How we are coming to know:
Ways in which Indigenous and non-Indigenous ways of knowing, being, and doing might circulate together in mathematics and science teaching and learning

Final Report

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Key messages

This review focuses on *How we are coming to know: Ways in which Indigenous and non-Indigenous ways of knowing, being, and doing might circulate together in science and mathematics education,* in both K-12 and teacher education. We note a fundamental contradiction in this work from the outset. Categories such mathematics and science are generally read as Western constructs that divide and separate (Donald, 2009; Tuck & McKenzie, 2015) rather than preserving more holistic, interrelated understandings. We have maintained such Western constructs in order to limit the scope of the work. At the same time, we emphasize that to look at the issue in a more holistic sense would return different results. While not easy to express in point form, *we see the act of engaging with and shifting responses to this tension as, perhaps, the primary message and challenge emerging from our review.* Moving towards an education system where Indigenous and Western ways of knowing, being, and doing circulate together in teaching and learning requires fundamental and ongoing questioning of the assumptions and frameworks that underlie the current system at all levels. We note that questioning what we think we know can be transformational, and we see evidence of such transformation within this review in work that addresses policy, teacher education, and K-12 teaching and learning. The following key messages are thus related both to what it means to engage in transformational work in what can be considered “a good way”, and more directly, actionable pieces that may support the transformation.

As we engage in this transformational work - the work must:

- Be based upon long-term relationships with Indigenous people, peoples, and communities
- Be collaborative, rather than consultative, processes with Indigenous people, peoples, and communities
- Address the structural system that has marginalized Indigenous peoples and their ways of knowing, being, and doing in post-secondary mathematics and science programs
- Encourage research funding structures that allow for long-term collaborative programs of research with Indigenous people, peoples, and communities

Executive summary

Context

This review focuses on *How we are coming to know: Ways in which Indigenous and non-Indigenous ways of knowing, being, and doing might circulate together in science and mathematics education,* in both K-12 and teacher education. It specifically examines academic and grey literature related to the theme within the Canadian context and published in the period 2006-2017.

The work reviewed arises from three interrelated, iterative responses to *Indian Control of Indian Education* (National Indian Brotherhood (NIB), 1972) that build and expand upon each other. The first iteration examined questions related to what mathematics and science education might look like in Indigenous contexts, alongside what supported or hindered success in those contexts. It largely falls outside the scope of this review in terms of time period, but very much informs more recent provincial/ territorial mandates to integrate Indigenous perspectives in K-12 curricula, and subsequent second iteration research focused on the mandates. Within the second iteration, there is an emerging third iteration that begins within and/or in deep conversation with Indigenous ways of knowing, being, and doing, and then questions fundamental assumptions about what the teaching and learning of mathematics and science entail and look like across Canada, in K-12 and teacher education. This third iteration serves as a primary area of focus for this knowledge synthesis and mobilization report, although second iteration work is still present within the review.

Approach

The study was conducted by combining elements of systematic reviews with Indigenous Research Methodologies in order to highlight the manner in which relationships are present/missing/working/not working in the work surveyed, as well as to generate theory and explanation, and view all contributions as important to emerging understandings. A Circle of Advisors consisting of people well-acquainted with mathematics and science education in their own jurisdictions via their roles as Elders, local knowledge holders, scholars, teachers, and policy makers reviewed and guided the work as it unfolded.

Implications

This review has implications for researchers, post secondary educators and administrators, K-12 educators and administrators, and educational policy makers. The foundational implication that informs all others is that relationship is fundamental to any work related to Indigenous and non-Indigenous ways of knowing, being, and doing circulating together in mathematics and science education.

Results

The work considered within the review suggests commitment (at various levels) to examining ways in which Indigenous and Western ways of knowing, being, and doing might circulate together in science and mathematics teaching and learning, in both K-12 and teacher education. as well as the importance of relationship, place, and process to what is occurring in the Canadian context. These elements were visible in both the overview and emerging themes.

Overview

Relationship is foundational to nearly all the work reviewed. It is evident not only in the content of the work, but in the manner that the work proceeds: the majority of the pieces reviewed emerge from formal and informal research partnerships that tend to predate collaborative research. While these

identifiable bodies of work point to potentially transformational practices, they also point to systemic barriers that challenge such transformation including existing funding structures and means of assigning expertise.

Place is present in the work reviewed in terms of geography, grade level, and dissemination. Most work has occurred in Western provinces and Nova Scotia, with Inuit, Mi'kmaq, Cree, Blackfoot, and Haida communities. In terms of education level, there is a focus on K-12 and particularly elementary and middle school, with some work in teacher education, and community/informal contexts. Dissemination of work occurs overwhelmingly in Canadian-based publications. As such, there is substantial room for growth of the work geographically, as well as in terms of levels of education explored and where developing understandings are shared.

Process plays a key role in the work that takes place, to strongly suggest that how the works occurs is as important as the content of the work. In this regard, many of the pieces reviewed indicate people are trying to work beyond existing research rules/frameworks and instead paying attention to what emerges from a relational process of learning together. Within process there is also a trend to theorizing from or reflecting on program implementation as opposed to description of programs in place, thus suggesting there is still significant room for considering what it looks like when Indigenous and non-Indigenous ways of knowing, being, and doing circulate together in science and mathematics education.

Emerging themes

Culturally relevant education and ethical/cultural relationality: Many reviewed pieces highlight the benefits of culturally relevant/responsive education for supporting student learning. Other pieces align more with a culturally relational approach that focuses more deeply on ethical relationships within communities and building knowledge together.

Language: Many Indigenous children are both learning the complex terminology of math and science while also learning the language of instruction. Furthermore, there are ways of knowing, being, and doing rooted in Indigenous languages that conceptualize mathematics and science in ways that are different from Western school-based approaches to mathematics and science.

Continual teacher learning/effort at all levels pre-service and in-service: The importance of teacher learning is emphasized in many of the pieces that were reviewed. The work clearly identifies a need to help teachers understand Indigenous ways of knowing, being, and doing through meaningful learning in community, with Elders, and on the land.

Unlearning colonialism and decolonizing: Much of the work reviewed addresses issues of colonialism and ways in which it can be challenged or unlearned through schools. Decolonizing work tends to elevate Indigenous knowledges, worldviews, and practices as ways to inform teaching and learning. Challenging and unlearning colonialism requires us to question fundamental assumptions of dominant educational discourses regarding what works in mathematics and science teaching and learning.

Conclusions

Despite nearly 50 years of work since the publication of *Indian Control of Indian Education* (National Indian Brotherhood, 1972), Indigenous and non-Indigenous peoples in this place called Canada are still very much engaged in this process of coming to understand how Indigenous ways of knowing, being, and doing might circulate together in education broadly, and in science and mathematics education more specifically.

1.0 Context

The *Final Report of the Truth and Reconciliation Commission (TRC) of Canada* (2015b) calls for a fundamental shift in relationships between Indigenous and non-Indigenous people, peoples, and communities in Canada so that future generations "can live together in dignity, peace, and prosperity on these lands we now share" (p. 13). It directly addresses the need for development of K-12 curricula and teacher education that "integrate Indigenous knowledge and teaching methods into classrooms" (p.121), and for research that considers the manner in which such processes can occur. While the focus on mathematics and science teaching and learning is not explicit within the TRC (2015a), it does clearly state that reconciliation from Indigenous perspectives, "requires reconciliation with the natural world. *If human beings resolve problems between themselves but continue to destroy the natural world, then reconciliation remains incomplete*" (p. 13, emphasis added).

The natural world is the very focus of science teaching and learning in Canadian provinces and territories (Wiseman, 2016). Taking the TRC seriously thus suggests that reconciliation requires deep consideration of what, how, and why we teach within the sciences. Our focus within this report is therefore, *How we are coming to know: Ways in which Indigenous ways of knowing, being, and doing and have been taken up in science and mathematics education*, teaching and learning, both in K-12 and teacher education.

We have included mathematics with science in this synthesis for three reasons. (1) Both science and mathematics are seen to be exclusionary in terms of openness to Indigenous perspectives because of their strong links with non-Indigenous ways of knowing, being, and doing (e.g. Perso, 2001). (2) Indigenous scholars frequently critique the fragmentation in understanding that occurs when subjects are taught in isolation from each other, and as a beginning place the sciences and mathematics have an affinity for each other (e.g. Cajete, 1994; MacIvor, 1995). (3) Our previous work (Lunney Borden & Glanfield, 2016; Lunney Borden & Wiseman, 2016; Wiseman, Onuczko, & Glanfield, 2015) suggests that Indigenous and non-Indigenous ways of knowing, being and doing circulate together more easily in open-ended inquiry projects where interesting questions arise and where mathematics *and* science might be necessary in order to consider the questions; that is where the context for learning comes first.

The current context with respect to this work is a result of iterative responses to the 1969 Trudeau government *White Paper on Indian Policy* (Government of Canada, 1969), and subsequent Indigenous resistance to assimilation that consolidated around a call for *Indian Control of Indian Education* (Assembly of First Nations, 2010; NIB, 1972). First iteration responses considered what the teaching and learning of mathematics and science looks like in Indigenous contexts (Cajete, 1999; Cole, 1998; MacIvor, 1995), and pointed to the importance of attending to tensions between Indigenous and non-Indigenous ways of knowing, being, and doing (Aikenhead, 1996), the benefits of Indigenous languages in schools (Battiste, 1987), and the emergence of teaching and learning from local contexts, practices, and land (Basso, 1996; Garrison, 1995). This work contributed to the recent provincial/ territorial mandates to integrate Indigenous perspectives in K-12 curricula (e.g. Alberta Learning, 2002; Ontario Ministry of Education, 2007), and subsequent second iteration research 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 (Blood, 2010; den Heyer, 2009; Kanu, 2011). (2) Analysis and implications for policy (Aikenhead & Elliott, 2010; Kim & Dionne, 2014; Wiseman, 2016). (3) Implications for pre-service teacher programs & teacher professional development (Association of Canadian Deans of Education, 2010; Deer, 2013; Donald, 2009; Kreuger, 2011, December 2; Lunney Borden, 2010; Lunney Borden & Wagner, 2013; Lunney Borden & Wiseman, 2016; Styres, 2011; Styres, Haig-Brown, & Blimkie, 2013; Wiseman et al., 2015; Zinga & Styres, 2011).

Within the second iteration, a third iteration is emerging. It begins within and/or in deep conversation with Indigenous ways of knowing, being, and doing, and then questions fundamental assumptions about what the teaching and learning of mathematics and science entail and look like across Canada, in K-12 and teacher education. Some of the work is explicitly about decolonizing mathematics, science, and education; some of it is less grounded in the academic discourse of decolonization but is about unlearning colonialism (D. Donald, personal communication, December 21, 2016) through teaching, learning, and practice. It points to practices–e.g. beginning in place (Zinga & Styres, 2011), questioning the primacy of planning to teach based on stipulated outcomes (Lunney Borden & Wiseman,

2016)–outcomes that while they might address the calls of the TRC (2015a) are void of place. This third iteration serves as a primary area of focus for this knowledge synthesis and mobilization report.

2.0 Implications

This review has implications for researchers, post secondary educators and administrators, K-12 educators and administrators, and educational policy makers. A core tenet in the implications for each of these groups is that relationship is fundamental. It must be the basis for any work related to considering ways in which Indigenous and non-Indigenous ways of knowing, being, and doing might be able to circulate together in mathematics and science education, as well as the impact of that work on Indigenous student achievement and engagement with mathematics and science. Glanfield, Sterenberg, and Donald (2013a, 2013b) describe this kind of work as culturally relational. It is based on practices where people learn to live together as relations, learning by listening respectfullly, and learning that, as relations, there will be ebbs, flows, and tensions in the relationships. In learning to live as relations generative ideas can emerge to transform research and practice.

2.1 Researchers

Challenge long-held institutional colonial constructs in order to develop culturally relational research programs in English and French that attend to:

- program implementation and the quantitative and qualitative impacts on student achievement and engagement for programs that attempt to allow Indigenous and non-Indigenous ways of knowing, being, and doing to circulate together in mathematics and science.
- longitudinal studies.
- in-depth analysis of provincial and school district policies around Indigenous education and the impact that those policies might have on mathematics and science education in K-12 and in teacher education.
- communities in New Brunswick, the Northwest Territories, Prince Edward Island, and the Yukon Territory.
- considering the possibility of impacts on mathematics and science teaching and learning if school systems shifted to giving priority to Indigenous worldviews and pedagogies.
- policy analysis with respect to how Indigenous ways of knowing, being, and doing are evident in mathematics curricula.
- Indigenous student voice and thinking in mathematics and science.
- ways in which Indigenous and non-Indigenous ways of knowing being and doing can circulate together in senior high school (Grades 10-12) mathematics and science.
- ways in which the language of instruction impacts Indigenous language speakers learning mathematics and science.
- ways in which Indigenous language structures can inform and challenge the long-held, taken-for-granted non-Indigenous assumptions about concepts in mathematics and science education.
- ways in which Indigenous language structures can inform mathematics and science teaching practices.

2.2 Post secondary educators and administrators

Challenge long-held institutional colonial constructs in order to:

- identify pathways for Indigenous peoples to pursue mathematics and science teacher education.
- recognize that Indigenous knowledges are lenses that can be used to explore the Western constructs of mathematics and science.
- recognize that the scientific and mathematical taken-for-granted notion of 'truth' needs to include context and place.
- create mentorship programs for Indigenous undergraduate students as they navigate post-secondary mathematics and science programs.
- develop mathematics and science content and education courses that are inclusive of Indigenous ways of knowing, doing, and being.

2.3 K-12 educators and administrators

Challenge long-held institutional colonial constructs in order to:

- recognize that Indigenous knowledges are lenses that can be used to explore the Western constructs of mathematics and science.
- recognize that the scientific and mathematical taken-for-granted notion of 'truth' needs to include context and place.
- recognize that Indigenous learners may come to school with Indigenous worldviews, because they speak an Indigenous language.
- develop open-ended inquiry projects in mathematics and science programs so that Indigenous ways of knowing, doing, and being might circulate together with other worldviews.
- invite Indigenous knowledge holders into mathematics and science programs in order to introduce learners to Indigenous ways of knowing, doing, and being.
- develop long-term professional development programs that promote ongoing dialogue between Indigenous and non-Indigenous knowledge holders and teachers in order for teachers to learn about the ways in which Indigenous and non-Indigenous ways of knowing, doing, and being can circulate together in mathematics and science teaching and learning.

2.4 Policy makers

Challenge long-held institutional colonial constructs in order to:

- develop research funding models that will promote and encourage long-term collaboration between Indigenous and non-Indigenous researchers, Indigenous communities, and educators.
- recognize that long-term collaboration between Indigenous and non-Indigenous researchers, Indigenous communities, and educators, are often based on consensual processes where a PI is antithetical to the process
- recognize that the scientific and mathematical taken-for-granted notion of 'truth' needs to include context and place.
- develop curriculum documents that recognize Indigenous knowledges are lenses that can be used to explore the Western constructs of mathematics and science.
- develop policy that requires all K-12 teachers in Canada are aware of Indigenous knowledges and the ways in which those knowledge systems can be used to interpret school curricula.
- develop funding models that will encourage long-term professional development programs that promote ongoing dialogue between Indigenous knowledge holders and teachers in order for teachers to learn about the ways in which Indigenous and non-Indigenous ways of knowing, doing, and being can circulate together in mathematics and science teaching and learning.

- conduct a review of current educational and research policies and programs for opportunities to engage with Indigenous knowledges.
- ensure that reporting of the results of initiatives related to Indigenous student perspectives and performance in mathematics and science are publically available.

3.0 Approach and methods

3.1 Methodology

Systematic reviews within the field of education frequently reflect the methods and approaches of the studies on which the review is focused (Gough & Thomas, 2016). Most of the studies that inform this review examine ways in which Western and Indigenous ways of knowing, being, and doing might circulate together in mathematics and science teaching and learning, in K-12 and teacher education. So, we have subsequently brought these ways of knowing, being, and doing together by combining elements of systematic review (Gough & Thomas, 2016) with Indigenous Research Methodologies (IRMs) (Kovach, 2009; Smith, 1999; Wilson, 2008). From IRMs, we attend to ethical relationality (Donald, 2009) and the ways in which relationships are present/missing/working/not working in the work surveyed. Ethical relationality defines relationship broadly. In research this means, we examine not only interactions between human beings, but interactions in the world between human beings, other living beings, the environment, place, and language(s). The approach thus attempts to attend to all relationships which sustain life and living (Donald, 2013). We find such relationality allies well with systematic reviews from what Gough and Thomas (2016) characterize as an Enlightenment approach (p. 87) where the intention is to generate theory or explanation, and view research in an iterative fashion where all contributions are valued and lead to emergent understandings. At the same Gough and Thomas (2016) note that systematic review is a continuum from Instrumental to Enlightenment approaches, where methods may often overlap. As such, we have found more instrumental approaches useful in terms of establishing limits and inclusion/exclusion criteria on the work.

3.2 Methods

Systematic reviews are generally structured around phases of work focused on the search strategy and limits (Phase 1), categorization and analysis of sources for fit and content (Phase 2), and synthesis (Phase 3) (Gough & Thomas, 2016). Given our relational Enlightenment approach, the phases overlap and feedback into each other.

3.2.1 Phase 1

Search strategy: Much of the work we are interested in occurs at very local levels and does not make its way into academic literature. As such, the overall search strategy was built to explore both academic and grey literature. While our review of academic work is comprehensive within the limits of the this systematic review, the grey literature returned in our searches only scratches the surface of what is available. So, while the impact of grey literature within our results is limited in terms of quantity, it complements the academic work in a number of ways, as we will discuss in Results and Next Steps.

Searches were conducted through 11 databases, e.g. Scopus. Search terms were: Aboriginal, Indigenous, First Nations, Inuit, Metis, Science, Mathematics, STEM, STEAM, Teaching, Learning, Land, Language, Decolonization, Integrative Science, K-12, Elementary, Secondary, Teacher Education, Canada, in multiple combinations (and corresponding terms in French). We used the same terms to search 16 journals, e.g. *Research in Science Education*, with a history of publishing articles relevant to the work. Given that the Canadian research community is relatively small and interconnected, we ran the

names of colleagues who are engaged in work in, with, or about Indigenous mathematics and science education (n=64) through Google Scholar. This search was particularly important in terms of returning publications in French. In addition, we searched Indigenous media sources, Treaty and community education reports, newsletters, and teacher professional development conferences using both databases and Google. (For more details please see Appendix A).

Circle of Advisors: A Circle of Advisors was identified early in the process. Members represent all regions in the country, and 10 of 13 Canadian educational jurisdictions. Both Indigenous and non-Indigenous, members are all well-acquainted with mathematics and science education in their own jurisdictions via their roles as Elders, local knowledge holders, scholars, teachers, and policy makers. The Circle of Advisors has reviewed and guided our work as it unfolds, as well as fed back into the work with connections to local initiatives which may not emerge via usual search processes. Two online group symposia have been held with the Circle to date. Circle Members will also play a role in dissemination of results and knowledge mobilization.

Limits/inclusion/exclusion: Chronologically, the search was limited to work published in the ten year scope from 2006-2017. Geographically, the search was limited to work being done in Canada. Inclusion criteria focused on work related to search terms. Sources outside mathematics, science, and STEM, or addressing education beyond K-12 and teacher education in those subject areas were not included in the final review.

3.3.2 Phase 2

Amalgamating work: Sources returned by searches were tracked in a spreadsheet that detailed bibliographic data. Each source was categorized as academic or grey, and further sub-categorized as a paper, chapter, video, etc. This list was shared with the Circle of Advisors and formed the basis for the first online Symposium held on May 17, 2017 (see Appendix B).

Fit and content review: Fit and review occurred in two stages. The first stage checked against limits and project focus. Sources found to be relevant were then more deeply read to ensure inclusion. Remaining sources were then summarized through the use of a Google form. Categories on the form were developed with a view to identifying themes, gaps, and promising practices. The form allowed for summarizing sources as well as identifying where work had taken place, who was involved in the work (e.g. students, teachers, Elders, etc.), the level at which work took place (e.g. elementary, secondary, post-secondary), methodology, etc. The form fed data to a common spreadsheet that then served as the base for deeper analysis and synthesis regarding themes, gaps and promising practices.

Data sources. Data sources for this work were the 333 sources identified from the search process described above. This original set was narrowed to 195 (32 grey sources and the rest academic) after review against limits and project focus.

3.3.3 Phase 3

Synthesis: Synthesis involved all team members, with project collaborators making decisions when there was uncertainty that required discussion. Weekly team meetings throughout Phases 1 and 2 had led to identification of potential emerging themes, gaps, and promising practices prior to deep review of results. These weekly meetings had also suggested potential initial codes for considering results as a whole. With completion of Phase 2, these pre-identified items served as a beginning point for synthesis. Results for each of the questions asked on summary form were exported to individual documents for coding. Multiple team members read each document. Additional codes emerged in the reading, and were added as they emerged. Where there was uncertainty regarding how to code particular pieces discussions were held in order to reach a decision. From this process a final reported was drafted and distributed to the Circle of

Advisors in advance of the second Symposia on September 1, 2017 (see Appendix C). Their feedback was then considered and incorporated into the final report.

4.0 Results

This review largely covers work undertaken prior to the publication of the TRC (2015d), and yet–with some exceptions, a few notable–the underlying ideas of reconciliation are traceable in the work taken as a whole. The review thus provides a base from which further and deeper thinking might develop, especially if the pieces that inform this review are reread in light of TRC recommendations. While we feel there is positive momentum in the national body, we caution that this recommendation is not a pathway to codifiying or building frameworks from results presented. In our experiences, even when such processes are well-intentioned, they lean towards recolonizing as opposed to opening up places and spaces where Indigenous and Western ways of knowing, being, and doing might circulate together. Instead, we advise constant questioning of what we think we know. In this way, it might become possible to find out what happens when:

- one way of knowing, being, and doing is not privileged as a starting place over the other,
- we do not try to fit things into existing frameworks or language
- we pay attention to what people are actually saying and doing in particular places and spaces.

We see distinct promise in work that occurs alongside Indigenous people, peoples, and communities and work that is initiated by Indigenous communities. Across results we highlight relationship building as the central point from which everything else flows.

While our results are based on both academic and grey literature, only the review of academic literature should be considered comprehensive. We nonetheless made the decision to keep grey literature within the review as a whole because:

1. It complements the academic literature. For instance, bodies of academic work associated with individuals or groups of researchers, often generate pieces within the grey literature that provide insight into relationships with specific nations, communities, and individuals. E.g. The Centre for Research in Youth, Science, Training and Learning (CRYSTAL) at the University of Manitoba has produced over 30 academic publications (e.g. Lewthwaite & McMillan, 2007; Lewthwaite, McMillan, Renaud, Hainnu, & MacDonald, 2010; McMillan, 2013) that fall within the scope of this review, along with online science teaching resources specific to Nunavut, the Northwest Territories, and the Yukon (University of Manitoba, n.d.).
2. It suggests that more work is occurring in some places than the academic literature indicates. For example, in Spring 2017 the Ontario Association for Mathematics Education (OAME) hosted a pre-conference e-conference which focused on First Nations, Métis, and Inuit initiatives in mathematics across the province. The full day event included more than a dozen sessions by educators who presented school based projects that are being supported largely by researchers in Ontario universities who have emerging interests in these areas. Much of this work is tied to provincial ministry initiatives (Ontario Ministry of Education, 2014).
3. It was one of the few places where work in French was evident.
4. It provides indications of relationships between people, peoples, and communities that are key to the work that is occurring, but often not evident in the academic literature. For instance, the research collaboration between Snively and Williams emerges from a long-term friendship that allowed them to build trust long before they did research together (Gillies, 2005).

We split results into two sections. The first section provides an overview regarding the who, how, and where of the work examined within the review. The second section is focused on the what and looks more deeply at the content of the work to present recurring themes and ideas.

4.1 Overview

Overall, the work considered within the limits of this review suggests commitment (at various levels) to examining ways in which Indigenous and Western ways of knowing, being, and doing might circulate together in science and mathematics teaching and learning, in both K-12 and teacher education, as well as the importance of relationship, place, and process to what is occurring in the Canadian context.

4.1.1 Who is publishing, and who is involved in the work: Relationship, bodies of work, time, and systematic challenges

There are more than 150 authors associated with the 195 publications reviewed in this report. From within this whole, there are identifiable bodies of work representing a clear majority of the contributions reviewed. These bodies are associated with individuals or research groups, both formally and less formally constituted. The groups do not exist in isolation, there are connections and conversations between most groups, not only in terms of theoretical engagement in the literature, but through deeply collaborative work that focuses on students (K-12 and in teacher education) in classrooms, and coming together to effect change. The bodies include:

- Work associated with the CRYSTAL at the University of Manitoba (e.g. Lewthwaite, 2007; Lewthwaite & Renaud, 2009), 1 of 5 national research groups through the NSERC CRYSTAL program that ran from 2005 to 2010.
- An informal research group involving the authors of this report and colleagues (e.g. Donald, Glanfield, & Sterenberg, 2011; Lunney Borden & Wagner, 2013; Wiseman et al., 2015) that was originally brought together through programming of the Native Access to Engineering Program (NAEP) which ran at Concordia University (Montréal, QC) from 1993 through 2006. The NAEP group acts as a central hub, particularly with respect to mathematics education. While members of this group, like Cynthia Nicol have their own bodies of work with colleagues beyond the NAEP group (Nicol, Archibald, & Baker, 2013), they also frequently collaborate with each other and have been key to ongoing conversations regarding the manner in which Indigenous and Western ways of knowing, being, and doing can circulate together at events such as the Canadian Mathematics Education Study Group (CMESG) (Doolittle, Lunney Borden, & Wiseman, 2011; Lunney Borden & Glanfield, 2016) and the Canadian Mathematics Education Forum (CMEF) (Sterenberg et al., 2010).
- Work by Cheryl Bartlett, Murdena Marshall, Albert Marshall and others (e.g. Bartlett, Marshall, & Marshall, 2012) facilitated through the Integrative Science program at Cape Breton University (CBU). This program was headed by Dr. Bartlett from 2001 to 2013 and closed upon her retirement. Michelle Hogue's (e.g. Hogue & Bartlett, 2014) work at the University of Lethbridge is informed by the work from CBU.
- The Aboriginal Knowledge and Science Education Research Project, a collaboration between Gloria Snively and Wanosts'a7 Lorna Williams (Snively & Williams, 2006, 2016) at the University of Victoria with support of the Government of BC that has run since 2005.
- Work by Glen Aikenhead and colleagues (e.g. Aikenhead & Elliott, 2010; Aikenhead & Michell, 2011) that extends his foundational work in science education and Indigenous ways of knowing, being, and doing (Aikenhead, 1996, 1997) to policy considerations (Aikenhead, 2006) and mathematics education (Aikenhead, 2017). Aikenhead's co-author, Herman Michell, also has a body of work of his own (e.g. Michell, 2012).

- Dawn Sutherland's work with colleagues (e.g. Sutherland & Henning, 2010; Sutherland & Swayze, 2012) undertaken within her role as Canada Research Chair in Science Education in Cultural Contexts that was established in 2006 and renewed in 2012.

In addition to these substantial bodies, there are a number of emerging bodies from more recent scholars whose work addresses the manner in which Indigenous and Western ways of knowing, being, and doing might circulate together in mathematics and science education (e.g. Elliott, 2009; Higgins, 2011; Russell, 2009).

These bodies of work are important not only in terms of their contributions to understanding, but also in terms of what they suggest regarding how we are coming to understand and what supports that process. Given the tension-filled history between Indigenous and non-Indigenous peoples in Canada, trusting relationships are at the heart of the process. One of the keys to relationship is time in which people are able to come to know and trust each other. Bodies of work thus largely emerge from long-term relationships that tend to pre-date any kind of research activity. In addition, much of the work emerges from Indigenous people, peoples, scholars, Elders, and communities, approaching university-based scholars (both Indigenous and non-Indigenous) who they trust to undertake community-based and -driven work that addresses locally identified needs. We note some systemic challenges to developing such relationships.

1. Funding contributes to sustained efforts in effecting real change for young people and educators in Canada. While, as in the case of the NAEP group, there are ways to build, sustain, and grow long-term community without formally instituted and funded partnerships, sustained funding facilitates the process and relieves burdens of ongoing search for monies. We note that given nearly 500 years of colonialism in what is now called Canada, even funding commitments in 5 year increments seem insufficient to redressing relationships. We also note that current funding structures do not allow for the time required to develop relationships. For example, while the SSHRC Partnership Engage grants are a welcome addition to the available sources, the 1-year timeline does not account for relationship building and collaboration that needs to occur on the ground before research can actually begin.
2. Successful partnerships need to involve both Indigenous and non-Indigenous collaborators. While such partnerships inform all of the bodies of work above, the Indigenous partners in such collaborations tend to be at the community level, rather than the university level. Such differences impact who can apply for research funding, who can act as Principal Investigator in research funding, authorship etc. The requirements of most funding agencies do not reflect deeply collaborative work where there is no PI, and work proceeds through consensus.
3. Most of the work we have reviewed is published by non-Indigenous scholars. This is not surprising given that proportionately there are fewer Indigenous students in mathematics and science programs that lead to specialization in mathematics and science education and subsequent advanced academic work in these areas. Additionally, if an Indigenous scholar is engaged in this work then the opportunity to publish is often delayed given other demands placed on Indigenous scholars as they enter the academy.

4.1.2 Where the work is taking place: Locatedness in terms of place, grade level, and dissemination

Just over 22% of the publications reviewed focus on projects or research located in more than one province/territory. Most of these pieces identify specific nations/groups, or people from specific nations/groups. While some of this multi-jurisdictional work offers comparison between jurisdictions (Kim & Dionne, 2014), almost none of it takes a pan-Canadian or pan-Indigenous approach, indicating that there is some understanding of the need to work within local contexts drawing upon the ways of knowing, being, and doing situated within specific cultural communities.

More than 50% of the publications reviewed represent work in 4 provinces: British Columbia, Alberta, Saskatchewan, and Nova Scotia (see Figure 1). There is little or no work evident in New Brunswick, the Northwest Territories, Prince Edward Island, or the Yukon. In some ways, the work in Western Canada can be correlated with larger populations of Indigenous peoples in these places. The work in Nova Scotia is linked to the existence of Mi'kmaw Kina'matnewey, and relationships built over time between MK communities and schools with particular post-secondary institutions in the province. Overall, the geographic distribution of work by province largely aligns with what is evident regarding locations of bodies of work associated with individuals and research groups.

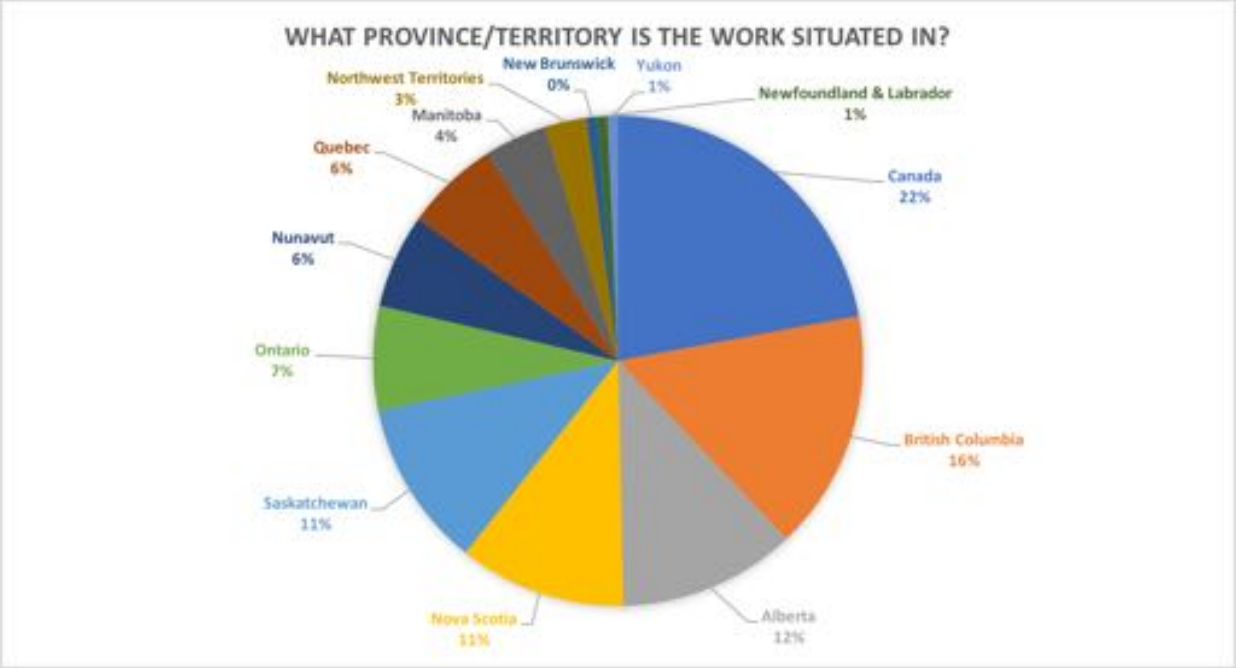

Figure 1: What province/territory is the work situated in?

Digging down into named Indigenous nations, larger bodies of work are situated within Inuit, Mi'kmaq, Cree, Blackfoot, and Haida communities. The Inuit work seems to be mostly situated in Nunavut and may point to projects emerging from the more recent establishment of the territory and the associated commitments to Inuit education; it is the only recent instance in the Canadian context where the emergence of an educational system could be examined as it develops. The Mi'kmaq work is rooted in capacities developed by Mi'kmaw Kina'matnewey, a regional management authority in Nova Scotia, as a result of jurisdictional agreements for education. Each of these larger bodies of work are primarily connected to research teams.

The pieces we examined overwhelmingly address K-12 generally or at specific grades/levels (particularly elementary and middle school). There is also identifiable work in the areas of post-secondary/teacher education and community-based/informal learning. Despite the work being located in settings where young people are the majority of participants, the work reviewed very much prioritizes the voices of adults (researchers, teachers, Elders/local knowledge holders, educational administrators) over those of students. Student voice is included in less than 10% of the pieces reviewed, more often, student experience is interpreted by teachers.

While we examined a broad range of publication types, in looking more closely at the academic pieces an interesting trend emerged: almost 80% of publications appeared in academic journals based in Canada. Of the few international journals listed, one was a special issue focused on Indigenous

mathematics education and co-edited by a Canadian. To be certain, there are multiple reasons that may contribute to this trend including the limits we have imposed on the review.

Overall, the work is located in specific places, with specific people, peoples, and communities (in both the academic and non-academic sense). In examining these locations, we note there is substantial room for growth of the work geographically, as well as in terms of levels of education explored and where developing understandings are shared.

4.1.3 How we are coming to know: Processes emergent

One key focus of our work was to determine how people are coming to know, inviting consideration of methodological approaches. The work we reviewed employed a wide variety of mostly qualitative approaches including case studies (e.g. Nolan & Weston, 2015), document analysis (e.g. Bechtel, 2016), and a variety of Indigenous Research methodologies (IRMs) (e.g. Beatty & Blair, 2015; Michell, 2012). The growing use of emergent methodologies (Hogue, 2014; Wiseman, 2016), processes named with words from Indigenous languages (Lunney Borden, 2010; Vickers, 2007), or working within existing IRMs/frameworks (Donald et al., 2011; Neel & Fettes, 2010) indicate people are trying to work beyond existing research rules/frameworks and instead paying attention to what emerges from a relational process of learning together and less on products or data. These bodies of work tend to situate Indigenous elders and knowledge keepers as essential in all aspects of the work; approximately one quarter of the pieces reviewed specifically included elder and knowledge keeper voices. While there are multiple ways of approaching the work presented in the publications considered within the scope of this review, we note there are very few authors who fundamentally challenge the idea that different worldviews should be considered together within mathematics and science teaching and learning.

Less than 30% of the sources summarized described the implementation of a program that engages Indigenous perspectives with mathematics and science with learners. Many of the academic articles focus more on theoretical considerations or reflections related to program implementation to explore future implications, rather than on describing the program itself. While these theoretical pieces can be helpful in advancing our collective understanding, the limited amount of research directly related to program implementation and the impact on student achievement and engagement was noteworthy.

Also noteworthy was how few of the pieces reviewed take a deficit approach to the work. Authors do underline the importance of addressing systemic issues such as the need for: ongoing teacher professional development (e.g. Berger, Johnston, & Oskieneegish, 2016) access to resources which support the coming together of Indigenous and Western ways of knowing, being and doing in science and mathematics teaching and learning (e.g. Blood, 2010); alignment of pedagogy and assessment (e.g. Kim, 2016); Elders in schools (e.g. Alfred, 2010); shifts in policy development to more collaborative structures where First Nations, Métis, and Inuit people, peoples, have a clear voice and authority (e.g. Aikenhead & Elliott, 2010). With a few exceptions, the majority of the work seems to be moving in the direction of considering how to work alongside Indigenous people, peoples, and communities, and what comes from building on strengths in place.

4.2 What we are coming to know: Recurring themes and ideas

The elements of relationship, process, and place identified in the overview are also present in the content of work reviewed. In fact, keywords associated with the work are more frequently ideas such as Indigenous perspectives/knowledges, worldviews, decolonization, land, place, and language, than mathematics, science, or STEM. This raises the question of whether mathematics and science are just the vehicles for relationship, process, and place, or perhaps, whether what we refer to in learning settings as mathematics and science are just some of the ways in which Indigenous people engage in process, place, and relationship. We do note, however, that in places where mathematics and science are more foregrounded, there is significantly more work related to science than mathematics. In general, in terms of

content there is a focus on the complexities of change and deep, meaningful transformation in teaching and learning. While we list recurring themes and ideas related to these efforts below, they should not be read in isolation of each other, but as an interconnected and interrelated whole.

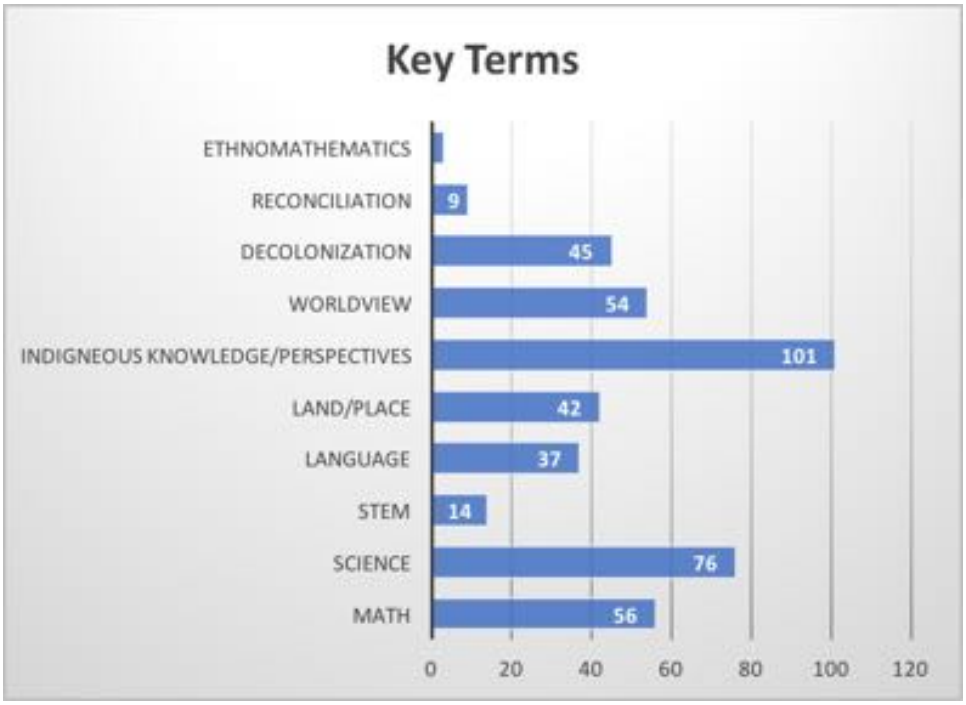

Figure 2: Key Terms appearing more than once

4.2.1 Culturally relevant education and ethical/cultural relationality

One theme clearly emergent within the review is focus on culture. A number of pieces demonstrated the benefits of culturally responsive/relevant education/pedagogy (CRE) (Ladson-Billings, 1992) in both mathematics and science. CRE tends to focus on pedagogy connected to students' social, intellectual, and political lives and areas of interest. CRE clearly has benefits by itself. For example, one 2-year study by Ezeife (2011) examined the implementation of a culturally responsive mathematics program in an Indigenous community school. Some students followed the CRE program while others were taught using a more standard mathematics program. While the students had similar initial mathematics performance, at the end of the intervention students who followed the CRE program significantly outperformed their peers who did not.

Some of the work draws on elements recognizable within CRE but aligns more deeply with what Donald, Glanfield and Sterenberg (2011) name as a culturally relational approach. Cultural relationality is more deeply tied to the ways in which researchers are in relation with community members and develop trusting, ethical spaces in which all members work towards shared understandings. This kind of work is embedded in more collaborative consensual processes where whole communities work to decide what is important in terms of focus and direction for research. While there are various kinds of expertise within cultural relationality–such as research, teaching, mathematics or science understandings–each type of expertise is important to the result and no one person or group of people is privileged over the other.

We note that while stand alone investigations or less established work seem to fall within CRE approaches, longer term projects tend to move more towards more culturally relational work.

4.2.2 Language

Another emerging theme centred on the complexities of language and its important role in teaching and learning. There was acknowledgement of the challenges related to learning in English (or French) for Indigenous students who may also be learning the language of instruction (e.g. Poirier, 2007) and the specialized jargon of mathematics and science (Hogue, 2012) within the work reviewed. At the same time, discussions of language tended to consider deeper issues of meaning and how language structures thinking. For example, the verb-based nature of Indigenous languages often stands in contrast to more school-based approaches to learning that favours facts over processes. In both mathematics and science the argument is made that the verb-based structure of Indigenous languages can be leveraged to support teaching and learning in these areas. Whether it is focusing more on motion and change in mathematics through what Lunney Borden (2010) called verbification, or drawing upon Metallic and Seiler's (2009) ideas of animating science, the key message is a need to focus on processes.

Such uptake of language suggests that in terms of having Indigenous and Western ways of knowing, being, and doing circulate together in mathematics and science teaching and learning it is better to focus on understanding processes and relationships between ideas as opposed to memorizing content. It also suggests that Indigenous languages may be more helpful in terms of student learning of complex ideas in mathematics and science, such as energy, that are presented in European languages as nouns, but are really ongoing processes of transformation and change.

4.2.3 Continual teacher learning/effort at all levels pre-service and in-service

The importance of teacher learning, not surprisingly, is emphasized in many of the pieces that were reviewed given that the majority of this work is focused on transforming pedagogy. Whether the pieces were focused on pre-service or in-service teacher education (e.g. Elliott, 2009; Wiseman, Glanfield, & Donald, 2012) or on other aspects of mathematics and science research (e.g. Mason, 2011), the message that teachers need professional development to support their understanding of and working with Indigenous knowledges in mathematics and science was a recurring implication in the work. Perhaps due to the large number of non-Indigenous teachers working in both public schools and Indigenous community schools, the key messages demonstrate a need to have teachers working with and learning from Elders and knowledge keepers (e.g. Iseke & Desmoulins, 2015) developing an awareness of community language and culture (e.g. Snively & Williams, 2006) and learning from land and seeing land as teacher (e.g. Harasymchuk, 2015). Yet it is also apparent from some pieces that there is a need to support Indigenous teachers in embracing and reclaiming these community ways of knowing within their math and science classrooms (e.g. Wiseman & Lunney-Borden, In press).

4.2.4 Unlearning colonialism and decolonizing

Given that nearly all people in Canada (Indigenous and non-Indigenous) have been educated in a system based on colonial assumptions about whose knowledge counts and is privileged, much of the work reviewed addresses issues of colonialism and ways in which it can be challenged or unlearned through schools. The approaches vary. What we would call decolonizing work tends to involve integrating Indigenous knowledges into existing curricula by focusing on Indigenous worldviews (e.g. Aikenhead et al., 2014), centering Indigenous practices as places for learning to begin (e.g. Belczewski, 2009), and/or drawing upon Indigenous ways of knowing, being, and doing to inform teaching and learning (e.g. Aikenhead, 2006). In these approaches discussion of relationships between mathematics, science, and European colonial expansion are often discussed.

Unlearning colonialism (D. Donald, personal communication, December 21, 2016), draws on the decolonizing practices listed above, but also tends to question fundamental assumptions of dominant educational discourses regarding what works in mathematics and science teaching and learning

preserves the colonial status quo (Wiseman, 2016). In this way, many of the larger bodies of work we identify focus on elevating rather than integrating Indigenous ways of knowing, being, and doing. For instance, the notion of two-eyed seeing (Bartlett et al., 2012) examines how Western and Indigenous understandings can be brought together on equal terms in science to emphasize how understanding is deepened and expanded by drawing on on both ways of knowing, being, and doing, rather than one or the other. In this way, unlearning of colonialism is not only about supporting non-Indigenous mathematics and science teachers in understanding Indigenous knowledge systems and teaching from within these perspectives, but also about supporting Indigenous teachers in drawing on cultural knowledge for teaching mathematics and science. The takeaway message from this particular theme is that people are fundamentally questioning the assumptions that underlie what it means to teach, to learn, and take up both these processes in terms of mathematics and science learning

While decolonizing and unlearning colonialism open up new possibilities within mathematics and science teaching and learning, among the work reviewed in which mathematics and science were mentioned, but not foregrounded, is another approach–beginning with Indigenous pedagogies (Goulet & Goulet, 2014; Marule, 2012; McGregor, 2012; Michell, 2012; Vickers, 2007). This work examines what it means to teach and learn in specific places, how language, land, and local ways of knowing, being, and doing can come together to frame the manner in which young people engage in and come to understand the world and the way it works. In these pieces, mathematics and science are not absent, but are embedded in the values and understandings of specific peoples and emerge in instances that are relevant to the issues at hand, effectively using the tools from Western math and science if they are deemed appropriate and effective (Doolittle, 2006). We suggest that such approaches move beyond decolonization as currently conceived, support thinking with respect to unlearning colonialism, and perhaps offer a viable means of addressing the challenge of the TRC (2015c) to “restore what must be restored, repair what must be repaired, and return what must be returned” (p. 6).

5.0 State of knowledge

5.1 Strengths

- The bodies of work do not exist in isolation, there are connections and conversations between most bodies, not only in terms of theoretical engagement in the literature, but through deeply collaborative work that focuses on students (K-12 and in teacher education) in classrooms, and coming together to effect change.
- Within the work there is a move away from deficit language to work focused on honouring Indigenous knowledges, beginning with Indigenous knowledges, and finding ways to collaborate so that one way of knowing, being, and doing is not privileged over the other. This move includes a broad commitment to work that occurs with and alongside Indigenous people, peoples, and communities rather than on Indigenous people, peoples, and communities.
- We note an ongoing shift in language to unlearning colonialism and considering what it means to foundationally question assumptions upon which the current educational systems (K-12 and post-secondary) are based.
- This an emerging body of work in pre-service and in-service teacher education. Within this work there is some indication that Indigenous and non-Indigenous ways of knowing, being, and doing circulate together more easily in open-ended inquiry projects where interesting questions arise and where mathematics *and* science might be necessary in order to consider the questions; that is where the context for learning comes first. We note that there is a need for more work in this regard, particularly at the K-12 level.

- While much of the work reviewed is reflective or theoretical, it reflects on and theorizes from mathematics and science education programs in place. That is, while the programs themselves are not described in detail, there are hints to promising practices noted in the literature that may generate possibilities for others seeking to engage in similar decolonizing work. This is particularly true at the K-12 level.

5.2 Gaps

- There is a limited amount of published literature directly related to program implementation, as well as the quantitative and qualitative impact on student achievement and engagement for programs that attempt to allow Indigenous and non-Indigenous ways of knowing, being, and doing to circulate together in mathematics and science education.
- While there is evidence of work being done in Indigenous communities around improving student performance in mathematics and science education (e.g. through programs such as INAC's First Nations Student Success Program), reports related to many of these initiatives were challenging to access.
- There was no evidence of longitudinal studies.
- There was little evidence of work related to an in-depth analysis of provincial and school district policies around Indigenous education and the impact that those policies might have on mathematics and science education in K-12 and in teacher education.
- There is little to no work evident in New Brunswick, the Northwest Territories, Prince Edward Island, or the Yukon Territory.
- There is no evidence of the impacts on mathematics and science teaching and learning if school systems shifted to giving priority to Indigenous worldviews and pedagogies.
- There is no policy analysis with respect to how Indigenous ways of knowing, being, and doing are evident in mathematics curricula.
- Student voice is largely absent in the work. Where student thinking is presented it is rarely direct and more likely to be interpreted by an adult (researcher, teacher, etc).
- There are very few studies which examine senior high school (Grades 10-12) levels of mathematics and science.
- There is a lack of work published in French.

6.0 Additional resources

For people looking to read more deeply within the topics presented in this review we suggest the following readings.

Policy

- Wiseman (2016), chapter 8, provides an analysis of provincial/territorial science education policy with respect to its positioning and uptake of Indigenous ways of knowing, being, and doing.
- Aikenhead and Elliott (2010) look specifically at the Saskatchewan context (with some reference to Nunavut) to outline the manner in which a shift in approaches to curricula development might occur.

Mathematics education

- Nicol, Archibald, and Baker (2010) focus on the literature regarding the underrepresentation of Indigenous students in mathematics and point to the promise of culturally relevant education as a means of addressing the issue.
- Aikenhead (2017) examines some promising practices in Indigenous mathematics education to inform policy around mathematics curricula development.
- The Show Me Your Math website, http://showmeyourmath.ca, highlights mathematics projects undertaken by Mi'kmaw students that examine mathematics in traditional and local contexts. It also includes a section of lesson plans and cross-curricular connections for teachers.

Teachers, teacher educators, and researchers

- Snively and Williams (2016) outline scientific knowledge and technological innovations of the Indigenous peoples who live in Northwestern North America, to provide science educators at all levels with numerous examples and cases for developing science lessons and curricula.
- Aikenhead and Michell (2011) similarly examine tensions and overlaps between Western Science and Traditional Ecological Knowledge in order to support pre- and in-service teacher engagement with Indigenous perspectives in science teaching and learning.
- Aikenhead et al. (2014) present how school science might be enhanced with Indigenous understandings given existing teacher practice and research.
- Donald, Glanfield, and Sterenberg. (2011) outlines the key tenets of cultural relationality.

Post-secondary

- The Integrative Science Program web site, http://www.integrativescience.ca, at Cape Breton University provides insight into how post-secondary science programs might be structured in a way that allows for Indigenous and non-Indigenous ways of knowing, being, and doing to circulate together in more advanced areas of science teaching and learning.

7.0 Knowledge mobilization

We split knowledge mobilization (KM) into 2 sections, KM already in progress followed by next steps in terms of broad KM and more specific lines of research emerging from consideration of results.

7.1 In progress

To date KM has focused on planning for publication and presentations in a number of venues, and to various audiences. We have also created the framework and introduction for a web site through which we will more publicly share results.

7.1.1 Publication and presentations

KM has proceeded alongside analysis and synthesis stages of the project through our individual teaching and research networks. Dr. Wiseman spoke extensively about the grant, its associated methodology and methods, as well as the approach to analysis and synthesis throughout her winter term qualitative research course, using it as a means of teaching graduate students about how research progresses, and raising awareness about Indigenous ways of knowing, being, and doing, in mathematics and science education in the Canadian context. She will also present results of the review to policy makers at Indigenous and Northern Affairs Canada on October 17, 2017. In addition, she has been

approached by a representative of the Ministère de l'Éducation du Québec (Anglophone sector) regarding the review; a call is being scheduled. Dr. Lunney Borden presented results at the IndigMEC Conference in Tromsø, Norway, September 4-7, 2017. This conference served as a gathering place for those working in Indigenous mathematics education globally and included a particular focus on work being done in Sámi, Maori, and Mi'kmaq communities. She will also discuss project results at the Saskatchewan Mathematics Teachers Society annual conference on October 23-24, 2017 and at the People for Education Conference in Toronto on November 11, 2017. With regard to reaching provincial ministries of education very initial conversations have been had with the Nova Scotia Department of Education and Early Childhood Develop and Treaty Education team to do a Fall 2017 sharing session on mathematics and science. Dr. Glanfield is attending the National Gathering of Elders in Edmonton, September 11-14, 2017 where she will bring results from our work to First Nations, Métis, and Inuit groups from across Canada. Dr. Glanfield is currently involved with the Alberta Education Curriculum ReDesign process; and will share this work with with provincial curriculum developers and policy makers.

Proposals have been submitted to the American Education Research Association (AERA), the National Association of Research in Science Teaching (NARST), and the National Council of Teachers of Mathematics (NCTM) for education-focused international research conferences to be held in spring 2018 (see Appendix D for example). Proposals are in preparation for two further conferences: TODOS: Mathematics for ALL, an international gathering of educators with a focus on diversity in mathematics, and the Canadian Society for the Study of Education as part of the annual Congress of the Humanities and Social Sciences. In addition, we have responded to a NARST call for a special panel to be held at the 2018 meeting highlighting work of people within its newest research interest group focused on Indigenous Knowledge and Science.

We have begun discussing the types of manuscripts that emerge from this work to identify open access journals and professional educator publications in which results can be shared. Similarly, we have begun compiling a list of policy conferences and professional educator events in order to reach a broader audience. In addition, on the advice of an RA from Brazil who feels this work would be of interest to people in South America, we are working to identify Spanish and Portuguese language journals/conferences for dissemination of results.

7.1.2 Web site

The introduction and structure for a website is in place, http://showmeyourmath.ca/comingtoknow/. We are currently discussing what raw elements of the review will be of interest to users of the site, and how best to migrate that information to a readable/searchable online format.

7.2 Next steps and future research

Future KM is aimed at disseminating results more broadly, and building on results of the review in terms of future research.

7.2.1 Next steps

In addition to the ongoing KM, we will apply for a SSHRC Connections grant to bring together mathematics and science educational researchers and practitioners from Indigenous communities, provincial ministries, and the not-for-profit sector. The purpose of this grant will be to develop research partnerships in order to further investigate the ways in which Indigenous and non-Indigenous ways of knowing, being, and doing circulate together in mathematics and science teaching and learning, in K-12 and teacher education. We anticipate that the SSHRC Connections grant will lead to the development of a proposal for a SSHRC Partnership Development Grant.

We intend to review results for key messages applicable to each of the stakeholder groups implicated in this review: researchers, post secondary educators and administrators, K-12 educators and administrators, and educational policy makers. Once the key messages have been identified, we will develop policy briefs and reports that directly address each stakeholder group. In addition, based on advice from the Circle of Advisors to reach out more broadly to the Canadian public, we will look to publish opinion pieces related to our results in key national venues.

Ideally, we would also like to talk with representatives of the Council of Ministers of Education Canada as nearly every jurisdiction across Canada is developing practices and policies related to addressing the TRC's recommendations (2015a). These ongoing processes might benefit from the results of this review.

7.2.2 Future research

A number of questions have arisen in through the process of review that we would now like to consider more deeply. For example, we have some indication that Indigenous and non-Indigenous ways of knowing, being, and doing circulate together more easily in open-ended inquiry projects where interesting questions arise and where mathematics *and* science might be necessary in order to consider the questions; that is where the context for learning comes first. And so, we wonder what it is about these contexts that is different and "more easy".

We have also noted many pieces focus on the importance of teacher learning and provide key insights into how this learning takes place. We wonder about the most effective ways to support non-Indigenous teachers as they come to understand Indigenous ways of knowing, being, and doing, and draw upon these understandings to transform their practice. We believe there is a need to research what effective professional learning might look like. We also wonder if the professional learning required for Indigenous teachers, who also learned mathematics and science in a colonial system, might be different.

While some policy analysis of science curricula with respect to Indigenous ways of knowing, being and doing is evident in the works reviewed, there is no such policy analysis for mathematics curricula. As provincial ministries mandate the inclusion of Indigenous perspectives across all content areas, clearly there is work to be done in mathematics curricula in this regard.

Culturally relevant/responsive education iss evident in many pieces we reviewed, we also note a shift to culturally relational education which considers more deeply the relational ways of working alongside community. We wonder about the implications for these two approaches for teaching, learning, and research, and believe future research needs to explore how people engaged in research learn to work together in more culturally relational ways.

Throughout the review we noted the prevalence of certain foundational, what we would call first oteratin, works that most authors were drawing on in order to develop more ecent work. We will be undertaken a citation analysis of academic literature in order to parse the impact of early work in the field more deeplu.

Some of the larger bodies of work are rooted in relationships that have been sustained over time where much of the work has emerged from community identified needs and concerns. We believe it is important to examine these bodies of work more deeply to identify the factors that have contributed to such sustained relationships and the lessons they offer for others who may be just beginning on this path. This sustained work provides insights not only about how partnerships are sustained but also about how they transform mathematics and science teaching and learning within these communities. Deeper study of these processes may provide insight into what works and why it works to answer the important question - What is the role of mathematics and science education in reconciliation? In addition, examination of these sustained bodies of work may help to address the question we are often asked

ourselves - what does it look like to have Indigenous and non-Indigenous ways of knowing, being, and doing circulate together in mathematics and science education?

8.0 Conclusion

Despite nearly 50 years of work since the publication of *Indian Control of Indian Education* (NIB, 1972), Indigenous and non-Indigenous peoples in this place called Canada are still very much engaged in a process of coming to understand how Indigenous ways of knowing, being, and doing might circulate together in education broadly, and in science and mathematics education more specifically. In listening to teachers, to colleagues, and to policy makers, we understand the urgency around the work that we do, but underline that doing the work in a good and relational way takes time. Given the history of the relationships between Indigenous and non-Indigenous peoples in Canada, and particularly given the history of education in those relationships as laid out in the TRC (2015d), there can be no short cuts. As a whole, this understanding is present in the work we have reviewed where research is emerging from relationships that, in some cases, have spanned decades. The importance of trust and respect, in ethically relational spaces that allow for knowledge to emerge, cannot be understated if the work is to be meaningful, impactful, sustainable, and transformational.

At the same time, by reviewing work from the last 10 years, we have not only Identified our own collective next steps, but also have noted areas where contributions are desperately needed. The review has solidified for us that there are indeed many promising practices happening across the country, and that people are engaged in the real work of reconciliation. These promising practices can lead the way for the rest of the country as they can give crucial insight into what it looks like in practice.

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Appendix A – Search and review guide

Search and Review Guide

How we are coming to know: Ways in which Indigenous and non-Indigenous ways of knowing, being, and doing might circulate together in mathematics and science teaching and learning

File naming (for when there are PDFs to keep)
With known authors
Author1lastnameAuthor2lastnameEtc_ThreeDescriptiveWordsFromTitle_Year

With organization name
OrgName_ThreeDescriptiveWordsFromTitle_Year

These go into Analysis>PDFs

Search guide
Use limits as described for both academic and grey lit searches

Search terms:

- Aboriginal, Indigenous, First Nations, Inuit, Metis, “First Nations, Inuit, and Métis”, Science, Mathematics, STEM, STEAM
- Teaching, Learning
- Land, language
- Decolonization, integrative science
- K-12, Elementary, Secondary, Teacher Education
- Canada

Limits for searches

- Time period: 2006-2017 (with some leeway)
- Geographical: Canada as a location for project AND research is Canadian
- Subject area limitation: Math and science, STEM, STEAM with the understanding that there maybe articles that do not fall in these categories that need further review, particularly those that point to how we do things are important

Sources

<u>Academic sources</u>

1. Dissertations and theses
    a. database search
    b. perhaps in outreach to people as well
2. Course syllabi
    a. online search
    b. outreach to people
3. Journals
    a. Database search
        i. SCOPUS

    ii. Web of Science
    iii. CBCA
    iv. Academic Search Complete
    v. Springer
    vi. T&F
    vii. Proquest
    viii. ERIC
    ix. JSTOR
    x. MathSciNet
4. Citation tracking
    a. By paper
5. Specific journals (if the aren't coming up in searches)
    a. CJSMTE
    b. Canadian Journal of Native Education
    c. Anthropology and education quarterly
    d. InEducation
    e. MFNERC's FirstPerspectives
    f. Journal of American Indian Education
    g. Mathematics Education Research Journal
    h. JRST
    i. Australian Journal of Indigenous education
    j. FLM-done
    k. Cultural Studies of Science Education - done
    l. RISE
    m. CJE
    n. Science Education
    o. Canadian Journal of Educational Administration and Policy
    p. Alberta Journal of Education
6. Search by key people (this list is not complete, but a place to start; again if they are not appearing)
    a. Karen Goodnough
    b. Kirk Anderson
    c. Jennifer Anderson
    d. Fiona Walton
    e. Cheryl Bartlett
    f. Michelle Hogue
    g. Kathy Snow
    h. David Wagner
    i. Andrea Belczewski
    j. Jrene Rahm
    k. Louise Poirier
    l. Beverley Caswell
    m. Annie Savard
    n. Joan Moss
    o. Liliane Dionne
    p. Ruth Beatty
    q. Astrid Steele
    r. Judy Iseke-Barnes
    s. Ann Kajander

t. Eve Tuck
u. Jean Paul Restoule
v. Barbara MacMillan
w. Dawn Sutherland
x. Brian Lewthwaite
y. Laara Fitznor
z. Gale Russell
aa. Edward Doolittle
bb. Kathy Nolan
cc. Hermann Michell
dd. Glen Aikenhead
ee. Marie Battiste
ff. Angelina Weenie
gg. Bonnie Shapiro
hh. Greg Lowan Trudeau
ii. Krista Francis
jj. Marc Higgins-
kk. Gladys Sterenberg
ll. Cynthia Nicol
mm. Gloria Snively
nn. David Blades
oo. Joanne Archibald
pp. Madeline McIvor
qq. Lorna Williams
rr. The math catchers (Melania Alvarez; Vesalyn Junik, Mark Mclean, Richard Guy; Kanwal Neel)
ss. Yvonne Vizina
tt. Paul Hart
uu. Frank Deer
vv. Leisa Desmoulins
ww. Sylvia Moore
xx. Glen Brocklebank
yy. Heather McGregor
zz. Maria Rodriguez de France
aaa. Julian Kitchen
bbb. Erin Hodson
ccc. Michelle Tanaka
ddd. Janine Metallic
eee. Florence G
fff. Robert Bechtel
ggg. L. Cherubini
hhh. Peter Cole
iii. C. Haig-Brown
jjj. Rob Regnier
kkk. Kathy Hodgson-Smith
lll. Harley Weston
mmm. Neel & Fettes

Grey lit sources

1. News and magazine articles
    a. Databases
        i. Canadian Newswire
        ii. Proquest Newswire - (Proquest has “the Canadian Newswire”)
        iii. CBCA has one too
2. Indigenous media
    a. People we know
    b. Online sources (google)
        i. Eastern Door
        ii. AMMSA
        iii. Windspeaker
        iv. Air Inuit magazine
        v. CBC Indigenous
        vi. Kukukwes.com
        vii. Muskrat Magazine
        viii. Wawaytay News
        ix. AP Trina Roach in NS local APTN
        x. Aboriginal Voices
        xi. Nunatsiaq News
        xii. Alberta Sweetgrass
        xiii. First Perspectives News
3. Reports and newsletters
    a. Organizations
        i. FNESC First Nations Education Steering Committee (Council), BC
        ii. FSIN Federation of Sk Indian Nations
        iii. MFNERC MB First Nations Education Reseach Centre
        iv. Treaty 6, 7, 8 organizations
        v. ITK Inuit Tapiriit Kanatami
        vi. FNEC First Nations Education Council of
        vii. FNESQC Quebec
        viii. MK Mi’kmaw Kina’matnewey (I’ve spelled that wrong)
        ix. Makivik
        x. FNER
        xi. Let’s Talk Science
        xii. Actua
        xiii. 7 Generations
        xiv. Indspire
        xv. Queen’s Aboriginal Access Program
        xvi. ENGAP UMan
        xvii. USask
        xviii. NAEP
        xix. PPW in education, a Martin family initiative
        xx. Indigenous education news
4. Social media (using same terms as on databases searches)
    a. Twitter
    b. FB
    c. Instagram

When you find something
Please search the file for the author/title to see if the entry already exists. You can do this by sorting column A from A-Z.
If not, enter it in Analysis>Potential Sources

If it is a resource list, children's book, text book - place a note with a link or reference in the Other Potential Sources File.

Review
When you are ready to review. Claim a piece from Analysis>Potential Sources

Step 1
- Skim title and abstract/summary
- Decide if it fits limits of grant
- If yes – proceed to step 2
- If no – Make note in Analysis>Potential Sources that indicates source is rejected
- If not sure – Make note in Analysis>Potential Sources that indicates source requires secondary review by Lisa, Dawn or Florence

Step 2-When you have something to review
The form for review can be found at
https://goo.gl/forms/tuBkLRSgmaZmVrSX2

Step 3
Repeat

Reading things
It may not be necessary to read every word of every paper if you read strategically. Here are some rules of thumb to follow:

1. Read the abstract and see what information you can gather from it. Often people identify who they worked with and where, or things like methodology in the abstract. The main take away should be present in a good abstract.
2. Read the introduction and Findings/Discussion/Conclusion of the paper. These sections should flesh out main ideas, if the abstract isn't clear.
3. If you can't find what people did or how they did it, look for sections called Methods/Methodology.
4. If you want an overall sense of the article quickly, and if there is information you can't identify, before committing to reading the whole thing read the paper through in its entirely by only reading the first and last sentence of every paragraph.
5. We are asking you to look at citations - you will start to recognize names and key pieces after you read 4 or 5 papers. You may want to start by looking at who the authors cite the most.

17-09-12

CIRCLE OF ADVISORS
SYMPOSIUM 1

How we are coming to know: Ways in which Indigenous and non-Indigenous ways of knowing, being, and doing might circulate together in mathematics and science teaching and learning

AGENDA

OPENING
COLLABORATE
INTRODUCTIONS
PROJECT BACKGROUND
OUR QUESTIONS TO YOU
DISCUSSION
CLOSING

Opening

CARLA BADGER

Collaborate

Introductions

Project background

- Knowledge Synthesis Grant (KSG)
  - Not original research
  - Systematic review/Meta-analysis aimed at exposing state-of-the-field
  - Requires dissemination
  - Intended to help frame work going forward

Project background

- Focus:
  How we are coming to know: Ways in which Indigenous and non-Indigenous ways of knowing, being, and doing might circulate together in mathematics and science teaching and learning

1

Project background

- Our goals
  - Mapping emerging themes
  - Identifying promising practices
  - Locating gaps in understanding

Project background

- Limits
  - 2006-2017 (SSHRC)
  - Within geographical boundaries of Canada
  - By people familiar with the context in Canada

Circle of Advisors

- A group of knowledgeable, experienced people with broad familiarity with what is going on in their own territories
  - examine the work-in-progress
  - provide direction in terms what is missing and what is coming together
- Particularly with respect to
  - How we are coming to know
  - Local, community-community based work that doesn't necessarily appear in academic literature

Are there academic references you would add?

Question 1

Where else might we find information about other projects, activities, etc?

Question 2

What other projects are you aware of (from your territory or others) that might not appear in academic lit?

Question 3


Other thoughts, suggestions, ideas...
What are we missing?


Mi'igwitch
N'ya weh
Thank you
Merci
Dawn Wiseman
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Florence Glanfield
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Lisa Lunney Borden
lborden@stfx.ca
And our whole team: Amy, Christine, Ellen, Katy, Mitch, Rebecca, Robbin, Simon

17-09-12

CIRCLE OF ADVISORS
SYMPOSIUM 2

How we are coming to know: Ways in which Indigenous and non-Indigenous ways of knowing, being, and doing might circulate together in mathematics and science teaching and learning

AGENDA

OPENING
COLLABORATE
INTRODUCTIONS
OVERVIEW OF REPORT
OUR QUESTIONS TO YOU
DISCUSSION
CLOSING

Opening

FLORENCE GLANFIELD

Collaborate

- Any questions

Introductions

Final Report Overview

- SSHRC Requirements
  - 1 page: Key messages
  - 3 pages: Executive Summary
  - 25 pages: report
  - Accessible language
- 25 pages include:
  - Context for the issue
  - Implications, high level to key audiences
  - Approach, methodology & methods
  - Results and how they support conclusions
  - State of knowledge, strengths and gaps
  - Additional resources
  - Knowledge mobilization
  - Conclusion

Final Report Overview

- SSHRC Requirements
  - 1 page: Key messages
  - 3 pages: Executive Summary
  - 25 pages: report
  - Accessible language
- 25 pages include:
  - Context for the issue
  - **Implications, high level to key audiences**
  - Approach, methodology & methods
  - **Results and how they support conclusions**
  - **State of knowledge, strengths and gaps**
  - Additional resources
  - **Knowledge mobilization**
  - Conclusion

1

Key points

THIRD ITERATION

OUR CHALLENGES IN WRITING REPORT

Results: Overview

- Looking at work as a whole
  - Who, where, how

Results: Overview

- Who is publishing and involved in work: Relationship
  - Bodies of work
  - Relationship
  - Time
  - Systemic challenges

Results: Overview

- Where the work is taking place: Place
  - Geographical
  - Levels
  - Dissemination

Results: Overview

- How we are coming to know: Emergent processes
  - Type of research
  - Shift away from established norms
  - Interventions

Results: Recurring themes & ideas

- Content analysis and coding
  - What (although process, place, and relationship are also in content)

Results: Recurring themes & ideas

- Issues of Indigenous perspectives/ knowledge, worldviews, decolonization
  - Math and science vehicle for relationship, process, and place?
- Science more present than math

Results: Recurring themes & ideas

- CRE and culturally relational education
  - Shift from one to the other

Results: Recurring themes & ideas

- Language
  - Really focused on issues of meaning and how it structures thinking/potential to approach teaching and learning

Results: Recurring themes & ideas

- Continual teacher learning
  - Pre-service, in-service

Results: Recurring themes & ideas

- Decolonizing & unlearning colonialism
  - Indigenous pedagogies

Within Results:
What should we move or highlight more/less?
What needs more/less explanation?

Questions 1

What are you take away messages?
What do you infer from results?
What are the implications for various stakeholders?

Questions 2

What are the strengths?
What are the gaps?

Questions 3

Who needs to know about this?
How should we reach out to them?

Questions 4

Other thoughts, suggestions, ideas…

What are we missing?

Mi'igwitch
N'ya weh
Thank you
Merci

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Appendix D – Sample conference proposal

NARST Submission: Indigenous ways of knowing, being, and doing in Canadian science and mathematics teaching and learning

Subject/Problem

Within Canada, education is a provincial/territorial responsibility. Since the turn of the century, the majority of Canadian provinces/territories have mandated integration of Indigenous perspectives across all subject areas K-12, including mathematics and science (e.g. Alberta Learning, 2002). More recently, the *Final Report of the Truth and Reconciliation Commission of Canada* (TRC) (2015), which examines the legacies of residential schools, laid out 94 Calls to Action aimed at redressing relationships between Indigenous and non-Indigenous people, peoples, and communities in Canada. The TRC identifies education as a key component in this project. As such, there is an ongoing conversation in the country regarding how Indigenous ways of knowing, being, and doing might infuse an education system that has been grounded in Western traditions. As science and mathematics teacher educators, our interest lies specifically in these subject areas.

The research upon which this submission is based is one of 28 projects undertaken within a Social Science and Humanities Research Council of Canada (SSHRC) Knowledge Synthesis Grant (KSG) cluster addressing the question: How are the knowledge systems, experiences and aspirations of First Nations, Inuit and Métis peoples essential to building a successful shared future for all Canadians? Within our specific project, we focus on ways in which Indigenous ways of knowing, being, and doing have been taken up in science and mathematics teaching and learning, in K-12 and teacher education, in Canada. The objectives of our project are:

- to summarize the state of the field through a systematic review of academic and grey literature published between 2006 and 2017;
- to map emerging themes, identify promising practices, and locate gaps in understanding from this body of work;
- to disseminate results as a means of supporting educators (at all levels), researchers, and policy makers as they work to address provincial/territorial mandates for integration and the Calls to Action of the TRC (2015).

Within the scope of this paper we report on results of the project.

Design/Procedure

Methodology. Methodologically, we frame the work as a systematic review (Gough & Thomas, 2016) informed by the tenets of Indigenous Research Methodologies (IRMs) (Kovach, 2009; Smith, 1999; Wilson, 2007). As Gough and Thomas (2016) report, systematic reviews within education frequently take on the methods/approaches of the studies on which the review is focused. Given that our report examines ways in which Western and Indigenous ways of knowing, being, and doing might circulate together in mathematics and science teaching and learning, in K-12 and teacher education, we find it appropriate to approach the work in a similar manner (Author 1, 2016). IRMs go beyond methods and methodologies to open up epistemological, ontological, and cosmological framings of research. Thus, in our work we attend to ethical relationality (Donald, 2009) and questions such as what relationships are present/missing/sustained/not sustained in the studies surveyed. Relationships in this sense are not solely about human interactions exposed within research, but also about the environment, place, and language(s) in which the research takes place. Thus, our approach attempts to attend to all those relationships which sustain life and living (Donald, 2013). We find such relationality allies well with what Gough and Thomas (2016) characterize as an Enlightenment (p. 87) approach to systematic reviews. This approach focuses on generating theory or explanation, and viewing research in an iterative fashion where all contributions are valued and lead to emergent understandings. While these commitments

inform the whole of this work, Gough and Thomas (2016) note that systematic review is a continuum from Instrumental to Enlightenment approaches, where methods often overlap. As such, we employ more instrumental approaches to establish limits and inclusion/exclusion criteria on the work.

Methods. Systematic reviews are generally structured around phases of work focused on the search strategy and limits (Phase 1), categorization and analysis of sources for fit and content (Phase 2), and synthesis (see results) (Gough & Thomas, 2016). Given our relational Enlightenment approach, the phases overlap and feedback into each other.

Phase 1: Search.

Much of the work we are interested in occurs at very local levels and does not make its way in to academic papers, so the overall search strategy was built to explore both academic and grey literature.

Search strategy: Searches were conducted through 11 databases including Scopus, ERIC, CBCA, and Érudit (a database that aggregates research published in French). Databases were chosen based on breadth of coverage as well as specificity to the Canadian context. Search terms were: Aboriginal, Indigenous, First Nations, Inuit, Metis, Science, Mathematics, STEM, STEAM, Teaching, Learning, Land, Language, Decolonization, Integrative Science, K-12, Elementary, Secondary, Teacher Education, Canada, in multiple combinations. We used the same terms to search 16 specific journals, e.g. *Research in Science Education*, because of their history of publishing articles relevant to the work. Given that the Canadian research community is relatively small and interconnected, we have a good sense of colleagues who are engaged in work in, with, or about Indigenous education. We ran their names (n=64) through Google Scholar. This search was particularly important in terms of returning publications in French. In addition, we searched Indigenous media sources, Treaty and community education reports, newsletters, and teacher professional development conferences using both databases and Google.

Circle of Advisors: Given the localness of much of the work we are interested in, some of the understandings we wish to access through this project are only located at the local level. As such, a Circle of Advisors was identified early in the process. Members represent all regions in the country, and 10 of 13 Canadian educational jurisdictions. Both Indigenous and non-Indigenous, members are all well-acquainted with mathematics and science education in their own jurisdictions via their roles as Elders, local knowledge holders, scholars, teachers, and policy makers. The Circle of Advisors reviews and guides our work as it unfolds, as well as feeds back into the work with connections to local initiatives which may not emerge via usual search processes. Members will also play a role in dissemination of results.

Limits/inclusion/exclusion: Chronologically, the search was limited in time by SSHRC which stipulated a ten year scope from 2006-2017 for reviews. Geographically, the search was limited to work being done in Canada as the question SSHRC poses is specific to that context. Inclusion criteria focused on work related to search terms. Sources that feel outside mathematics, science, and STEM, or addressed education outside of K-12 and teacher education in those subject areas were not included in the final review.

Phase 2: Analysis

Amalgamating work: Sources returned by searches were tracked in a spreadsheet that detailed bibliographic data. Each source was categorized as academic or grey, and further sub-categorized as a paper, chapter, video, etc. The spreadsheet was checked and sorted regularly to remove duplicates.

Fit and content review: Fit and review occurred in two stages. The first stage checked against limits and project focus. Sources found to be relevant were then more deeply read, to ensure inclusion. Those sources were then summarized through the use of a Google form. Categories on the form were developed with a view to identifying themes, gaps, and promising practices. They allowed for summarizing sources as well as identifying where work had taken place, who was involved in the work (e.g. students, teachers, Elders, etc.), the level at which work took place (e.g. elementary, secondary, post-secondary), methodology, etc. The form fed data to a common spreadsheet that then served as the base for deeper analysis and synthesis regarding themes, gaps and promising practice.

Data sources. Data sources for this work were the 333 sources identified from the search process described above. These original sources where narrowed to 195 (32 grey sources and the rest

academic) after review against limits and project focus. The aggregate spreadsheet then served as the primary source for analysis and synthesis from which results have emerged.

Results

Given the number of sources, and extent of the work, we highlight key themes, gaps, and promising practice in what follows. Details will be shared in the presentation.

Break down of sources. In the 163 academic sources there were: 93 journal articles, 23 dissertations/theses, 18 books or chapters, and 28 others sources (primarily conference proceeding and reports of various kinds).

We identified 16 bodies of work, clusters of research largely representing groups of scholars joined in formal and informal research networks. These bodies represent more than half of the academic sources. The prevalence of this work within the review points to the importance of sustained and sustainable relationships as key to developing understandings in what is an area of national priority.

Geographically, the work skews largely to the western provinces of Saskatchewan, Alberta, and British Columbia where Indigenous people form a significant percentage of the population. There are also clusters of work located in Nunavut and Nova Scotia largely emergent from the structure of educational governance in these jurisdictions.

Themes. A number of themes have emerged in the analysis. Issues of *decolonization* are taken up over a good portion of the work either explicitly or implicitly through questioning of the assumptions underlying Canadian science and mathematics curricula (e.g. Author 2, Author 3 et al., 2010) and pedagogical approaches to teaching and learning in science and mathematics (e.g. Poirier, 2007). There is clear identification of the importance of Indigenous *languages and land* as primary locations from which understandings about the world and the way it works emerge (e.g. Author 1, 2016; Author 3, 2010; Michell, Vizina, Augustus, & Sawyer, 2008). While *culturally responsive teaching* appears in work regarding delivery of programs or program change particularly in Indigenous communities or to Indigenous students/teachers (e.g. McMillan, 2013), the concept of *ethical/cultural relationality* (e.g. Author 2 et al., 2011) seems to define work that occurs alongside and with students, teachers, and communities.

Gaps. Teacher and teacher educator practice, as well as curriculum considerations appear frequently across the body of work reviewed. While some pieces report K-12 student comments regarding their experience of mathematics and science, most student voices were reported through teachers' interpretations. In addition, while about one third of the pieces report Elder involvement, the voices of parents and other community members are also noticeably absent.

There is a significant gap in work related to policy development and implementation that is somewhat surprising given that the recent impetus for integration of Indigenous perspectives in mathematics and science education emerges from policy. A noticeable exception here is work in Saskatchewan (Aikenhead, 2006; Aikenhead & Elliot, 2010; Aikenhead, 2017).

Another gap appears to be a lack of focus on promising practices at the K-12 level. Within the grey literature there are hints of interesting potential approaches, but even in these cases the focus is often on teacher professional development without follow up into the classroom.

Finally, despite anecdotal understanding that work related to Indigenous math and science education is ongoing in all Canadian provinces and territories, there is little published evidence of what that work looks like in Québec, Newfoundland, the Yukon, and the Northwest Territories. There is, in fact, a significant gap in terms work published in French, undertaken with Francophone teachers/students, or in Indigenous communities where French is the language of instruction.

Promising practices. There are some interesting promising practices in teacher education, both undergraduate (Author 1, 2016) and graduate (Hogue & Bartlett, 2014) and policy development (Aikenhead & Elliott, 2010). These practices tend to draw on the themes identified above.

In terms of research, we note that ethical/cultural relationality (Donald, 2009) offers an alternative to deficit approaches to educational actors or culture that are often active in research involving/related to Indigenous people, people, and communities, and/or their ways of knowing, being, and doing. This approach allows for the development of shared understandings regarding possibilities for generative teaching and learning.

Finally, with respect to research, we also note an emerging practice which requires confirmation via deeper citation analysis. It seems that many of the sources within the current review are drawing on the same, or similar bodies of foundational work for framing and contextualization. This foundation appears to emerge from previous iterations of work, largely by Indigenous scholars, originating with calls for Indigenous control of Indigenous education in the early 1970s (National Indian Brotherhood, 1972).

Contributions to the teaching and learning of science

Within the Canadian education context, there is a current urgency regarding this work given the national push to implement concrete responses to the TRC's (2015) Calls to Action. Schools, school boards, universities, and Ministries of Education across the country have established task forces and committees focused on reconciliation, and what that means in terms of teaching and learning. Our results have the potential to point these organizations in the direction of existing good work and suggest ways for engaging in the processes of reconciliation meaningfully within mathematics and science teaching and learning. Beyond the Canadian context, we note that other settler nations (e.g. Australia and New Zealand) are engaged in similar processes of attempting to redress relationships between Indigenous and non-Indigenous peoples. It is likely that some of the process and practices identified in this work may be useful to people in these places.

Interest to the NARST community

This presentation will be of direct interest to members of the NARST community who are members of the Indigenous Science Knowledge Research Interest Group established at NARST 2017. In addition, the presentation may be of interest to colleagues whose research includes or focusing on systematic reviews.