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Intergenerational transdisciplinary knowing toward stewarding the land of refuge: learning through the pandemic

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Abstract
The knowledge of historically marginalized learners, including racially and linguistically minoritized learners, tends to be obscured in institutionalized learning contexts and by the dominant discourse of "learning loss," which was reinforced during the COVID-19 pandemic. Based on critical ethnography and the methodology of shared walks, this article highlights intergenerational ways of knowing embodied and emplaced in the context of traditional farming sustained and mobilized by a Syrian refugee family. We illustrate what children were indeed learning in the land of refuge during the pandemic, with their family, beyond narrowly defined in-school learning. We conceptualize the recentering of intergenerational ways of knowing, often overlooked in colonial institutionalized learning spaces, as *transdisciplinary* acts for disrupting the hegemonic disciplinary formation of science, technology, engineering, and mathematics (STEM).

Keywords Anti-colonial transdisciplinarity · Intergenerational ecological knowledge · Embodiment and emplacement

The modern food system is impacted by the forces of settler colonialism, militarism, capitalism, and racism, which have a long and oppressive history of violently dispossessing Indigenous peoples of their lands and food sources (Settee and Shukla 2020). Furthermore, this system continues to rely heavily on the exploitation of migrant and racialized labor (Encalada Grez 2019). These structures of oppression are deeply entrenched in the globalized food system, and their effects are far-reaching and long-lasting. Food production, distribution, and consumption have largely evolved toward improving efficiency while simultaneously creating an unsustainable and unjust food system (Date et al., 2021). These inequalities were exacerbated during the COVID-19 pandemic, during which migrant

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laborers experienced a loss of livelihood and an increased risk of infection (Vosko and Spring 2021).

The globalized colonial food system has not only exploited racialized migrant bodies that are vulnerable in the order of the global economy but also damaged the land and ecology for the sake of cost-effectiveness and capital accumulation for the "haves." This study shines a light on how transdisciplinarity in science, technology, engineering, and mathematics (STEM) education can be expanded through intergenerational ways of knowing shared by a Syrian refugee family, who have engaged in traditional farming on their terms without the use of herbicides or pesticides. During the COVID-19 pandemic, this family exercised their agency to share freshly harvested vegetables with fellow refugee and immigrant communities on their urban farm, at a time when indoor grocery shopping was considered a high-risk factor for infection.

Colonial practices enacted through institutionalized learning spaces continue to dismiss ways of knowing and agency by Indigenous, racially, and linguistically minoritized refugee and migrant learners, thereby perpetuating "cognitive imperialism" (Battiste 2011, p. xix). Cognitive imperialism alienates the colonized from their knowledge deeply rooted in the land, ancestors, and spirituality (Battiste 2011). One of its manifestations is the discourse of "learning loss" (McKinney de Royston and Vossoughi 2021), which circulated during the pandemic. As Maxine McKinney de Royston and Shirin Vossoughi (2021) argued, the use of the rhetoric of learning loss to describe the educational plight imposed on youth of color functions as a "dog-whistle for white entitlement," which obscures the fact that educational policies and funding have long been used to perpetuate racism, classism, and ableism. To counter this problematic discourse of "learning loss," we depict the portraits of abundant learning shared by racialized, linguistically minoritized refugee children and their parents during the COVID-19 pandemic. Focusing on the period 2020–22, a vast amount of literature was published on learning loss (e.g., Pier et al., 2021), while the literature illuminating the acts of learning for racially and linguistically diverse children was comparatively lacking (e.g., Orellana et al., 2022). Racially and linguistically minoritized refugee children are particularly vulnerable to becoming entangled by the dominant, problematic discourse of learning loss. We aim to challenge such deficit depictions.

The act of learning that we depict in this article is historical: Learners are conceptualized as "historical actors" (p. 291) who can repurpose a set of available tools to redress dilemmas and resist local and historical sociopolitical inequities (Gutiérrez et al., 2019). This expansive vision of learning situates learners within an evolving collective history and ecology, and it focuses on "the reorganization of systems of activity in which participants can become designers of their own futures" (Gutiérrez 2016, p. 192). In the context of food justice movements, historically invisibilized works and relational tools exercised locally by migrant activists and community workers can be depicted as instances of learning that bring consequential learning for social causes—changes in the temporal, spatial, and social scale of participation and practices created in the ways that learners desire and value (Jurow et al., 2016). In our engagement with the Syrian refugee family depicted in this article, we analyzed the phenomenon of learning historically through a micro-level unit analysis, which was able to indirectly reflect macro-contexts of displacement and refuge as well as the impact of globalized food production and distribution. While carefully observing what was unfolding as learning in local and tangible contexts, we also observed macro-level histories that situated these local acts of learning as historical acts of resistance (Gutiérrez et al., 2019). The micro, moment-to-moment unfolding of learning depicted in our findings cannot be detached from the historical acts of the refugee family members who were displaced from the land they had cared for over generations.

Transdisciplinarity as an anti-colonial act

Disciplinary knowledge, such as soil taxonomy or soil chemistry, affords the depth of the phenomenon of our inquiry. On this enabling and agentive nature of disciplinary knowledge, Pickering maintained that "disciplines—acquired in training and refined in use—carry human conceptual practices along, as it were, independently of individual wishes and intents" (1995, p. 115). However, disciplinary knowledge can be a site of power struggles, wherein the historical hierarchy is reinforced by the knowledge that is valued as that of insiders of the discipline (Medin and Bang 2014).

Lewis Gordon (2006) argued that this disciplinary process of control could lead to the ossification of disciplines or the process of critical decay within the discipline. Disciplinary decadence, named by Gordon (2006), is also a bodily matter and urges us to consider whose bodies are (il)legitimized in disciplinary spaces. On the connection between bodies and discipline, Michel Foucault (1997/2007) argued that "discipline produces subjected and practiced bodies, 'docile' bodies. Discipline increases the force of the body (in economic terms of utility) and diminishes these same forces (in political terms of obedience)" (p. 138). "Othered" (Said 1978) bodies can become less extended and less mobile in certain places and can turn to "the body that is 'out of place'" (Ahmed 2006, p. 140). Relinquishing the rigid borders that the hegemonic disciplinary practices have reified should thus move us toward the liberation of Othered bodies (Lorde 1984) as well as toward fuller recognition of the acts of resistance and agency manifested in the transformation in the everyday transdisciplinary acts of Othered bodies, thus making their presence visible by occupying, gathering, and renewing the place (Takeuchi and Aquino Ishihara 2021). Transdisciplinarity as an anti-colonial act should transcend disciplinary boundaries through what Gordon termed teleological suspension, which emerges "when a discipline suspends its own centering because of a commitment to questions greater than the discipline itself" (2006, p. 34). Facing the pressing issues of soil degradation and food injustice that motivated us to conduct this study, we perceived the urgency of orienting our research toward questions that are larger than the sustenance of a discipline.

The disciplines of STEM have been intimately associated with hyper-capitalistic (Bazzul 2012), colonial (Philip et al., 2018), and militaristic (Vossoughi and Vakil 2018) agendas, and they have perpetuated excessive and violent control of and censoring gazes on Othered bodies (Takeuchi et al., 2020). The discipline of science has long perpetuated neoliberalist and Eurocentric discourses, which privilege siloed, measurable, and marketable knowledge (Strong et al., 2016). STEM education toward transdisciplinary imagination requires the expansion of the existing epistemological and ontological boundaries to embrace those who have been colonized and disciplined through racialized, gendered, heteronormative, and classist disciplinary practices (Takeuchi et al., 2020). Critical transdisciplinary heuristics can transform the Eurocentric and neoliberalist agendas that have long been unquestioned through the dominant practices of STEM education; moreover, legitimizing "informal" lived experiences of STEM within historically marginalized communities can disrupt the hegemonic epistemology (Strong et al., 2016).

The traditional agricultural knowledge and practices of migrants and resettled people can create opportunities for reviving local ecology and building communal resilience through intergenerational knowledge sharing (Shava et al., 2010). In centering community-grounded farming knowledge, educators and children can reorganize disciplinary spaces, transform their pedagogical approaches (Dutta 2022), resist systemic injustices through micro-interactions, and create alternate ways to engage with STEM knowledge (Shea and

Sandoval 2020). Racialized youth can exercise subtle yet unmistakable agency in carving out urban spaces and re-engaging with "nature" (Rahm 2018) as well as identify STEM inquiries salient to their lives, often with playfulness and joy (Kopparla et al., in press).

The sociohistorical and political issues that refugee youth of color are keenly aware of can be connected meaningfully with STEM learning (Ryu et al., 2019), and through asset-based pedagogical approaches, they can engage in critical inquiries to reclaim their agency and reimagine healthy collective futures (Visintainer 2023). In particular, through justice-centerd approaches to STEM learning (Morales-Doyle 2017) rooted in community engagements (Selby et al., 2020), youth can be repositioned as competent knowledge producers and transformative agents of social change (Cachelin and Nicolosi 2022). "Ethical response-ability" (p. 208) should be at the core of such pedagogical acts, as exemplified in the pedagogical move to respond to youth's inquiries into the toxins that surround them in a post-industrial city overshadowed by technoscientific development and environmental degradations (Kayumova et al., 2018).

Portraits of decolonial intergenerational learning situated in caring movements on the land (depicted by Marin and Bang 2018) can amplify alternative visions for STEM education (O'Neill et al., 2023) settler-colonial, that are grounded in critical hopes (Kato et al., 2023) and decolonial love (Betasamosake Simpson 2013, as discussed in Takeuchi and Marin 2022). As we center the land as a source of intergenerational knowledge for refugee farmer communities, we affirm that decolonial intergenerational sense-making of and in biological worlds is deeply grounded in the caring movements that foster an understanding of human relationships with ecosystems and more-than-human worlds (Marin and Bang 2018). Engaging with the land for Indigenous communities is an act of resurgence, as youth can reconnect with their ancestors' relationship to the land and ways of knowing embedded in the land (Bang and Medin 2010). Newcomers to the land can learn from and align their epistemology and ontology with intergenerational, embodied, and emplaced wisdoms, which are entangled with the acts and languages of care and love that extend to more-than-humans (Kimmerer 2013). In the context of the food justice movement, the caring practices of diasporic and immigrant communities could be mobilized toward building solidarity with the food sovereignty of Indigenous communities toward the vision of "restoring self-determination, control, and autonomy to eaters and growers alike" (Mares and Peña 2011).

In this study, we examined how the intergenerational practices of sustainable farming could penetrate the seemingly impermeable disciplinary borders perpetuated by the siloed and elitist systems of scientific knowledge production. For the critical expansion and porousness of a discipline, we focused on knowing demonstrated through embodied actions entangled with the land that is salient to the refugee family in our study—namely, a community urban farm that the family has been cultivating since their forced displacement.

Methodology

We framed this study within the framework of a critical ethnographic research methodology that unveils "the beneath surface appearances, disrupts the status quo, and unsettles both neutrality and taken-for-granted assumptions by bringing to light underlying and obscure operations of power and control" (Madison 2011, p. 5). Our ongoing ethnographic study started in 2020, focusing on a Syrian refugee family that has been engaging in small-scale farming with traditional methods, without herbicides or pesticides, since their

resettlement in Canada in 2016. The family participants included three of the five siblings in their early elementary years (aged 6–9 years at the start of the study in 2020), namely, Aisha (9 years), Rabih (8 years), and Abir (6 years), and their mother (Nahima) and father (Mohamed). Previously, the family was farming in Deer al-Fardees, a village near the city of Hama in Syria. As attacks on civilians in Hama and Deer al-Fardees escalated, the family evacuated to Lebanon before moving to Canada as refugees in 2016.

Local activists Saima Jamal and Sam Nammoura, refugee resettlement leaders through the Calgary Immigrant Support Society, found a donor who lent the family the land for the collective good. The family has been cultivating this land with their agency. At this small-scale farm, the family grows plants that remind them of their farm in Syria. Saima said the following: "No human was taking care of the land five years ago. It looked barren." The land has been regenerated through the family's passion, commitment, and intergenerational knowledge. The parents (Mohamed and Nahima) said that their knowledge of farming was acquired from their families and their own experiments rather than from formal schooling.

We critically reflected on a gaze that problematically depicts minoritized people as other and foreign in "ethnographic" works. Our study was critically ethnographic because of (1) our longitudinal engagement with the family while immersing ourselves on the farm that was salient to their lives; (2) our understanding of children across contexts (at school, at home/farm, and in a summer program that we designed); and (3) our interrogation of well-circulated deficit assumptions about refugees through media. One of the co-authors, Raneem Elhowari, was involved in the fieldwork. Her involvement was crucial because she was fluent in Arabic, had lived experiences to connect with the family, including the Syrian civil war and deeply understood what it means to be Muslim in the West. Her position as a teacher also helped us to generate questions about informal and formal STEM learning.

In our work, walking together with the family on their farm was essential for us to observe particularities of embodied knowing and movement situated in places. *Walking* can simultaneously constitute a methodology, pedagogy, and learning that can weave in multiple intergenerational stories of the land, as Marin and Bang (2018) vividly demonstrated. *Together* with the family participants, we engaged in a "shared walk" on the farm: "[W]alkers have a particular way of being together that is more than just co-presence because it has sociability as the basis for bodily movement" (Lee and Ingold 2006, p. 83). The methodology of walking together showed us the participants' sense of place by revealing "the profound in the mundane" through the process in which "the rhythms of time and fleeting glimpses of the unconscious are integrated with knowledge of place to reveal hidden designs" (Kincheloe et al., 2006). With these methodological sensitivities, *walking together* on the farm with each member of the family allowed us to understand the embodied and embedded knowledge of STEM enabled at eye level and through physical interactions with soil, plants, and animals on the farm. In addition, we came to see what it means to be on a farm as racially minoritized people in predominantly white farming areas, including the risks of experiencing verbal abuse, vandalism, and bodily harm. As critical ethnographers, our stances on manifestations of racism were not neutral. We stood beside the family in solidarity and joined the collective action to name racism against racialized small-scale farmers.

Toward the subsequent design works with which we engaged (descriptions of which are outside the scope of this article), our ethnographic works have continuously oriented us to "critical historicity" (Bang and Vossoughi 2016, p. 175) for understanding histories unfolding in the everyday life of a racialized refugee family attempting to grow their roots in the land of refuge. Furthermore, our learning as researchers is reflected in two of our ongoing design projects. One of the projects aims to visually illustrate historically hidden

knowledge of sciences and mathematics to envision transdisciplinary learning with teachers, teacher candidates, and racially minoritized refugee families (https://illustratestem.net/). The other project aims to design spaces, networks, and programs for listening to the voices of the soil and the land through transdisciplinary dialogs with Indigenous Elders and Knowledge Keepers, educators, scientists, and refugee families who have experienced forced displacement (https://www.soilcamp.ca/).

Data

To reflect on what we learned during the COVID-19 pandemic and continue to learn, we focused on video- and audio-recorded interactions collected over 11 visits to the family's farm (each visit lasted 60–150 min) from August 2020 to September 2021. Takeuchi was involved in all of the visits (with or without video cameras) and took fieldnotes after all of them; Dadkhafard was present for two visits; and Elhowari was present for four visits. Video interactional analyses were collectively conducted by all authors. We collected video data with wearable and handheld cameras during the shared walks (worn either by the researcher or family members), photos taken by the researchers and children, drawings by the children, and dialogs with the parents to obtain a deeper understanding of the nuances of their practices on the farm and their interactions with their children.

Embodied and emplaced knowings toward transdisciplinarity

Places are never neutral; whose bodies and whose voices can be seen, legitimized, and safe in places are very much political. The farm that we focused on, characterized by diverse plants, stood in sharp contrast to the large-scale monoculture farms that surround it. The languages, racial identity, and Muslim identity embodied by the family in a largely white farmland marked their bodies as "out of place" (Ahmed 2006, p. 140). Yet, they continued to occupy and transform the place, along with the intergenerational wisdom of "STEM," which has been passed down from generation to generation in the context of farming. This family has played agentive roles in regenerating the abandoned land, exercising embodied STEM knowledge. In doing so, they have changed the landscape while creating "autopographies"—"the creation of deep senses of place" (Mares and Peña, 2011, p. 204). A critical synthesis of embodiment and emplacement in disciplinary learning urges us to see resistance, agency, and transformation in the everyday acts of Othered bodies, making their presence visible by occupying, gathering, and renewing the place (Takeuchi and Aquino Ishihara 2021).

In this context, our findings are woven together to illuminate how acknowledging and respecting historically unseen embodied and emplaced wisdoms can challenge hegemonic disciplinary norms in STEM. We first invite the readers to visualize the farm we walked around together with the family:

> As I pass through a series of corn fields and canola fields, cows, and goats on farmlands, I start seeing some children running among green leaves of fava beans, sturdy dark green leaves of kouza, and golden yellow sunflowers. I also see toddlers running barefoot on the farm, and we see children eating beans from the field. This farm that Mohamed and Nahima have been cultivating is quite distinctive, compared to surrounding farms (from fieldnotes dated 09/04/2020, taken by Takeuchi).

Mohamed and Nahima have tirelessly nurtured this land, which they affectionately call "Peace Farm." Mohamed explained his vision for their farming practice as follows: "It is very important to establish something that is missing in which people are looking forward to in this country, especially in Canada where people depend on imports coming outside of the country." Similarly, Nahima explained that, "especially during the pandemic, we wanted people to be provided with fresh produce." During our shared walk on the farm, Aisha (9 years old) pointed out the green onions growing in the field in the distance. As we walked toward the field, Aisha mentioned that they were going to pick the green onions before winter comes and donate them to the food bank. Reciprocity and gifting were acts that had been passed on intergenerationally, as reflected in the following quote from Nahima: "We donated a lot of produce to the food bank—this is the least we can do for our community." This way of seeing themselves as a part of the community and being in reciprocal relationships was at the root of their farming practices. Through said practices and their engagement with the community, the family was actively making and transforming places (Mares and Peña 2011), as they imagined new mobilities in those places that were salient to them (Adams 2013).

Every plant is special and will have something to give to the soil

During our shared walks, Mohamed repeatedly said that "I just look at the ground or soil and I will know" in response to our questions about the quality of soil, when to seed, and which plants to grow. The family's embodied and emplaced knowing unfolded as we walked together, observed together, and described the soil, plants, and animals. Mohamed slowly walked to the field where fava beans were planted and explained the following:

> This year, I planted fava beans in this area, but in the upcoming year, I cannot plant fava beans in the same area because it dissolves in the soil and gives Azote (An obsolete name for nitrogen that is used in some languages including Arabic) to the soil. Therefore, every year I must change the place where I plant my produce [while pointing at the field].

Mohamed then walked to some Kouza plants and said, "this plant likes Azote," and explained that he also plants soy beans to provide nitrogen to the soil. Mohamed explained that "in addition to Azote, the fava beans are in need of minerals in the soil. So, I cultivate the soil. The plants that I grow will dissolve in one year into the soil and make the soil better quality as it gives more minerals." We then walked toward a field where various types of legumes were planted. Mohamed picked up a fava bean and showed us the root nodules where bacteria reside and produce nitrogen (Fig. 1). Mohamed noted plant–microbe nitrogen fixation, where legumes pair with rhizobia, a group of bacteria, to convert atmospheric N_2 into a bioavailable form for plants (Krzic et al., 2021). Both Mohamed and Nahima said that they learned about plants and the soil in the ground intergenerationally, not through formal schooling.

When we asked whether their farm in Syria always had fava beans and chickpeas, Mohamed responded as follows:

> I will give you an example from Syria. If this year I have 10 acres and I plant chickpeas, next year I must plant wheat or barley, meaning I cannot grow chickpeas 2 years in a row in the same spot.

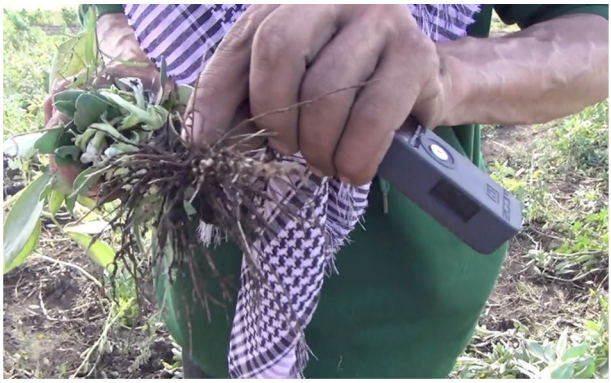


Fig. 1 Root nodules of fava beans for nitrogen fixation

He then said, "every plant is special and will have something to give to the soil." Mohamed's approach to farming was centered on caring for the plants and soil by ensuring an amicable relationship between them. As María de la Bellacasa maintained regarding "care time" for soil, "to properly care for the soil, humans cannot be only producers or consumers in the community of soil making organisms but must work, and be, in relation to soil as a significant living world" (2015, p. 705). Instead of merely focusing on the produce from the plants or extraction (the view perpetuated under hyper-capitalism), Mohamed paid attention to how his practice of farming can contribute to the overall ecosystem of the soil and sustainable growth of the plants—an anti-colonial act that we see as transdisciplinary.

The soil in Canada generates approximately 200% more produce in the summer

As we walked on the land, we discussed differences and similarities between the farm they had in Syria and the farm in Canada. Mohamed said that they grew the same variety of plants that we saw on the farm: kouza, fava beans, parsley, chickpeas, beets, carrots, and so forth. Mohamed explained as follows:

> The difference is… here it is a short summer season, while in Syria it is a longer summer season. The summer season lasts 4 months, from when we plant until the end of the season. But we cannot forget that the daylight is twice as long here during the summer season [compared with Syria]. For example, we pick zucchini every 3 days in Syria, while here, we have to pick it every day and sometimes twice a day because it is very quick to grow.

Mohamed grabbed soil from the ground and touched it with his hands to show us the moisture content in the soil. He then said the following:

> The land in Syria is a little hard to work with because there is no snow. We plant every month of the year. We always need to add stabilizers to the soil in Syria. Here, we have about 6 months of snow or cold, which adds moisture to the soil and benefits us when we start planting in the summer. The soil in Canada generates approximately 200% more produce in the summer.

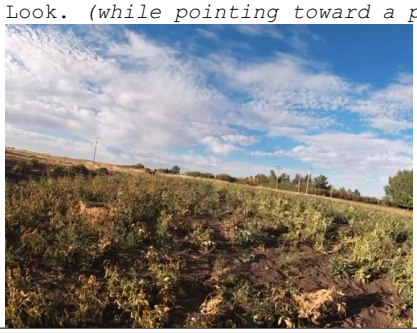
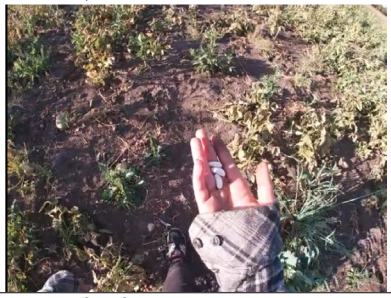
These excerpts from our dialogs demonstrate proportional reasoning for relationships among the length of daylight, rate of plant growth, and length of the summer season between Syria and Canada. Mohamed had come to notice that the same plant (kouza) produced "approximately 200% more produce" during the summer season where they were in Canada. Based on this proportional reasoning, the family rationalized that shorter summer seasons in Canada would not be a disadvantage in the harvesting of produce. As this example demonstrates, interanimated relationships between a place and learners as mutual agents (discussed further in Marin et al. 2020) are key to this family's knowing, which is inextricable from the land they are cultivating.

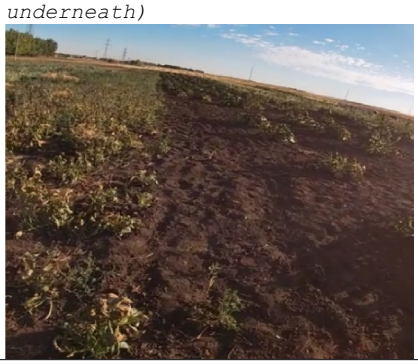
Once the plants get like this, we get the seeds out

It was a sunny day in early fall (September 10, 2020). Even in the early evening, it did not cool down, and it was close to 30℃. Aisha (9), Abir (6), and Rabih (8) were walking around the farm with us to show plants whose leaves were drying and turning yellow. "They are almost done," Aisha took green bean plants to her hands and showed them to us. Aisha added, "when they are completely yellow, it's good for collecting seeds." As we continued our walk, Aisha stopped in front of another plant and pointed toward the plant, saying, "look." She showed us what plants look like when they are ready for seed collection (from fieldnotes dated 09/10/2020, taken by Takeuchi).

The following Excerpt 1 demonstrates the intertwinement of embodied and embedded knowledge regarding when to collect seeds based on observing the state of plants and how to grow plants from seeds.

Excerpt 1.

1	0:00	Aisha	Look. *(while pointing toward a plant)* Yellow. 
2	0:04	Miwa	Oh, it's yellow. *(while glancing at the plant)*
3	0:07	Aisha	The seeds. Inside it.
4	0:10	Rabih	Once the plants get like this we get the seeds out. *(while approaching and pointing at the plant)*
5	0:13	Miwa	Oh, I see. Do you collect them?
6	0:15	Aisha	Yeah. *(while collecting seeds and walking around in the farm with Miwa, Rabih, and Raneem)* 
7	0:18	Rabih	We cook them.
8	0:20	Aisha	They are gonna grow.
9	0:22	Miwa	You cook them?
10	0:24	Rabih	Yeah we cook them.
11	0:31	Aisha	No, next year, we plant these. When next year. *(while walking through the field)*
			…
12	1:36	Rabih	Here you go. Here are some seeds. *(while handing them to Miwa)*
13	1:39	Miwa	Thank you Rabih. I will plant them.
14	1:48	Miwa	How do you plant it? *(Miwa asks while walking)*

15	1:51	Aisha	Just add… dirt. You can take dirt from here, it is so organic. *(while pointing at the soil underneath)* 
16	2:00	Aisha	And then just add water [Rabih: put the dirt in, and water] and you need sun. Then it's gonna grow.
17	2:03	Miwa	Lots of sun or a little bit of sun?
18	2:04	Rabih	A lot.
19	2:11	Aisha	Maybe put the plant in front of a window or put it in front of the door.

As we walked together, Aisha and Rabih collected some seeds and gave some to us (utterances 6 and 12 in Excerpt 1). Aisha told us what plants need to grow as well as that pole bean seeds would require full sunlight (utterances 15–19). In Excerpt 1, Aisha did not distinguish dirt from soil as she spoke in English. When we asked the family about an equivalent word for soil and dirt in Arabic, they chose the word تراب (*turab*). They explained that this word can be used for both soil and dirt. As Aisha touched the soil, she excitedly added that "you can take dirt from here, it's so organic." Later, when we asked what "organic" meant to her, Aisha said the following: "It's like, taste good, and better, you can taste more and taste better." This meaning of the term "organic" or the distinction between soil and dirt is not necessarily aligned with institutionalized definitions that certify and commercialize organic produce. Instead, the *sense* of the word (the word "organic" or "dirt," which is more closely seen as the Arabic word *turab*), namely, "a dynamic, fluid, complex whole" (Vygotsky 1978, p. 245), was developed through the child's embodied and emplaced experiences as well as through care for others passed on intergenerationally. In describing the family's care for farming, Mohamed said the following: "[I]t's very important to plant something healthy for people, especially since for 7 months out of the year, it is very cold and there is not much exposure to sunlight here." Given that their farm attracted mostly classed, racialized refugees and immigrants in the city, the family's acts of care are at the center of their everyday transdisciplinary acts. The family's everyday acts (which include their linguistic acts) challenge the exclusion of racialized refugee communities in scientific inquiries around plant growth and human health (Kayumova et al., 2018).

They are like medicine

As we continued our walk (Excerpt 2), Aisha stopped in front of a plant, picked it up, and said to us, "if you are sick, you go and boil them" (utterance 4). Without naming the

plant, Aisha told us, "they are like medicine" (utterance 9). This plant is named *Matricaria discoidea*, or pineapple weeds or wild chamomile in English. However, we recognize that naming is a political act. The plant name index in Western science or English does not necessarily reflect ways of seeing and listening to the plants stewarded by Indigenous communities across the globe (Kimmerer 2013). As she gifted the "medicine plants" to us, Aisha told us to boil them and drink the tea if we were sick (utterance 14). With Aisha's guidance, we all picked the plants. Their aunt, who is also from Syria and was on the farm, confirmed that the plant was used to ease the symptoms of asthma in Syria.

Aisha knew that these plants were wild plants grown on the land without the family planting them. Our shared walk, depicted in Excerpt 2, reveals the children's careful observation of plants as well as their knowledge of the gifts that plants offer to humans. Like in languages around "organic" or "soil," Aisha's use of the word "medicine" does not conform to the institutionalized definition of medicine that is regulated through governmental authorization and credentials. For the family, the *sense* (Vygotsky 1978) of "medicine" was rooted in embodied experiences on the farm in both Syria and Canada, where their access to institutionalized resources can be limited. Aisha and Abir described how when their mother was infected by the COVID-19 virus in April 2021, they went to search for the "medicinal" plant in an attempt to ease her cough and chest pain. Intergenerational embodied and emplaced knowledge for identifying plants is rooted in wholistic understanding of body, as reflected in the notion of medicine in Indigenous communities (Kimmerer 2013). The act that we highlight here is a manifestation of children's agency and dignity (Espinoza et al., 2020), even in the midst of seemingly powerless, fearful, and overwhelming situations during the pandemic. Facing the lack of pharmaceutical treatment for their mother, both Aisha and Abir resorted to their embodied knowledge about "medicine" to exercise their agency.

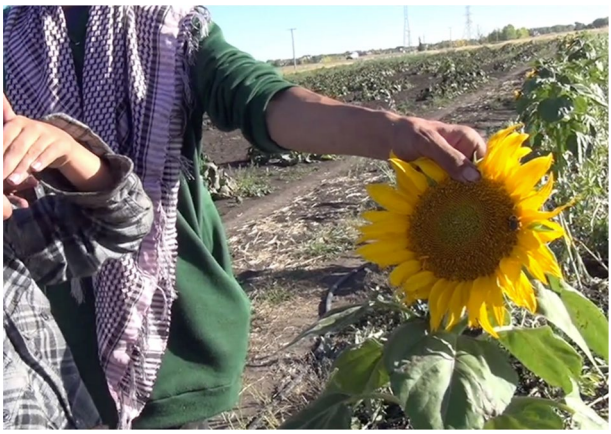


Fig. 2 Intergenerational acts of seeing

Excerpt 2.

1	0:22	Aisha	This is not dead yet. *(while picking some plants)*
2	0:28	Miwa	What are they? *(while pointing at plants in the ground that Aisha was picking)*
3	0:29	Aisha	Oh these? I don't know, they are herbs. *(continuing to walk around)*
4	0:38	Aisha	Oh these? If you are sick you go and boil them.*(stops at one of the plants)*
5	0:45	Raneem	What's that? Rosemary? No, what's that? *(Aisha picks the plant and shows the plant to Raneem, who sniffs it)* 
6	0:46	Miwa	Chamomile?
7	0:50	Raneem	شو اسمها بالعربي، بتعرفي شو اسمها بالعربي ؟ [What is it called in Arabic, do you know what it's called in Arabic?]*(looking at Abir)*
8	0:54	Abir	لاء [No]
9	0:55	Miwa	*(Aisha passes the plant to Miwa and she also sniffs it)* Hmm what are they?
10	1:01	Aisha	They are like medicine.
11	1:02	Miwa	Oh, they are medicine.
12	1:05	Raneem	Maybe chamomile.
13	1:07	Abir	Yup.
14	1:07	Miwa	Oh wow. They are chamomile?
15	1:10	Aisha	So you boil them in water then drink it. If you are sick in winter. *(while walking in the field where the medicinal plants are growing and picking the plants)* 
16	1:23	Miwa	Did your dad plant this too?
17	1:25	Aisha	No, they grow by themselves. [Miwa: oh, really.] They are literally everywhere. There is a lot here. *(while walking around)*
18	1:30	Miwa	Interesting.*(while walking around and looking at the plants closely)*
19	1:45	Aisha	I don't know if you get sick in the winter? You can just make, one piece, and you can just boil it and drink.*(looking at Miwa)*

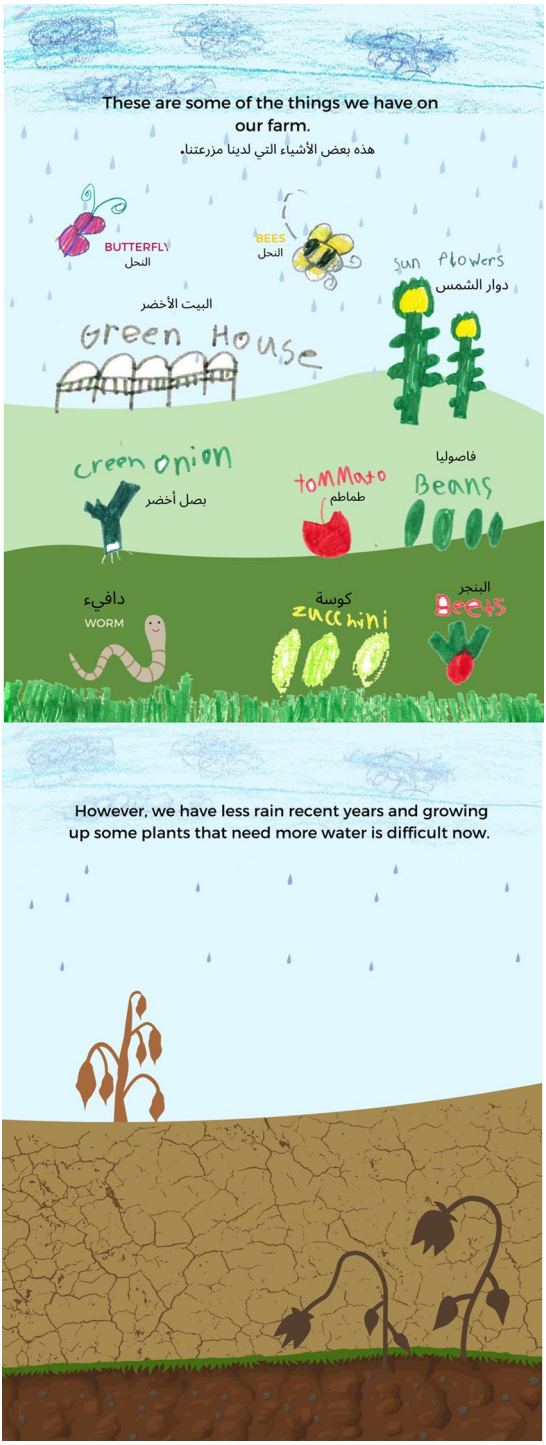


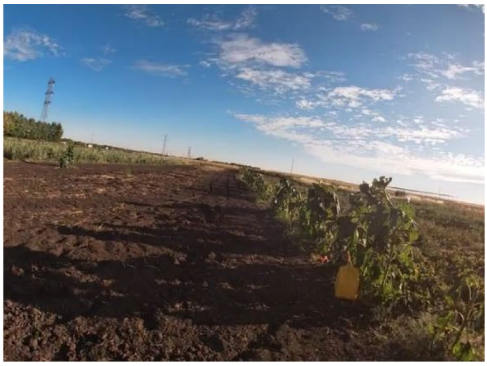
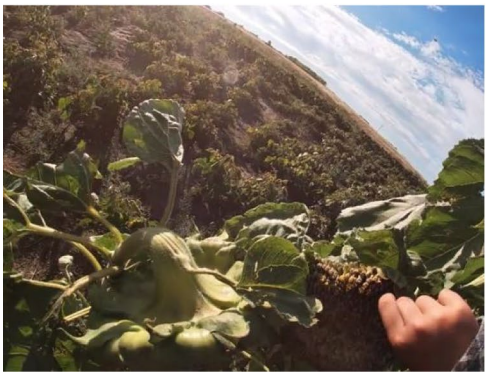
Fig. 3 Excerpts from the collectively illustrated picture book (https://illustratestem.net/): The family's lived experiences of climate change

Both Excerpts 1 and 2 demonstrate how these children's emplaced and embodied knowing were intertwined with their sense of care for others—preparing for the next season by collecting seeds, sharing them with others, and gifting medicine to them.

Seeing near and afar, seeing inside

Through the shared walk, the children helped us to become aware of the presence of more-than-humans on the farm (Marin and Bang, 2018). In one of our conversations while walking together on the farm, Abir saw and named various types of more-than-humans (Narrative 1). When asked what she would see in the soil, Abir shouted with excitement, "worms!" Abir also identified bees as we were walking together, and while pointing to sunflowers, she said, "I like sunflowers because they are so beautiful." She then continued to describe the relationship between sunflowers, butterflies, and bees: "If we don't have flowers, how will all butterflies eat? They eat only flowers. Even bumblebees." Specifically, regarding sunflowers, Abir made the following comment: "I like the sunflower because it is good. Lots of bees go to the sunflower." Excerpt 3 also indicates that both Abir and Aisha had an emerging understanding of how bees help plants to grow (utterance 4). According to Abir (utterance 8), "bees are farmers." These children were able to keenly observe and articulate how more-than-humans were interacting with them on the farm.

Excerpt 3.

(We are walking through the field of sunflowers) 			
1	0:00	Miwa	Do you know why your dad planted sunflower?
2	0:02	Aisha	For an…
3	0:04	Abir	The bees come here.
4	0:05	Aisha	Bees that come… they are what makes the stuff grow.
5	0:09	Miwa	How do they help make your stuff grow?
6	0:13	Aisha	I don't really know. (…)I am not really a farmer.
7	0:17	Miwa	*(laughter)*
8	0:20	Abir	Bees are farmers.
9	0:21	Miwa	Bees are farmers. *(laughter)*
	0:22-0:27	Abir, Miwa, Raneem	*(laughing all together)*
		Aisha	*(touching a sunflower)* 

Acts of seeing more-than-humans are passed on intergenerationally through shared, embodied, and emplaced experiences (Marin and Bang 2018). In one of our shared walks, Mohamed stopped in front of some sunflowers, gently touched a flower, and explained the following to us: "When I planted sunflowers for the first time this year, I realized that sunflowers bring bees. I know for next year that around the greenhouse I should plant sunflowers to bring bees for flower pollination." Mohamed then took the sunflowers in his hand, pointed at the bees collecting pollen on the flower, and showed them to his children (Fig. 2). This understanding of the relationships between different species were passed down intergenerationally through such moments. The family adapted their farming practices to ensure mutual well-being on the farm, and through their movements and actions, they demonstrated reciprocal relationships that they were fostering with other lives.

In addition, the act of seeing from afar had led the family to closely witness the impact of climate change. As we end this section, we wish to highlight the challenges that the family currently faces to paint a complex picture of working with the land in the current climate. To achieve the goal of enhancing communication about this complex problem to a wider audience, the family, Dadkhahfard, Takeuchi, and a teacher (Ehsan El-Birani) illustrated the experience of climate change (https://illustratestem.net/). In the process of collective illustration, Abir noted the importance of illuminating rain, as it plays a significant role in the family's farming practices. Nahima also explained how the lack of rain from climate change affects their farm. As Abir tried to think of a message to communicate to the audience, she said the following: "The challenge is the rain. We have less and less rain, and the climate is changing." Abir emphasized the importance of rain to earthworms by saying that "earthworms always have to be in soil that's wet. Because… if the soil is not wet, they will die." We conclude this section with our shared concerns arising from embodied and emplaced experiences of climate change in Fig. 3:

Discussion

In this article, we have illustrated the possibility of anti-colonial transdisciplinarity through a refugee family's knowledge grounded in traditional farming practices enacted in the land of refuge: occupying space in the traditionally white farmland by reclaiming the presence of Othered bodies, changing access to fresh produce and green spaces for racially minoritized refugee and immigrant communities in urban spaces during the pandemic, and stewarding the land with intergenerational wisdom. By reclaiming the depth of wisdom and care of a refugee family who were forcibly displaced from the land, our study attempted to challenge hegemonic disciplinary formation, which has constantly excluded or exploited other bodies. Furthermore, this study amplified counter-deficit views toward refugee and immigrant learners and families in the context of STEM education as well as the problematic "learning loss" rhetoric (McKinney de Royston and Vossoughi 2021). It did so by highlighting what children were in fact learning on the land during the pandemic, along with their family, beyond narrowly defined in-school learning. Acknowledging and respecting these historically unseen embodied and emplaced wisdoms can expand and renew the discipline of STEM by grounding the experience of learning with a deep sense of place, which cuts through the surface of colonial, white-dominant, and capitalistic senses of place (Kincheloe et al., 2006).

In this article, we have also attempted to reposition the everyday acts of racially and linguistically minoritized refugee farmer families as essential for epistemological and ontological expansions of the discipline of STEM. From the perspective of historicizing learning (Gutiérrez 2016), the phenomenon of learning depicted in this article can be considered an activity that could lead to the disruption of the conditions of inequities. We see this family's everyday acts of resistance and love as a condition for challenging the currently dominant globalized mass production of foods that rely heavily on the use of herbicides and pesticides, sacrificing human health and biodiversity in the name of efficiency. The family's intergenerational knowledge of STEM (e.g., about plant–soil and plant–insect relationships), mathematical rationales (e.g., about the relationships among the amount of produce, daylight, and frequency of harvesting), and the design and building of green houses for winter farming were interwoven with their care for the land, plants, and more-than-humans that surround them (Marin and Bang 2018). This practice of care cannot be conformed to Western ways of understanding care that center person-to-person but rather stretches into the more-than-human world (Kimmerer, 2013). Their practice of caring for fellow racially minoritized refugee and (im)migrant communities was rooted in and expressed through intergenerational embodied and emplaced wisdom and actions. By legitimizing the historically devalued embodied and emplaced wisdoms that emerged from care for the land of refuge, we were able to move closer to "care-full" STEM education, where "we can question effects of our own care work, and how we ask students to care, with whom, where, how, and for what ends" (El Halwany and Alsop, 2023, p. 1336).

We believe that using visual art in the form of digitally illustrated stories as a medium could facilitate transdisciplinary dialogs that center the voices of refugee families and children. As we have provided just a snapshot, digitally illustrated stories could bridge art, disciplinarity in STEM education, and families' everyday intergenerational knowledge and experience to invite conversations with wider audiences, including children, teachers, and teacher candidates. Diversifying resources for meaning-making in science investigations is pedagogically and politically important, especially for multilingual learners (Siry et al., 2022). To challenge siloed and enclosed disciplinary knowledge production to open dialogs on complex problems, such as migration, food justice, and climate change, we see the possibilities of mobilizing the power of (visual) arts.

The embodied and emplaced knowing depicted in this article could invite pressing questions such as the following: How could we collectively learn to intervene to address injustices in modern and globalized food production and the exploitation of colonized bodies? How could intergenerational embodied knowing that is deeply connected to the land help to envisage the sustainable practice of food production for healing environmental damage in the post-pandemic world? Engaging in transdisciplinary inquiries could guide us toward envisioning and enacting a future for STEM education that is more socially and environmentally just.

Author contributions Takeuchi led data collection, analysis, theorization, and writing of the main manuscript text. All authors (Takeuchi, Dadkhahfard, Kopparla, and Elhowari) participated in collective data analysis and literature analysis appeared in this manuscript. Dadkhahfard led illustrations with the family and teachers (figure 3). Elhowari served as a translator and interpreter during the fieldwork and analysis.

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Declarations

Conflict of interest The authors declare no competing interests.

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