent design follow the lead of Black feminist critiques of technoscience (e.g., Benjamin, 2016; Haraway, 1998) and sociocultural studies of

learning in classrooms, homes, and community settings (e.g., Lave & Wenger, 1991; Nasir & Hand, 2006). These models acknowledge and value pluralism, affect, context, aesthetics, and labor/care in STEM learning (D'Ignazio & Klein, 2020; Uttamchandani, 2020). While these qualities have always been essential to advances in science, technology, engineering, and mathematics, we view the dominant culture of STEM as instead valuing interpretive distance and unbiased accounts too often removed from the context in which knowledge was constructed. Morales-Doyle et al. (2020) provide the following provocation about STEM learning:

> Imagine, if instead of regurgitating the work of Newton, Darwin or Avogadro, high school students were regularly challenged to think about health, food production, energy and transportation as complex, systemic challenges with social and scientific components. Thinking about such locally relevant problems as embedded in global systems would better equip learners to deal with pandemics and racial inequities, and better approximate the complex problem-solving required of STEM professionals. (excerpted from:https://truthout.org/articles/in-an-era-of-pandemic-and-protest-stem-education-cant-pretend-to-be-apolitical/)

One enactment of this reorientation is engaging the *whole scientist* in STEM curricula (e.g., McGee & Martin, 2011; Nasir, & Hand, 2006); how learners identify racially, culturally, and sexually, for instance, fundamentally informs their sense-making processes, what questions for inquiry are important to them, and exposes the limits of standardized instructional methods. Additionally, recognizing that geography, or learners' locations in the world, inform how inquiry takes shape (e.g., Taylor & Hall, 2013) is part of engaging the whole scientist. Rather than idealizing standardization, STEM curricula focused on the whole scientist explicitly invite and engage the various identities and contexts learners bring with them to an educational interaction. Additionally, when studying other scientists and their accomplishments (e.g., Alice Ball, Annie Easley), instructors teaching in this way support learners to consider how racism and sexism, for instance, constrained or supported the person to do her/his/their work.

Enacting anti-racist and anti-sexist STEM learning and teaching cannot solely engage the various identities of individual students, it must also de-settle the *nature of science* and how particular explanatory processes and frameworks take precedence over others, historically and in the present (Tuck, 2009; Bang et al., 2018). To focus merely on inclusion in STEM is to treat these disciplines ahistorically and move toward assimilating learners into fields and paradigms rooted in white supremacy (e.g., Morales-Doyle, 2019; Warren et al., 2020). How, then, might educators think about explanatory frameworks typically so implicit in STEM learning and teaching?

Because STEM is a fundamentally human activity, it stands to reason that, like all activities, it is culturally situated. Southerland (2000) describes the Western/US paradigm of "quality science" as follows: "scientific inquiry is understood to rely on the accumulation of objective sense experience, systematic investigation, and the assumption that the natural world is not altered by a supernatural being" (p. 290). In this characterization, accumulation and objectivity stand out as

essential qualities of what it means to do STEM in US schools and labs, for instance. Indigenous STEM learning and teaching are no less systematic, but relationality and purpose take primacy over production (e.g., Barajas-Lopez & Bang, 2018). Different paradigmatic orientations to STEM set-up different forms of participation, different questions, and different ways of organizing knowledge. When learners are invited to think across different explanatory frames, they experience knowledge construction as dynamic and contested, a more authentic version of STEM practice (Morrison, 1989).

Education research describes the coexistence of multiple ways of knowing as *epistemic heterogeneity* (e.g., Warren et al., 2020). Within an explanatory framework, learners make sense of a question or phenomenon through various modes of interacting with the world (Taylor, 2020) including reading a story, walking around an area or "ground-truthing" (e.g. Marin, 2020), or recreating the phenomenon in their own kitchen. These different modes of learning directly map onto the problem being addressed but also the forms of participation that are valued and supported in a given context. For instance, Taylor & Hall (2013) worked with African-American youth in a midsouth city to map, using geospatial technologies, a possible community that was more conducive to their daily lives, interests, and desires. Within this context, youth and facilitators walked neighborhood streets recording pathways and observations and also visualized aggregate patterns in a GIS software. While these modes of learning (embodied and representational) differ, they both offered valuable and complementary information for the phenomenon under investigation (Taylor, 2020).

Reorienting STEM learning to acknowledge and value pluralism, affect, context, aesthetics, and labor/care necessarily de-centers the myth of the individual and his solo accomplishments (e.g., Sefa Dei, 1999; Vossoughi, Hooper & Escude, 2016). Learners working collaboratively on one of the several existential crises facing society--rather than in contrived, highly individualized and competitive contexts--more authentically mirrors many STEM professions. In formal and out-of-of school contexts, young people need practice working *with* one another and the environment rather than against or in a role of domination. Warren et al. (2020) describe "withness-pedagogies" as those "that make expansive world-making, delinked from empire building, possible" (p. 290). Withness-pedagogies ensure that learning and care operate in tandem so that STEM is in pursuit of planetary survival rather than the carelessness of neoliberalism and militarism (The Care Collective, 2020).

Methods

This project worked in partnership with Black and Brown Immigrant and/or refugee youth and their families to explore principles of STEM learning and teaching that actualize their deep moral concern and visions for their futures. As researchers and facilitators, some white and all *not* from the High Point community, we did not presume to know and therefore design for the values and concerns of youth and families (e.g., Gutiérrez & Jurow, 2016). We do, however, consider ourselves experts and critics of STEM learning and teaching and so brought various theoretical and experiential frames to the work. Therefore, this project treats families as co-designers and

co-facilitators (e.g., Bang & Vossoughi, 2016) of the OST curriculum we describe and analyze below.

As youth and adult facilitators participated in the OST STEM curriculum, members of the research team took field notes of and video recorded the programming. We conducted interaction and multi-modal analyses (Jordan & Henderson, 1995; Jewitt et al., 2001) of video and artifact data from afternoons of programming that occurred before and during social distancing restrictions due to COVID-19. Therefore, some of the sessions we analyzed occurred in-person, at Neighborhood House while others occurred over Zoom in which youth and facilitators were participating from their homes.

Our analysis “unpacked signs”--talk, gestures, text productions, representations, body positions and movements, eye gaze--of youth and facilitators *staying with the trouble* of contradictory explanatory and experiential frames to enact anti-racist and culturally regenerative learning and teaching in the complex sociopolitcal environment of STEM programming within a community-serving organization. We find Haraway’s notion of staying with the trouble useful for understanding the ingenuity youth and adult facilitators enact when making moment-to-moment choices about what to refuse and what to reimagine within STEM learning. We looked across these signs for consistencies, patterns, and existence proofs of interaction (e.g., Erickson, 2011). Using our theoretical framework, we noticed “care-in-practice” (Chatzidakis et al., 2020), or the ways in which feeling a responsibility and mutual obligation for others, organized activities. We thematically named patterns as three categories of STEM learning as care work: STEM learning as nourishment, STEM learning as maintenance, and STEM learning communities as supporting families of choice.

Summary of findings

Our STEM curriculum design committed to engaging the whole scientist, working across explanatory frames (ie., epistemic heterogeneity), and de-centering individualized, meritocratic myths of scientific “discovery” through collaborative, caring configurations of learning and teaching. Looking through a feminist lens of care (e.g., Collins, 1998), our findings synthesize how learners (including adult facilitators) enacted the curriculum. These enactments, we believe, provide implications for teaching STEM that are anti-sexist and anti-racist. Below, we report on how youth, their families, and facilitators enacted *STEM learning as nourishment*, *STEM learning as maintenance*, and *STEM learning communities as being families of choice*.

STEM Learning as Nourishment

We have found that the curricular units that *nourish* youth, their families, and communities, have been the most engaging. By nourish, we mean that the STEM phenomenon of study is, in some way, essential for learners’ development, growth, and sustenance. Nourishment happened at the scale of the individual and the family through the World Through Food curriculum and also at

the scale of the community through the Mobile City Science curriculum. We go in more depth below and provide examples.

In World through Food, facilitators guided youth through various cooking projects that allowed learners to experience properties and processes like macromolecules, protein chains, and pH. Making hummus, for instance, provided a familiar context for youth from several African countries to consider the best ratio between starch and lipids for the longest (read creamiest) macromolecule. Youth and facilitators considered arriving at the “answer” as synonymous with providing delicious and smooth nourishment for their parents and siblings at home and for each other in the program. After experimentation, youth and facilitators sat together in a circle (Figure 1) and literally ate their science projects together, feeling fed and nourished physically and emotionally by collaboratively building and consuming robust chains of lipids and starches.

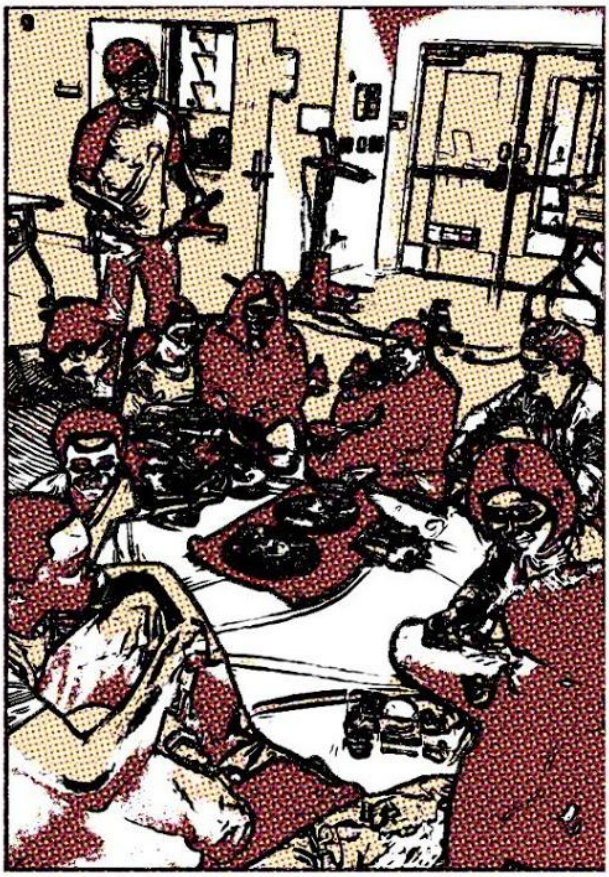

Figure 1. STUDIO facilitators and youth sit together and eat hummus, injera, and pita after experimenting with macromolecules through creating the creamiest hummus.

Baking cakes using different variables, mixing pizza dough and watching it rise, and mixing peanut butter have all provided experimental conditions to not merely study a phenomenon but to *share* this phenomenon with one another. Even over a video conferencing platform, the group communally experienced food together by emphasizing the aesthetic qualities: holding the food

up to the camera to share how it looked, reporting on how it smelled, and evaluating out loud taste and mouthfeel.

During one World Through Food session over Zoom, facilitators led youth through an exploration of how bubbles are created. Exploring the science of bubbles occurred in the context of making dalgona coffee, a drink made famous on the internet by actor Jung Il Woo. In the lead up to a lot of whipping, mixing, and sugar-adding, one facilitator asked the youth if they would be making their dalgona coffee *for* anyone. Two of the youth reported making the coffee for their mother and sister and then invited members in their household to "get excited" about drinking the ultimate creation. A little later in the activity, spirits were nourished in the showing and commenting on the beauty of each other's foam (Excerpt 1.).

Excerpt 1. Attempting to get the perfect looking foam for dalgona coffee.

1	Melyssa:	Looks like what?
2	Sydney:	It's already sticking together more.
3	Tam:	Jiyoung.
4	Jiyoung:	Tam, show it to us, show it how it looks like.
5	Sydney:	Is it working, Bao?
6	Jiyoung:	*((to Tam))* Lift it up, I cannot see. So, it's dissolving.
7	Bao:	*((Shows mixture to the camera.))*
8	Sydney:	*((to Bao))* Keep stirring.
9	Jiyoung:	*((to Tam))* Keep whipping it. Gotta wait until little bit to add sugar.
10	Bao:	*((Holds up bowl to show off the peak of his foam.))*

11 Sydney: It's working *((showing her foam to the camera))*!

12 Bao: It's working!

13 Sydney: *((Continues lifting-up her foam to show to the camera.))*

Figure 2. Participants share with one another how their dalgona coffee--especially the foam--looks. At this moment, participants circled in red share, though everyone shared how their foam looked at some point. Others commented on how the foam is "working" based on how it looks.

Sydney, an undergraduate facilitator, shared in the overall enthusiasm of showing-off and sharing her foam with the group (Lines 11 & 13). Regardless of age, gender identity, race, or educational status, the participants shared equally with one another as learners in this activity, finding ways to build common ground even over Zoom. Even though they were unable to physically eat and drink together, youth and facilitators nourished one another with attention, support, and shared interest. The smiles, laughter, and banter throughout this session signify emotional nourishment wrought from a cooking experiment. This exchange also exemplifies generational reciprocity not typically seen in schools (e.g. Rogoff, 1994; Marin, 2020).

STEM Learning as Maintenance

Care is not always about nourishment--feeding the body and one's emotional well-being. Maintenance, or keeping things in working condition, is another integral part of caregiving and highlights that which we care for *in common* (Chatzidakis et al., 2020). Households, neighborhood spaces, walking trails, and gardens are shared places that require maintenance by all who use them. Effective maintenance, importantly, requires that caregivers share a common understanding of that which is being cared for, how it works, its purpose, what it needs to survive and thrive, etc. Potentially, this disposition (that of maintenance) scales to caring for a warming planet in a time of climate crisis (e.g., Pettifor, 2019).

We found that youth and facilitators maintained their community through STEM learning in STUDIO. Across the curricula, STUDIO facilitators set up entry points for youth to ask questions about their surroundings and their daily lives. Often, youth-elicited questions were about particular conditions of the immediate neighborhood. In Mobile City Science, a curriculum that supported youth to reimagine their neighborhood with geospatial technologies, many of the activities were about noticing the assets of the area that were worth preserving for future residents (Taylor, Silvis, & Bell, 2018). The p-patch, the bee garden, and the pond, for instance, came into focus for youth as community qualities worth maintaining. In this way, the objective of STEM learning was *not* always about innovation, disruption, and change, but about observation and understanding as a form of stewardship (e.g., Glaze-Crampes, 2020). This reorientation to STEM is especially important for communities of color whose neighborhoods are too often used and abused in the name of "innovation," only to pollute and harm those living there (LaDuke & Cowen, 2020).

In one example, youth wondered about the safety of the pondwater for drinking. To pursue an answer, an undergraduate facilitator brought a pH testing kit to an afternoon's programming to test the water. Youth and facilitators walked to the pond, collected samples, and then tested the water's alkalinity. Youth then translated the results of the litmus test to numbers on the pH scale, using a color chart. This process kept up a lively conversation about the *safety* of the water and young people were left considering what additional information and tests they would need to reach an adequately informed conclusion. While youth participants learned about the pH scale, their sense of maintaining and caring for their community propelled them, not just to do the experiment, but to desire more information about the pond.

This example and others like it, foreground a caring gap in which youth--residents of the community in which STUDIO programming occurred--are compelled to do STEM inquiry because they care about maintaining some aspect of daily life. On the other hand, we see adult facilitators who are not community residents caring more about the scientific process or the capacity to perform some investigation over care for the commons. But because STUDIO facilitators commit to learning from youth as much as they teach them, adults (sometimes reluctantly) follow the lead of young people to make the inquiry process about maintenance rather than about innovation. We think here about the essential work of Catherine Coleman Flowers (2018) and, though occurring in the Southeastern US, addresses the urgent necessity of caring with and for communities enough to engage in ecological study and stewardship as

climate change inequitably impacts the daily lives of people living in predominantly poor, Black communities.

STEM Learning Communities as Families of Choice

We borrow the term *families of choice* from LGBT activists (Weston, 1991) to describe how youth and facilitators enacted kinship relations with one another and non-human entities through STEM learning. We are not setting-up families of choice in opposition to, or in lieu of, youth and facilitators' own families. We use the term instead to highlight an infrastructure of care that developed and is maintained by STUDIO participants and the entities they care about. What perhaps is most notable about this family of choice is that youth and facilitators enact care and interdependence across cultural, generational, racial, gendered, educational, and geographical difference: middle and high schoolers from East African and Southeast Asian families, caring for and with college students from Atlanta, Georgia and the Pacifc Northwest, caring for and with adult facilitators from Korea, Canada and North Africa.

Families of choice are complex, interconnected webs of relations. For clarity, our findings focus on Jiyoung, co-author and lead STUDIO facilitator, to exemplify STEM learning communities as families of choice. As the main liaison between the University of Washington and Neighborhood House for several years, Jiyoung came to know and thus care deeply about both the undergraduates and the youth. She facilitated curriculum design, but more importantly, ensured that the youth had the necessary resources to participate in STEM learning activities each week. Her role arguably became more essential at the onset of COVID-19 when materials had to be distributed across households rather than centrally accessible at Neighborhood House. Her resource management included visiting the homes of youth to drop off boxes of ingredients and tools for World Through Food, shuttling undergraduates (and thus spending up to two hours of commute time with them) across Puget Sound to West Seattle, and providing one-on-one Zoom conversations and phone calls to check-in on the emotional well-being of all involved. Jiyoung also provided pointed and thoughtful feedback to undergraduates' written reflections about their time spent in STUDIO.

While Jiyoung was a kind of "other-mother" (e.g., Collins, 2000) to youth and undergraduates, she served as a vital nexus for all STUDIO participants to connect and learn from and with each other; she co-arranged when, where, and how people came together to learn. Tam and his brother invited Jiyoung into their home to get help baking and building a "Fourth of July Gingerbread House" (the boys' concept). Another set of brothers were elated to discover that the measuring cups Jiyoung dropped off were "a gift" from her, so they could keep the tools in perpetuity. Even over Zoom, Jiyoung demonstrated care through embodied synchronicity with youth, as in the example below (Lines 5-6) when Tam shows off his finished cake.

Excerpt 2. Tam finishes baking his cake and Jiyoung joins him in a dance over Zoom.

1	Jiyoung:	How does it look?
2	Tam:	*((holds cake up to camera))*
3	Jiyoung:	Ooooooohhhhhh, that looks good!
4	Tam:	We can work on the frosting while it's cooling down. *((Dances in side-to-side motion for the camera))*
5	Jiyoung:	I know, let's do that. *((Imitates Tam's dance, joining him in the motions))*
6	Tam:	Should I use the same bowl or a new one?
7	Jiyoung:	Uhhhhh, you should wash it and then use the same bowl.
8	Tam:	That's what I was thinking. Perfect. Thank you, Jiyoung.
9	Jiyoung:	You're welcome.

Moments like these were not exceptional but representative of how youth felt Jiyoung's care and reciprocated. To Jiyoung, Tam's dance was a valuable communicative cue that baking was going well, and he was enjoying himself. His questions about the bowl signalled that he cared about her opinion. This opened an opportunity for Jiyoung to communicate the importance of being mindful of dishwashing, and thus care for another family member who might be helping Tam with clean up. Her care was truly indiscriminate, equitably turning her attention to newcomers and oldtimers, youth and undergraduates, mothers and siblings. Still, the carelessness of neoliberalism and militarism snuck into programming interactions.

Figure 3. Jiyoung working alongside youth to make dumplings as part of the World Through Food curriculum.

Neoliberalism vis a vis STEM-education-as-defined-by-standards continued to inforrm moments of interaction: How does this map onto Next Generation Science Standards? How will tonight's STUDIO programming support the STEM youth are already learning in school? How will this experience make them more competitive for college? Many adult facilitator and researcher reflections landed in this space; we rarely if ever heard these questions coming from youth. Jiyoung, however, often began and/or ended STUDIO programming with a heartfelt appreciation of the time she spent being in relation with the other participants. At times, she talked about how what they learned together sustained her emotionally and physically because she too is an immigrant who needed relational support and care from her chosen family. Others concurred. These discursive turns of the program's most central figure demonstrated that care--being together, watching out for each other, listening to one another, and enjoying each other's company voluntarily as a family of choice--was the gestalt of the program. As Chatzidakis et al. (2020) write, "We have relied upon 'the market' and 'the family' to provide too many of our caring needs for too long. We need to create a more capacious notion of care" (p. 41). STUDIO provides one example of the capacity of STEM learning for such care work.

Conclusions & Implications

Educators often use the word care to describe their motivation for teaching: care for children, care for the future, care for the planet. However, the structures of neoliberalism and militarism, especially in STEM learning and teaching, make care difficult to enact. Teaching to standards, testing, and upholding false claims of objectivity and race-neutral and genderless processes of knowledge production require teachers *and* learners to operate within individualized and competitive spheres of carelessness. The top grade earner, the top scorer, the top performer wins, made to care little for the others stepped on and left behind in order to "succeed." The implication within such a system--created in the US to maintain white supremacy--is that some children, particularly children of color, lose, as if by natural causes. Isabel Wilkerson (2020) describes our racialized and militarized infrastructure as caste, and writes:

> So, too, with the caste system as it goes about its work in silence, the string of a puppet master unseen by those whose subconscious it directs, its instruction an intravenous drip to the mind, caste in the guise of normalcy, injustice looking just, atrocities looking unavoidable to keep the machinery humming, the matrix of caste as a facsimile for life itself and whose purpose is maintaining the primacy of those hoarding and holding tight to power (pgs. 34-35).

STUDIO, however, starts at a different point, acknowledging and attempting to move outside the carelessness of neoliberalism, racialized hierarchies, and white supremacy. Participating youth of color come to STUDIO already brilliant, caring, and full persons. Their ingenuity shines through as they stay with the trouble of living/learning within contradictory frames of being; at home they are typical young people developing into adults, while at school they are students of color requiring intervention and remediation. Our aim is to create a brilliant and caring afterschool context worthy of their time and attention, a context that centers pluralism, affect,

context, aesthetics, and labor/care in STEM learning. We argue that this radical reorganization of STEM learning requires what LaDuke and Cowen (2020) call an *alimentary infrastructure*--nourishing for (rather than exploitative and extractive of) our bodies, our spirits, and the land. Drawing upon Indigenous ways of knowing, they write:

> ...infrastructure is not inherently colonial—it is also essential for transformation; a pipe can carry fresh water as well as toxic sludge. We suggest that effective initiatives for justice, decolonization, and planetary survival must center infrastructure in their efforts, and we highlight alimentary infrastructure—infrastructure that is life-giving in its design, finance, and effects (p. 245).

In this spirit, and in recognition of the importance of science, technology, engineering, and mathematics, we conclude with some possibilities for (re)making STEM learning as an alimentary infrastructure for learners, teachers, and all human and non-human stakeholders. Out of respect for space, we offer three possibilities; we hope to imagine many more in conversation with readers of this report.

One possibility is to **consider and articulate how STEM learning objectives and intended outcomes are nourishing bodies and relationships between people and our non-human kin** (Marin et al., 2020). How is this activity life-giving and to whom? Does nourishment come at the expense of someone or something else? Additionally, we imagine creating learning *processes* that are not distal to acts of care but are one and the same with caring for each other. Once nourishment becomes a leading STEM practice for young learners amongst more immediate relations (e.g., siblings, classmates), then learners can begin to imagine and extend this same practice to non-human and non-proximal relations around the globe. If articulating STEM learning outcomes and processes as care work is difficult, then let us re-consider the purpose of learning and who/what it actually serves.

A second possibility is to **identify within a learning community, that which all members care for in common**, and pursue processes of STEM inquiry at that scale. Do we all care about the school or the neighborhood or the park? How can we learn to be better stewards of the commons? As in Flowers' (2018) study of basic sanitation, can we all care that some in our community cannot cleanly dispose of toilet waste because of inadequate municipal water management? If so, how do scientific methods guide learners to possible solutions? This turn toward that which we care for in common means academic endeavors can no longer be about knowledge production but about knowledgeably enacting meaningful change *through* learning (Maxwell, 2000; Gutierrez & Jurow, 2014; Hall & Jurow, 2015; Jurow & Shea, 2015). We no longer have time to pursue knowledge for knowledge's sake.

A third, though by no means final possibility is to **consider differences and complexities within STEM families of choice as essential for health, thriving, and equitable future-making.** Within a typical household, a family does not consist of, for instance, all six year old sons, or all fathers who excel at gutter cleaning, or all lap dogs. Families endure *because* of the different perspectives, experiences, and desires each member brings. These differences, in

relation to each other, create uneasiness, ambivalence, and require almost constant negotiation. Yet, it is within this negotiation that learning through relationality--about how to better care for one another, and how one's own care depends on someone else's (Butler, 2020)--comes about. STEM learning communities as families of choice center the essential truth that interdependence, even across major differences, is the only solution to the existential threats we face.

We acknowledge the barriers to STEM learning as care work, especially in schools, and see these barriers as systemic and intentional ways of failing children of color. Care work runs counter to the carelessness of neoliberalism and militarism. However, the synchronous pandemics of COVID-19, anti-Blackness, and ecological degradation and annihilation require a turn (back) to STEM as an alimentary infrastructure. We hope STUDIO provides an illustration that turning to care is possible and life-affirming.

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