

## Considerations of Land, Language and Healing in Decolonizing Mathematics Education

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## Abstract

This paper describes how a research study intended to focus on case studies of locally meaningful STEM teaching and learning in Indigenous communities across what we now call Canada, has pivoted due to the pandemic and has instead become an online learning collective focused on understanding what it looks like to do this work in a good way. We describe our collective process of how we engage in learning, which is perhaps more important than the product. We also share emerging ideas related to concepts of land, language, and healing, that are among the many considerations coming from our collective work. We ask what the obligation of mathematics education is to address these ideas as we seek to transform and decolonize mathematics education in ways that honour Indigenous knowledges.

**Keywords:** Mathematics, STEM, Science, Land, Language, Land-Based Learning, Indigenous Education

### The Provoking Question

In the context of what is currently Canada, all of the members of our collective work with teachers to consider and discuss how Indigenous ways of knowing, being, and doing might inform and deepen teaching and learning. Some of us have been engaged in this work for decades, others are newer at it. Some of us come with lived experience and kinship relationship to the communities we work with, others have built relationships over time. Many of us, but not everyone, focus on curricular experiences in science, technology, engineering, and mathematics (STEM) teaching and learning. In the work we each do, we often engage with teachers helping them to consider the complexity of curricula in ways that move beyond rote memorization of facts and procedures and towards explorations of interrelationships and interdisciplinary connections between the elements of STEM. Typically, we consider how disciplinary understandings can come together in problem solving and inquiry. We explore how local Indigenous ways of knowing, being, and doing inform and deepen the questions we can ask and our ability to think through and conceive of solutions. In the best circumstances, STEM emerges from local knowledges and understandings with questions that reflect land, kinship, and language. When this happens, everyone appears to get it. The conversation is lively. In these

shared experiences, almost without fail though, a hand goes up, and—to nods all around—someone asks the inevitable question: “What does it look like in the classroom?”

“What does it look like in the classroom?” has been an ongoing focus for our collective for since its inception in 2020. We are all educators from different Nations (Cree, Dene, Métis, Mi’kmaw, Naskapi, Canada) who have engaged in a monthly learning circle over the course of the pandemic to think together about what (in Western contexts) we tend to call STEM teaching and learning. Our collective brings together academics with decades of experience in Indigenous education, Indigenous and Canadian graduate students who are in various stages of their doctoral journey, and educators situated in various Indigenous contexts. We are guided by an Elder who provides wisdom, context, and grounding in how to do the work in a good way. We come together online and share stories, as we strive to deepen our own ideas and understandings of what it looks like to do the work, and to share what we do in specific local contexts. It was never our intention for the work to be stuck online. We had imagined local groups, on the land in specific places, and sharing—both locally and more broadly—through in-person engagement. The pandemic and our obligations to care for each other made the choice to pivot online easy. And while we have missed much, we recognize that perhaps we have gained something in that shift because, as we have come to understand, the question in which we are engaged is not solely “What does it look like in the classroom?” but also, “What does it sound like, smell like, feel like, and (yes, even) taste like in the classroom?”, “What do we mean by classroom?” and “Who do we consider to be teachers?” With these questions, part of what we recognize is that the process of how we engage in learning is perhaps more important than the product. And what is research, if not learning?

With that focus in mind, in this paper we take time to describe our process of coming together and how the process itself became the data for our study. We also highlight some emerging findings that we have chosen to share with a wider audience. First, we begin by describing the larger study and situating it within the literature.

### **Situating the work**

Canada is a nation-state mapped on to the unceded territories of over 60 Indigenous nations through the ongoing processes of colonialism. The contemporary constitution of the country includes 10 provinces and three northern territories (the newest of which, Nunavut, was established as a governing entity only in 1999). There is a complex split of responsibilities between the federal and provincial/territorial governments, where jurisdiction for some responsibilities (e.g. national defense) lie with the federal government, some (e.g. resources) are split between the federal and provincial governments, and others (e.g. health care) are solely the purview of the provinces and territories. Education is a bit complicated because while it is largely a provincial/territorial responsibility, education of Indigenous students lies constitutionally with the federal government. However, in 1969 the Trudeau government put forth the *White Paper on Indian Policy* (Government of Canada, 1969); it leveraged education as a mean of assimilating Indigenous people into Canadian society. Subsequent Indigenous resistance to the policy beginning with a response called *Indian Control of Indian Education* (National Indian Brotherhood, 1972) has over time resulted in the devolution of the responsibility for the education of Indigenous young people to Indigenous communities, governments, and school boards, that can establish their own curricula. We ground our collective focus on the role of education in defining/shifting relationships between Indigenous and non-Indigenous people, peoples, and communities in Canada. More specifically, we position it within

a series of iterative responses in education to *White Paper* (Government of Canada, 1969) that have led to our current context.

Much of the first iteration response considered STEM teaching and learning in Indigenous contexts (Cajete, 1994; McIvor, 1995; Mount Pleasant-Jetté, 1998), and pointed to the importance of attending to tensions between Indigenous and non-Indigenous ways of knowing, being, and doing (Aikenhead, 1996; Lipka, 1994), the benefits of Indigenous languages in schools (Battiste, 1987), and the emergence of teaching and learning from local practices and land (Basso, 1996; Garrison, 1995). This work underlined epistemological and ontological tensions that alienate Indigenous learners from schools (Ermine, 1995) and render some subject areas—particularly those related to STEM—more alienating than others (Little Bear, 2000). First iteration work contributed to provincial/territorial mandates to integrate Indigenous perspectives in K-12 curricula (Aikenhead & Elliott, 2010) that began to appear around 2000 (Wiseman, 2016). Subsequent second iteration research has largely focused on the mandates.

To date, the second iteration has followed three primary lines of inquiry: (1) challenges, barriers, and resistances to integration reported in various subject areas, including STEM (Blood, 2010; den Heyer, 2009; Kanu, 2011); (2) analysis and implications for policy (Aikenhead & Elliott, 2010; Kim & Dionne, 2014); and (3) implications for pre-service teacher programs and teacher professional development (Deer, 2013; Kreuger, 2011; Styres, 2011; Wiseman, et al., 2015).

The third iteration emerges from the second, and has been informed by the Calls to Action of the Truth and Reconciliation Commission of Canada (2015a). The TRC documented the violence perpetuated against Indigenous youth who were forced to attend residential schools between 1831 and 1996 and their communities. The TRC outlines sweeping systemic changes to

be implemented across Canadian institutions in all sectors with a particular focus on education. The third iteration thus begins by taking seriously Indigenous ways of knowing, being, and doing, and then questions fundamental assumptions about what teaching and learning entail and look like across Canada, in both K-12 and teacher education contexts. It points to promising practices—e.g. beginning in place (Zinga & Styres, 2011), questioning the primacy of planning to teach based on singular outcomes or disciplinary areas (Lunney Borden & Wiseman, 2016), and figuring out how Indigenous and non-Indigenous peoples in Canada might face each other as human beings (Donald, 2018) so that we might “live together in dignity, peace, and prosperity on these lands we now share” (TRC, 2015b, p. 13). The work is wary of reconciliation as a problematic concept that lacks “deep engagement with Canadian colonial legacies in relation to Indigenous insights” (Daniels, et al., 2018, p. 202), but it takes up the spirit of the TRC’s Calls to Action (2015a) in operational ways. Our work is rooted in this third iteration and begins with locally meaningful K-12 STEM teaching and learning in Indigenous contexts as promising practices from which new understandings can emerge.

Our current research also intersects with work examining Indigenous education, STEM teaching and learning, and engaging with Indigenous knowledges in K-12 education. From this body of work, we know a number of things that play into how the research is conceptualized. For example, there is an overlap in the resistances, barriers, and challenges identified by teachers in both implementing STEM and engaging with Indigenous knowledges in teaching and learning.

Teachers point to a lack of:

- personal experiences in the field;
- support from school administrators with respect to implementation;
- alignment with provincial curricula;
- available resources and professional development (Deer, 2013; Friesen, et al., 2015; Fitzgerald, et al., 2019; Goulet & Goulet, 2014; Higgins, et al., 2015; Marshall, et al., 2009; Scott & Gani, 2018).

Thus, we begin with practices that teachers in classrooms themselves identify as locally meaningful in order to move beyond a deficit discourse to dig into questions of what conditions enable development and implementation of locally meaningful STEM, and what renders STEM teaching and learning locally meaningful.

### **Framing the work**

Theoretically, we frame this work in ethical relationality which works against binaries of “colonial logics” (Donald, 2009, p. 7) that divide people and peoples from their relations instead of opening a space where they might co-exist (Donald, 2012). The framing allows us to attend to ongoing tensions in between ways of knowing, being, and doing of different people and peoples/Nations, between perspectives and experiences of Indigenous and non-Indigenous participants (Elders, researchers, educators, graduate students), between languages (Mi'kmaw, Cree, Dene, Naskapi, English, and French), while still creating spaces where we might move closer together through iterative processes of collective learning (Donald, 2009). Within our learning circle these commitments are embedded in consensual collaborations where all members decide what is important in terms of sharing, research, analysis, and findings (CLEAR Lab, 2021). While there are various kinds of expertise within such relationality—e.g. two of us who have years of experience with academic writing have taken on the responsibility of drafting this paper so that we may all share our work—each is important to the result, no one person or group is privileged over the others, and all insights are important to what emerges (Donald, et al., 2012). This framing leads to “research” (or learning) that is not tidy and that has no clear beginning, middle, or end (Archibald, 2008), but nonetheless nurtures continuing engagement through which learning and unlearning (particularly of colonial perspectives and processes) becomes possible.

Such commitments, lead to conversations within our circle about what constitutes research, how to take it up in a good way, and how an ethics of care might be embedded in and move through the entire research process. We have struggled collectively with standard assumptions about research in Canada such as the notion that the principal investigator is the owner of the data, or that results need to be shared broadly in full detail. We have deeply considered guidance from other research groups and agencies that take up work in, with, and alongside Indigenous people, peoples, and communities (e.g. CLEAR, 2021; OCAP, 2019; Aurora Research Institute, 2019) about what constitutes knowledge mobilization, what of and when to share findings. We recognize the specific examples we discuss in our circle are fruitful to our thinking, but not necessarily transferable and applicable in places beyond where they originated. We think what might be most transferable from our work is the process of how we engage in it, which is less about analysis and much more about co-constructing meaning to come to collective understanding.

For this paper, then, the data or sources/ideas which we think with are conversations undertaken in learning circles as well as collective and individual processes related to sharing in the circle. Data thus includes our experiences of teaching and learning in community with and from land (air, water, and all our relations in place (Donald, personal conversation, 2019)), and artefacts that reflect how we are thinking and coming to understand (e.g. digital interactive whiteboards, recordings, notes, poetry, artwork). Part of our process involves cycles: returning to ideas, circling back and going deeper, as we come to understand together what matters, what is most relevant for sharing. Thus, what we might consider data collection and analysis occurs in a more emergent and organic way than may occur in more standard academic work. As ideas



become more clear to the collective, we are then able to choose what to share. What follows are very early findings about emerging ideas that we return to regularly.

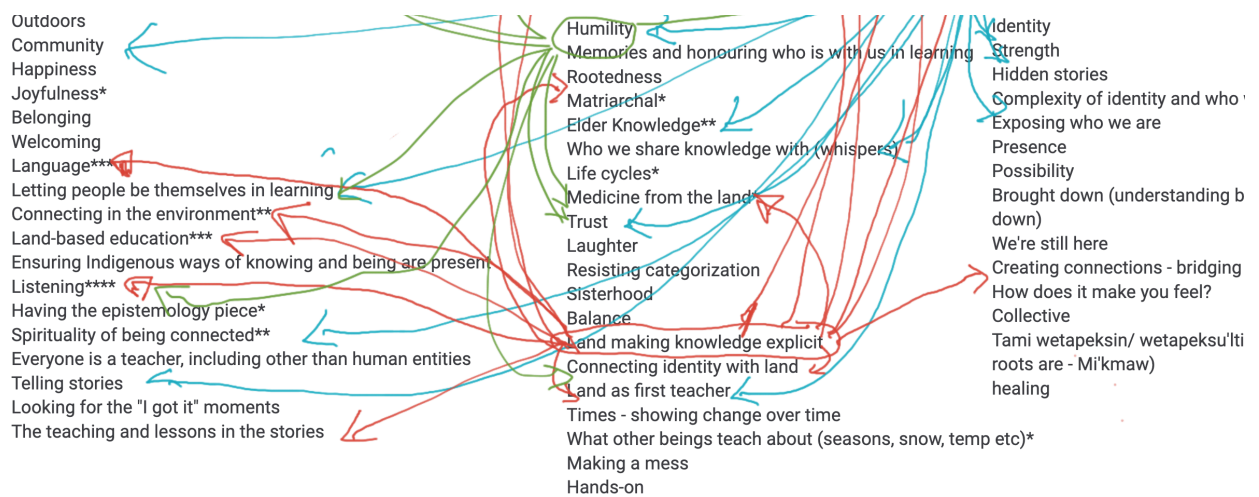
### **Emerging findings**

Our conversations are generative for us and offer emerging ideas that are foundational to our work. Some of these ideas, such as building learning experiences from local stories and contexts or drawing upon Elders to bring community knowledge into lessons, are not surprising. The results reflect what we already know from experience, and also reflect much of what we see emerging in research conducted in, with and alongside Indigenous students, schools, and communities in the contemporary context of Canada (Wiseman, et al., 2017). In returning to ideas, however, each new conversation has taken us to deeper levels of understanding. We have chosen here to share a few of these deepening ideas here, in particular those relating to land, language and healing, which may not be typically taken up in mathematics education literature. We summarize and explain these themes below, while recognizing we do not offer an exhaustive list but, instead, a sampling of our insights.

### **Connection to land**

Inspired by work being done at the CLEAR Lab (2021), we spent several sessions early on in the process sharing stories while documenting key words from these stories on a Jamboard. Each of us took turns sharing an experience of locally meaningful STEM while one member pulled out words that stood out and wrote them on the Jamboard. As subsequent stories were told, new words were added and repeated words were identified with an asterisk. This process allowed us to see connections in and between our stories. In a later session we engaged in a process of identifying words from the Jamboard that stood out for us and then made connections to other words on the Jamboard from this word. In this process we began to make meaning from

our stories in a way that brought us further towards understanding the characteristics of STEM education rooted in Indigenous knowledge systems. A piece of the Jamboard is shown in Figure 1. For example, you can see circled in red that one member chose to begin with the expression ‘Land making knowledge explicit’ and connected this to “Connecting identity with land”, “language”, “Land-based education”, “Listening” and “Land as first teacher” among other ideas. This process of making connections, helps to focus our thinking on emergent themes.



**Figure 1 Section of the Jamboard**

From discussions like this we were able to determine key ideas, for example, the notion of STEM as connected to the land and emerging from the land. We recognize that STEM is enacted differently in different geographic contexts. Learning to read the ice may be more important in one context, and knowing what plants offer medicine might be more relevant in another. Recognizing cycles and patterns in nature, and changes to those patterns in nature, offers insight into changes in our environment that are impacting our world. This knowledge comes from a deep connection to where we are located and a willingness to pay attention to what the land has to teach us. Recognizing land as a relation and teacher shifts how we think about STEM teaching and learning on the land. It commands a different ethic of care for and relationship with the land.

These discussions generate many new questions for us such as: How does STEM education help to promote a connection to the land? Does it help us to learn from and read land? Do the stories and voices from the land have a place in our STEM classrooms? How do living and nonliving beings find space to come into conversation with STEM? When we think of the purpose of STEM education, do we consider the role of land as teacher and relation? These questions take us deeper into understanding, and the process of returning on multiple occasions to them seems essential to considering what it might look like, feel like, smell like, taste like, to meaningfully engage with Indigenous knowledges in K to 12 STEM teaching and learning.

### **Language**

Elmer, our Elder, regularly reminds us that Indigenous languages “are verb based, we talk in verbs. Everything is in motion all the time.” One beautiful thing about our shared sessions is the way Indigenous languages emerge, circulate and are honoured in the space. Naskapi, Cree, Mi’kmaw, and Dene words are taken up as a way to express ideas for which English and French will not suffice. For example, the Mi’kmaw concept of *netukulimk* loosely translates to living sustainably, but its actual meaning is much deeper as it recognizes the interconnectedness and interdependence of all relations including the animals, plants, rocks, water and more (Wiseman, Lunney Borden, & Sylliboy, In Press). Such a concept is foundational to a consideration of STEM education in Mi’kmaw communities. Similar words are shared in other languages as well. In fact, complete conversations in one language occur between participants with speakers of other Indigenous languages remarking “I hear sounds I recognize, I almost understand it.” Land and languages are interconnected (Styres, 2011) and so we remember, the languages, the sounds come from the land. The land is always moving, nothing is constant in an Indigenous worldview. Language is the key to knowledge systems and understanding knowledge systems is the key to

determining the ways in which Indigenous and Western knowledges might circulate together in STEM education.

Our conversations regularly return to the languages of the places where we live and learn. Revitalization of Indigenous languages thus is seen key to the work we do. A frequently emerging comment in our circle is that we must protect and nurture languages ahead of and above any other concerns-including whether students have adequate mathematics skills to perform well on provincial/territorial assessments. In fact, within our circle, we understand that there can be little mathematics, STEM, or any learning in the absence of language. That is, there is clear recognition that language holds the science and mathematics young people need to understand to live well in place with all their relations, and without language we cannot meaningfully bring Indigenous knowledges into STEM teaching and learning.

The questions we return to include: As we consider STEM education what is our responsibility to *netukulimk*? How might Mi'kmaw concepts of sustainability or a sustainable way to harvest by taking only what you need transform how we plan for STEM teaching and learning? How do we take up the idea of *wahkotowin* in our educational spaces? *Wâhkotowin*, a Cree word meaning the connections of family, unity, and community, something that was disrupted by the recent pandemic and even more so disrupted by experiences of colonization and residential schooling. *Tami wejien*? Where are you rooted? (Mi'kmaw) How does this rooting inform our STEM teaching and learning? Learning from the Indigenous languages allows our collective to engage in different ways of thinking about STEM.

## **Healing**

Ethical relationality resists the colonial barriers that often ask us to separate ourselves from the research; instead, in our conversations, we are able to bring our whole selves into the space

which means our conversations often extend beyond the topic of STEM teaching and learning to include matters of significant concern to members of the group. We have had days where our attention was brought to focus on issues pertaining to Missing and Murdered Indigenous women, a well-documented issue within what we now call Canada (National Inquiry into Missing and Murdered Indigenous Women and Girls, 2019). On other days we have focused on topics that, although more closely related to STEM education, still bring with them the emotional trauma of nations deeply impacted by colonialism: How do communities deal with migrational changes of species due to extractive resource activities in their territory? Why do community artifacts reside in museums and not within communities? These and other questions, require care in how they are discussed. When we discuss how such topics address teaching and learning of mathematics and science, we also recognize when done well, educational experiences that focus on these topics can also support healing (Kokka, 2019).

We recognize that STEM Education cannot ignore the realities of the lived experiences of Indigenous peoples that have been so greatly impacted by settler colonialism on these lands we now call Canada. In the spring of 2021, almost a year into our collective work, 215 children were found in unmarked graves at a former residential school. While the TRC (2015c) documented the stories of children who never returned from residential school, this horror provided clear evidence of genocide that finally brought many non-Indigenous Canadians to understand this reality. Naturally, finding these, and subsequent, unmarked graves at other former residential schools, has influenced our conversations. The number is now in the thousands and climbing (Deer, 2021). These are children who never made it home. Their families never learned what happened to them. As each new sight is unearthed, as the land reveals each truth, we wonder together what our responsibility is to address this issue and help to heal these wounds.

These missing children remind us of others who are missing, the thousands of missing and murdered Indigenous women and girls across this land. What power these numbers have when we truly consider that each represents a real person with family who miss them and search for answers. The violence against these children and these women is reflected in the violence against the land, enacted by colonial governments and extractive, capitalist industries. The scars are real and the trauma is carried by community members into all spaces, including our STEM classrooms. So again, we have questions: What is our responsibility to make learning spaces where healing can take place? How does STEM education contribute to the violence we witness? How can we ensure that STEM education can tackle head on this colonial violence and imagine new ways forward? We speak often of healing spaces and wonder together what they might look like? How does STEM support us to be engaged citizens who act for justice in our world?

### **What Are Our Obligations Within Mathematics Education**

Given the focus of this special issue on Mathematics in Indigenous and Migrational contexts (and papers presented at the accompanying 2022 conference held in Alta, Norway) , we now ask directly how mathematics is implicated in addressing the ideas we have described in the previous section. Mathematics educators might be quick to dismiss the idea that mathematics is implicated in the colonization of these lands and in the attempted erasure of Indigenous knowledge systems. Yet, as Joseph (2010) has stated, colonialism has meant that “The contributions of the colonized peoples were ignored or devalued as part of the rationale for subjugation and dominance” (p. 4) even in the field of mathematics. Furthermore, mathematics is implicated in the sorts of extractive colonialism/capitalism that has removed Indigenous peoples from their lands (Abtahi, 2020). Mathematics is not and has never been neutral. Yet Jardine, et al., (2006) invite us to consider “What if ... the *world* of mathematics (as a living, breathing,

contested, human discipline that has been handed to us) needs our memory, our care, our intelligence, our work the ‘continuity of [our] attention and devotion’” (p. 90-91, emphasis in original). So we wonder, how might we transform our relationship with mathematics while nurturing mathematics itself to transform?

### **Mathematics and Land**

When we think about land and connections to land, we might consider what mathematical ideas are embedded in the land and how mathematics itself might emerge from the land. For example, Doolittle (2018) has drawn from Indigenous concepts of land to explore and challenge ideas in Western mathematics. A particular example involves how to solve the bridges of Königsberg problem when conceptualizing it from an Indigenous land-based approach. Glanfield, et al., (2021) similarly attend to land and language as they explore the ways in which Indigenous and ecological approaches might allow us to reimagine STEM. Nicol (2018), through a critical place-based approach to mathematics education, examines the ways in which mathematics is connected to the land in Indigenous Haida Gwaii territory and how critical use of mathematics can help students understand complex issues such as food insecurity and the impact of logging practices. From these few examples we see how considering land and mathematics can both allow us to explore mathematical ideas in new ways and support deeper understanding of community concerns using mathematical tools. In our shared work, we have begun to ask about the mathematics that might emerge while harvesting ptarmigan, exploring traditional medicines, or taking a walk along a river. We have also begun to wonder, if and how our other-than-human relatives thinking mathematically, and what they might be able to teach us about mathematics.

## **Mathematics and Language**

Our conversations have made clear that Indigenous languages have much to offer mathematics education and that revitalizing Indigenous languages can go hand in hand with decolonizing mathematics education. Some Indigenous communities have worked to create mathematics lexicons in their Indigenous language. One prominent example is the work done in the Maori community, however this process was not always straightforward as conflicts exist between the linguistic structures of mathematics as taught in English and the linguistic structures of Māori (Barton, 2007; Trinick & May, 2013). Māori, like other Indigenous languages, is verb-based and as such mathematics concepts are conceptualized more as verbs and actions within these Indigenous languages (Barton, 2007; Edmonds-Wathen, 2014; Lunney Borden, 2011). Mathematics as taught in school tends to focus on nouns and turns processes into nouns in what is described as nominalisation (Schleppegrell, 2007). While many scholars argue that educators must be mindful of these conflicting perspectives when teaching mathematics, Lunney Borden (2011) has advocated for verbing mathematics teaching and learning so that concepts are learned through experiences emphasizing actions and processes over nouns. We believe that mathematics education must make space for Indigenous languages and their linguistic structures to inform and be honoured within mathematics education. Elmer has often reminded us that there are no constants in Indigenous languages, everything is in motion. This way of thinking about mathematical ideas as being in constant flux has significant implications for mathematics curriculum, teaching and learning.

## **Mathematics and Healing**

Mathematics classrooms are often dehumanizing spaces where exclusion rather than inclusion is the norm (Martin, 2019). It has been well documented that Indigenous students, and



other racialized and minoritized students, are often excluded from quality mathematics learning experiences through tracking or streaming, and are often made to feel like that math is not about them or for them (Martin, 2019, Meaney 2002). Many equity efforts have focused on access and achievement, without questioning the mathematics itself. Gutiérrez (2012) has argued that we must move beyond these limiting ideas, considering also how mathematics is fostering identity and power for learners of mathematics. To rehumanize mathematics, we must recognize the damage current mathematics educational practices are causing and find new ways forward that recognize the need for social justice, epistemic justice, and healing centered approaches. Informed by work in social justice mathematics (Gutstein, 2006) and healing centered engagement (Ginwright, 2018), Kokka (2019) has advocated for healing-informed social justice mathematics. She has argued that teaching math for social justice and radical healing can create a space where students can see that mathematics can be used to solve important problems and that these students have the power to address these problems with mathematics. Some of our team have engaged in similar work where meaningful mathematics emerges from and contributes to the local communities in ways that honour wholeness rather than division (Wiseman, et al., 2020). We wonder what more might be accomplished if mathematics education focused more on healing, justice and wholeness. For example, how do our mathematics lessons address concerns over lack of clean drinking water in Indigenous communities in Canada? How might mathematics take up treaty questions relating to land, resources, and livelihood in Indigenous communities? How is mathematics education treaty? These are real issues of justice in the communities where we work and think together and we believe mathematics education has a responsibility to address them. We believe that such a shift will lead us in decolonizing ways.

## Conclusion

In this paper we have shared our wonderings so that we might invite readers to wonder with us. We encourage reflection on these emerging ideas and what they might mean in your own context. In our collective work, we continue to share stories while engaging in collective meaning making, as we consider what might need to be shared with the wider STEM education community. As we go forward, we will continue to share the products of our learning together so that others might be informed by and engaged in this shared learning experience.

We have also described our process which we believe is equally important data for others to consider. Having this shared community in which we come together and learn together, then return to our own contexts where the learning shapes how we proceed in our work. This learning collective is as much the way forward as the ideas that emerge from it. We invite the reader to consider how they are finding space to engage in such meaningful conversations and how such processes might move us forward in creating a more meaningful and deep response to the question of what it looks like.

We are often asked for stronger conclusions but as Loretta said in one of our sessions, “How can we write conclusions for work that is ongoing?” As we continue our collective thinking, we will continue to learn and work together. What we are sure about, is that the process in which we are engaged is allowing us incredible space to learn and think together and we believe that such conversations are essential for any groups doing similar collective work.

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