Learning Together about Culturally Relevant Science Teacher Education: Indigenizing a Science Methods Course

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Abstract

This paper captures our co-learning, two science teacher educators, about indigenizing a science methods course in Canada. A self-study was conducted in the context of a pilot bachelor of education program (IBED) for a group of Indigenous students, to engage ourselves in reflective conversations about transforming the curriculum of a science methods course and making it culturally relevant for pre-service science teachers. The purpose was to determine our tacit and personal knowledge, as it contributes to our understanding of inclusive science education practices. In particular, we focused our conversations on written reflection about the perceived effectiveness of pedagogies used by Saiqa, the first author, who was the course instructor. Karen, the second author and critical friend, carefully examined these reflective narratives and provided comments, which were then considered in the context of other course materials, to initiate an ongoing dialogue about culturally relevant teaching (CRT) as it relates to science teacher education. The findings are framed using an arts- based concept, a circle, to present our co-learning journey. This allowed us to connect our personal histories to our role as inclusive science teacher educators in the present, and to consider our future aspirations to indigenize our science methods courses.

Introduction

There was a long history of colonization and residential schools in Canada before the Truth and Reconciliation Commission (TRC) report came out in 2015 and verified the historical records of the serious harm caused to the Indigenous peoples, their cultures, and languages. The TRC report identified the growing crisis of Indigenous youth as a social justice issue, which is evident from their lower representation in post-secondary institutions and over-representation in Canadian jails and family services (TRC Report, 2015). One of the concerns of the TRC was that education had been used as a tool to enculture and assimilate Indigenous youth into the dominant Western culture. One of the reasons for this enculturation issue is a lack of cultural relevance of school experiences for these youth, pointing to the urgent reform needed in Canadian education to keep Indigenous youth in schools, a focus of the National Committee on Inuit Education—First Canadian, Canadian First (Inuit Tapiriit Kanatami, 2011). This reform should also include Indigenous ways of knowing in school science in Canada as well as other Indigenous-inhabited countries around the world (Michell, 2009). To implement the recommendations of the Truth and Reconciliation Commission (TRC),

professional learning needs of pre-service and in-service teachers about Indigenous perspectives in education should be a priority (TRC, 2015).

To accomplish the purpose of meeting the needs of teachers from Indigenous communities, there have been many Indigenous teacher education initiatives in Canada since the 1960s (for example, Yukon Teacher Program, The Nunavut Teacher Education, and Inuit Teacher Education Program). However, including Indigenous perspectives in mainstream teacher education is relatively new in Canada (Blimkie, Vetter, & Haig-Brown, 2014). The Association of Canadian Deans of Education (2010) emphasized the need for professional development opportunities for educators to understand and incorporate Indigenous content and pedagogies into their teaching. The Truth and Reconciliation (TRC) Call to Action 63 has particularly focused on the needs related to teacher education, and emphasises that teacher education programs should prepare teachers who understand Indigenous issues and appreciate other cultures, specifically the Indigenous cultures in Canada. Teachers need to be able to keep K-12 Indigenous learners in the classroom while helping other K-12 learners to maintain "inter-cultural understanding, empathy, and mutual respect" (TRC, 2015, p. 7). This TRC call to action has implications for science education and initial science teacher education. Pedagogy and practices need to be adopted to create K-12 science curricula that are culturally relevant for all students. Likewise, science teacher education needs to prepare teachers who can effectively integrate Indigenous cultures, issues, and ways of knowing in their science teaching.

This paper reports on self-study research conducted in the context of a pilot teacher education program for a group of Indigenous students from communities in Canada. We describe our co-learning as science teacher educators regarding culturally relevant science teaching and how we decolonized our teaching to indigenize a science methods course. The following research questions guided our learning in three main areas: course instructor learning, critical friend learning, and course modifications.

- Instructor learning: What does the course instructor (science teacher educator and first author) learn from a methodical examination of reflective narratives on practice?
- Critical friend learning: What does the critical friend (science teacher educator and second author) learn from the methodical examination of reflective narratives?
- Course Modifications: What course elements and strategies are effective in indigenizing a science methods course?

Theoretical perspectives

This self-study research was influenced by two theoretical perspectives: (i) Two-Eyed-Seeing; and (ii) culturally relevant teaching (CRT). The Two-Eyed-Seeing principle provided a vision to infuse Indigenous perspectives within the science methods course offered to IBED students, while CRT provided a framework to analyze the data.

Two-Eyed-Seeing

Two-Eyed-Seeing is a guiding principle for integrative science that means "to see from one eye the strengths of Indigenous knowledge and ways of knowing, and from the other eye with the strengths of Western knowledge and ways of knowing" (Institute for Integrative Science & Health (IISH), n.d.). In a classroom setting, this principle values diverse worldviews and promotes a common

ground for learning "where one does not have to relinquish either position but can come to understand elements of both" (Hatcher, Bartlett, Marshall, & Marshall, 2009, p. 141) by allowing the best of both worlds to co-exist, merge, and flourish. We considered concepts, approaches, and challenges involved in integrating Western science with Indigenous cultural knowledge. Applying the Two-Eyed-Seeing principle by connecting the best of two worlds allowed us to avoid knowledge domination and potential assimilation of pre-service science teachers (PSTs).

Culturally Relevant Teaching (CRT)

In this study, we relied on Gay's (2010) conception of CRT, and the characteristics of CRT (5Rs and 1T) by Garcia (2005) to examine our learning. Gay (2010) conceptualized CRT as "using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them" (p. 31). Gay also claimed that this type of teaching, through relevant cultural filters, may improve the achievements of diverse students (Gay, 2013). Ladson-Billings (1995) introduced the term *culturally responsive teaching* and defined it as identifying and using students' cultural references throughout their learning experiences. Respect for and understanding of *difference* is the foundational principle of CRT.

Characteristics of CRT.

Garcia (1996) presented six essential characteristics of CRT as 5Rs and 1T, which include: (i) respect, (ii) responsiveness, (iii) responsibility (iv) resourcefulness (v) reasonableness, and (vi) theory. *Respect* (R1) means showing respect for the culture that students belong to and valuing the knowledge background and worldview they bring to the classroom. This can provide a sense of belonging to students and help them stay in school and progress. Respect can also lead to a better relationship between students and teachers, leading to better engagement. *Responsiveness* (R2) describes the ability of teachers to familiarize themselves with the cultures, knowledge backgrounds, and worldviews of their students and adapt their teaching accordingly to optimize their students' learning. *Responsibility* (R3) entails the realization of a teacher regarding any disadvantages and achievement gaps that their students might have experienced, their understanding of the reasons that contribute to these gaps, and showing a commitment to minimize these gaps through their teaching. From the CRT perspective, responsibility also demands staying away from "deficit models" and avoiding lowering standards for diverse student populations. *Resourcefulness* (R4) includes gaining access to financial, logistical, and intellectual resources that the teacher can use to engage students and eventually help them to be successful. Garcia (2005) valued intellectual resources over others, and considered financial resources as only providing professional development for teachers to have more access to intellectual resources to teach their diverse students. *Reasonableness* (R5) requires a teacher to be realistic and reasonable with their expectations, teaching strategies, and assessment tools. A reasonable teacher will carefully and thoughtfully design curriculum experiences that diverse students can make sense of and respond to. *Theory* (1T) includes "conceptual and theoretical approaches" to learning and teaching to engage all students. Research-based pedagogies should be considered for planning and teaching, resulting in science teachers becoming facilitators of learning while using student-centered, inquiry-oriented approaches to teaching.

Methodology

Context of the Study

The context for this self-study was a science methods course offered in a pilot Bachelor of Education (IBED) for a group of 17 Indigenous students in Canada who belong to and wish to serve their communities as primary/elementary teachers. The IBED program is a 150-credit-hour integrated four-year program of study that includes two supervised school placements (internships). The first year of the program was the preparatory year, where teacher candidates completed 30 credit hours (10 courses including mathematics, psychology, science, and learning strategies) to be fully admitted to the program. In the second year, the teacher candidates completed introductory education courses (e.g., child development, teaching in the Labrador setting, teaching in specific subject areas), non-education courses (Inuktitut Language and selected humanities courses), and two weeks of an introductory internship. In the third year, the teacher candidates completed education courses (e.g., exceptional learners, technology, science methods, non-education courses such as Inuktitut Language and selected humanities courses). In the last year, they are completing education courses (e.g., children's literature in Indigenous contexts) and non-education courses (Inuktitut Language and selected humanities courses, such as Law & Society; Indigenous people and Colonialism; Folklore in Education), and a 12-week internship.

The science methods course was offered during the third year of the IBED program (Winter 2017), and was similar to the course that is offered in the mainstream primary/elementary Bachelor of Education Program in the Faculty of Education.

Research approach

Self-study, which "promotes intersections between pedagogy, self, and reflections" to generate meanings about a phenomenon (Ragoonaden, Sivia, & Baxan, 2015, p. 3), was employed. While its meaning may vary, it is usually self-initiated, aimed at improving practice, interactive in nature, includes multiple qualitative methods, and operates on the basis of trustworthiness (LaBoskey, 2004). Self-study allows teacher educators to be critical and reflective of their pedagogical practices and helps them to understand and support teacher candidates as they learn to become science teachers. Self-study is a venue for the propagation of teacher educators' collective efforts as they engage in the scholarship of teaching and learning (Loughran & Russell, 2002). Craig (2006) noted that self-study has many facets and can be conducted in multiple educational contexts.

According to Loughran (2006), "there is no one way, or correct way, of doing self-study. Rather, how a self-study might be done depends on what is sought to be better understood" (p. 15). Borrowing the ideas of Loughran and Northfield (1996), we view self-study as "an extension of reflection on practice, with aspiration that goes beyond professional development and moves to wider communication and consideration of ideas, i.e. the generation and communication of new knowledge and understanding" (p. 15)

In this self-study research, Karen was a critical friend who provided an alternative lens to examine diverse perspectives, asked stimulating questions, contributed data through her alternative lens (Kallick, 1993), and was an advocate for promoting Indigenous perspectives within science education (Costa & Kallick, 1993). We engaged in the self-study with a purpose "to develop new insights and perspectives that can challenge and strengthen [our] own work" as inclusive science teacher educators (Berry & Russell, 2014, p. 195).

Participants

The participants in this self-study were two science teacher educators, Saiqa and Karen, the authors of the paper. To generate meaning and support each other's professional learning about CRT, we engaged in dialogue and reflective exchange to learn from the practice of one participant as an instructor of the science methods course offered in the IBED program to a group of Indigenous PSTs.

Data collection and analysis

Saiqa reflected critically on the process of (re)designing and modifying the science methods course, and created six lengthy reflective narratives (RNs). Karen, the second author, as a critical friend, provided feedback and comments on these reflective narratives. Then, we both examined this feedback to initiate and carry out dialogue about CRT as it relates to science teacher education. Curriculum materials related to the science methods course for the IBED program were also a source of data. The data were analyzed using the six characteristics of CRT (respect, responsiveness, responsibility, resourcefulness, reasonableness, and theory) as themes, to highlight the effectiveness of using different culturally relevant learning experiences to engage PSTs.

Findings

Despite cultural differences within Indigenous communities and groups, the image of a circle is used to "symbolize wholeness, completeness, and ultimately wellness" and represents "the synergistic influence of and our responsibility towards the generations of ancestors, the generation of today and generations yet to come" (Archibald, 2008, p. 11). The circle in Indigenous thought represents learning as never-ending and lifelong process which occurs in a cyclic way. To present our learning as a journey in this self-study research, we used an art-based cyclic view presented in Roy Thomas' art series 'Time and Life'. This unique framework has been used in research for analyzing PSTs' learning (Blimkie et al., 2014) and to situate researchers and reveal their identity (Clarke, 2015). Using this framework (Figure 1), we present our journey of learning together to decolonize our science teacher education practice, and to indigenize our science methods course.

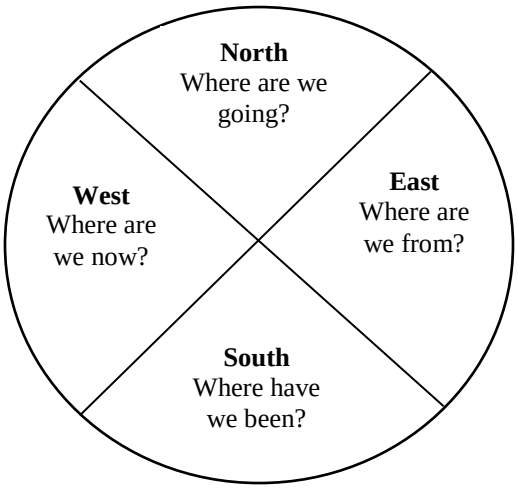

Figure 1: Framework to represent our journey to indigenize a science methods course

1. Eastern direction: Where are we from?

We begin our journey of learning by knowing and accepting our own diversity and examining our own identity, as suggested by Nieto (2010). In this section, we describe the foundations of our cultures, languages, and homelands to explain the context from which our knowledge and practices of teacher education emerged and to reveal any personal biases that may have influenced our learning in this self-study. We disclose our past experiences to make sense of our present reality and to shape our future identities as inclusive science teacher educators.

Saiqa:

> *My name is Saiqa Azam, and I was born and raised in Pakistan, a land with enduring symbols of colonization, which I was never able to comprehend fully till the time I moved to Canada and came to know the Aboriginal people of Canada. The stories about the loss of Indigenous languages and cultures made me realise the humiliation of my mother tongue, and I was able to recognise and acknowledge the influence of English on our national language. This is still astonishing to me, as to why it took such a long time for me to understand the impact of colonization on generations of Pakistanis. While teaching in the IBED program, on my way to reconciliation, I was able to liberate my colonized inner self and accept new meanings of decolonization.*

Karen:

> *My name is Karen Goodnough, and I was born in Newfoundland and Labrador (NL), Canada and have spent most of my life in NL. I grew up in a White neighborhood and all of my friends, throughout my school years, were similar to me - White and from a lower socioeconomic background. Issues related to diversity, equity, and inclusion and schooling only became a priority for me as I prepared to become a high school teacher in the mid 1980s. I recognise my privilege, having had access to educational opportunities that are denied to many others in life.*

2. Southern direction: Where have we been?

Next, in the Southern direction, we describe our prior engagements with inclusive science education, our efforts to learn about Indigenous cultures and ways of knowing, and how they have shaped our teacher educator identities.

Saiqa:

> *I had learned a considerable amount about the Indigenous peoples of Canada and their perspectives through taking a few courses, attending conferences, as well as multiple readings and peer discussions. While planning for the science methods course for Indigenous PSTs, I recognised that I still had a lot to learn. Embracing the principle that "not knowing is an opportunity for learning" (Vetter, Blimkie & Haig-Brown, 2014, p. 306), I found myself eager to learn more about specific Indigenous groups, because my knowledge about Indigenous people was not specific enough to help me adapt my teaching to their ways of knowing. I recognised the gaps in my learning despite my efforts over the last few years. My current 'place' was different, and my prior learning was limited in its help in my new context of creating new opportunities for learning and affirming the importance of "place" in learning. After creating small opportunities for PST to learn about Indigenous perspectives, I feel I am empowering them not only to challenge their personal biases, but also ones which may exist in their future classroom and schools in a systematic way.*

Karen:

> *Over the last three to four years, I have pursued opportunities to develop more insight into inclusive practices and Indigenous perspectives. I have always, in my modeling of inclusive pedagogical approaches for PSTs, focused on inquiry-based, experiential teaching and learning; differentiated instruction and assessment; and problem-based learning, to name a few approaches. Through more recent individual readings and workshops, I have become more knowledgeable about Universal Design for Learning and how it may be used to help all students gain access to the curriculum. Likewise, I have completed readings, attended a workshop, and completed a course on Indigenous perspectives. It has allowed me to delve deeper into the complexities of Reconciliation and to examine ways to decolonize my own thinking.*

3. Western direction: Where are we now?

In this section, we orient ourselves in the present and review our understanding about CRT that has emerged as a result of our conscious engagement with learning about Indigenous perspectives in science education through RNs based on experiences of teaching in science methods to a group of Indigenous prospective teachers. Using Garcia's six characteristics of CRT (5Rs-respect, responsiveness, responsibility, resourcefulness, reasonableness, and 1T-Theory) as an analytical framework, we present an analysis of the data.

R1 - Respect

Showing respect is one of the characteristics of CRT, which has been agreed on by Indigenous and non-Indigenous scholars. Therefore, showing and infusing respect for Indigenous cultures and perspectives was at the forefront of the science methods course for our IBED students. The following is an example of demonstrating respect for Indigenous ways of knowing by using the talking circle for relationship-building purposes and to learn about the students (RN #1, 'Building Relationship')

> *Being different, whether as a student or a teacher, has a unique significance for planning and teaching science. The "difference" that I possessed regarding language, culture, and heritage never inhibited me as a teacher or teacher educator. . . . [However], I generally never get into deeper conversations about my cultural background. I started wondering: do I even care about my cultural background? I came to believe that using the idea of 'colonizer vs. colonized' was reasonably appealing and worth a try. So, the very first day of the course [during the talking circle], I introduced myself in a very different way than in my regular classes. The first time, instead of showing a strong accomplished woman, I showed my vulnerable side, my true self - a person whose ancestors were colonized and who was impacted by the perpetual effect of colonization, particularly loss of language and overemphasis on a foreign language, English. These deep-rooted aspects of my personal history provided a new dimension to my identity as an inclusive science teacher educator.*

Karen, the critical friend, selected the above segment to respond, challenge, and clarify the thoughts that have influenced my practice. In here words:

> *I really think it's important to build community at the beginning of a course and you were very conscientious about doing this. You showed your vulnerable side; I think this takes a lot of courage and many professors might not be willing to do this. Sharing your personal experiences and life history with the students can be risky. . . . It seemed the PSTs were very comfortable with sharing their histories, beliefs, and perspectives. Positioning yourself as*

> *one who has been ''colonized' like the students in this class really helped to make that connection – border crossing in terms of you being an outsider. You were showing them that you understood and appreciated their culture.*

The above dimensions of our learning reveal our understanding of the importance of community building as a strategy to engage learners, as we realise that community-building practices should be planned carefully, and should particularly take into consideration linguistic and cultural differences.

R2 - Responsiveness

Being responsive towards their culture is key to engaging students from diverse cultural and linguistic backgrounds, and therefore, responsiveness has been considered an important characteristics of CRT. This characteristic of CRT has been acknowledged as a condition of learning for African-Americans (Gay, 2010) and English language learners (Garcia, 2005). Similarly, cultural relevance has a special place in Indigenous pedagogies, and needs to be infused within science education curriculum (Aikenhead, 2001). Cultural knowledge and ways of knowing should be goals of science education, inform pedagogies, and be part of our assessment practices. Excerpts from a reflective narrative written by Saiqa highlight the importance of open-mindedness in understanding other cultures:

> *I decided to use talking circles in my science methods course due to it being relevant for the IBED student teachers. Talking circles are used as a cultural tool for sharing, discussion, and decision-making in various Indigenous groups in Canada. The purpose was twofold: learning about my students through the use of their culture, and acknowledging the usefulness of this as a pedagogical tool. I was trying to be respectful of Indigenous culture and trying to connect with my students in order to build meaningful relationships and to share a teaching and learning space in this course. To me, this was being a culturally responsive teacher.* (RN#1)

Karen, the critical friend, selected the above segment to respond to, challenge, and clarify the thoughts that have influenced Saiqa's practice.

> *Being responsive in this way aligns with how many Indigenous Peoples are recovering and reaffirming the validity of their own cultures. From my reading of the research, teachers and schools who support and nurture children's culture foster more positive learning outcomes for their students. Engaging future teachers in these types of CRT activities can help them see that Indigenous Peoples were engineers and scientists and functioned in highly organised, skilled societies.*

One of the important aspects of culture is its language, which is a tool for learning. For bilingual learners, knowing their language is helpful to show respect to their language and culture, and can also provide relevance. Here is an example of a strategy that Saiqa used to connect with PSTs through language.

> *Language is another significant cultural tool which I believe can also help in building relationships. I started my class by saying Ulukut ('Hello' in their language) to students entering the classroom, a word that I learned from a friend. With some doubt in their eyes, they were probably trying to judge my cultural background. Later in the course, we had the usual language exchanges, where in my language I would share a word parallel to an English word, and similarly, they would share the parallel word in their language.*

> *I think that besides just being a fun activity, we were showing respect for various languages and acknowledging the value of each language as well as language's place in cultures and individuals.*

Karen responded to the above segment to highlight the importance of valuing other cultures and languages in the classroom in the process of decolonization.

> *Showing respect for someone's culture and language is a way to connect with them on an equal basis, dismantling any power dynamics. I think this is a key to decolonization when teaching in cross-cultural settings. I really like the language strategy that you used; sharing your first language with them and likewise, they were sharing their first language with you.*

The above dialogue reinforced the idea that decolonization can happen through learning and appreciating other languages. Through this cultural responsiveness, knowing other languages and using them in instruction in an appropriate way can help engage science learners, as well as future teachers.

R3 - Responsibility

In a cross-cultural setting, a teacher has a responsibility to recognise any achievement gaps and realise the disadvantages their students may have with regard to other students. Teachers need to counteract these detriments though responsible pedagogies that reflect an understanding of the deep issues causing these inequalities. One major issue leading to achievement gaps is the lowering expectations for students with specific cultural and linguistic backgrounds, which underpins dispositions of "deficit models" that lead teachers to think that a group of students might not be able to learn or excel in certain subject areas. Culturally responsive teachers show a commitment to minimizing achievement gaps by keeping their expectations the same or higher for culturally diverse students, and ensuring "rigor" in their courses while providing consistent support and mentorship to students to become successful in their lives and careers.

The goal of science education in Canada is to develop the scientific literacy of K-12 learners (Council of Ministers of Education, Canada, 1997). Scientific literacy is one of the pivotal topics in science education, and Saiqa emphasized this in her science methods courses. Criticising school-taught science as representative of the dominant culture, Mckinley (1996, 2000) noted the absence of Indigenous perspectives in science curricula and found that science teaching was lacking in Indigenous pedagogies. He argued that existing science curricula, authorised through the Pan-Canadian framework and aimed at developing scientific literacy among young Canadians, fail to acknowledge the "aspirations of local [Indigenous] communities along with their knowledge, ways of coming to know, values, and beliefs as thoughtful and purposeful cultures" (Lewthwaite, McMillan, Renaud, Hainnu, & McDonald, 2010, p. 6). Here is an excerpt from RN #2, written by Saiqa, which focused on introducing the topic of scientific literacy to the prospective Indigenous science teachers in a responsible manner so that it is rich and authentic.

> *This question kept my mind engaged: How do I introduce the topic of scientific literacy as well as acknowledge Indigenous science knowledge and Indigenous ways of knowing? I kept searching for ways to make this topic relevant for IBED students, and eventually came across a video titled 'Qulliq', the Inuit word for 'oil lamp', which is part of the Indigenous culture and heritage. This video presents two Indigenous women on the land preparing a Qulliq lamp and sharing their traditional knowledge about related science and technology ideas. Using video analysis, I decided to provide a framework for the characteristics of a*

> *scientifically literate person, and then asked my student teachers to think critically and evaluate whether the women in the video were scientifically literate. I also asked them to provide reasons to support their responses*. (RN # 2)

Karen responded to the above segment of the RN, initiating a dialogue about CRT and student engagement.

> *What a wonderful learning activity to examine the tenets of scientific literacy, while honouring Indigenous science and traditional practices. I look forward to hearing about how the students responded to the activity? Had any of the students experienced lamp making themselves? What questions did the student raise?*

Our dialogue enriched our understanding of maintaining rigor in our courses with diverse students, by carefully selecting learning experiences that carry cultural relevance for the learners. We felt committed to avoiding deficit thinking about students from other cultural and linguistic backgrounds.

R4 - Resourcefulness

Being a resourceful teacher is a precondition for being culturally responsive. Teachers needs to gain access to intellectual resources that they can use to engage students and eventually help them to be successful. Having access to financial and logistical resources may sometimes be needed in order to gain access to intellectual resources such as relevant professional development. Saiqa revealed her resourcefulness, which is evident in the following excerpt from RN#4.

> *The issue of the local hydro-electric project was fresh and important for the IBED students, as some of them had been involved in the protests. So, I decided to use this issue to engage the IBED students and to help them understand the socio-scientific approach to science teaching. . . . I selected a recent research paper, published in Environmental Science and Technology in November 2016, titled Future Impacts of Hydroelectric Power Development on Methylmercury Exposures of Canadian Indigenous Communities, which was authored by a group of Harvard University scientists, Ryan Calder, Amina Schartup, Miling Li, Amelia Valberg, and Prentiss Balcom. This was the first paper that provided some evidence of the possibility that the Muskrat Falls project may result in methyl mercury in the water, causing danger for humans, the fish they rely on for food, and the overall environment. The paper included complicated scientific ideas like the statistical methods used to project the ratio of peak methylmercury (MeHG) enrichment as compared to the baseline values, which were quite complex.*

Karen responded to Saiqa's resourcefulness as an instructor, as well as the role of examining science through an STSE lens:

> *Capitalizing on relevant and current STSE issues provides a context to help PSTs and K-12 students make connections to many ideas that can impact society. This ongoing issue, situated in the backyards of the IBED PST, was highly relevant and helped them explore the complex set of relationships that exist amongst many groups in society. And, more importantly, it may have allowed them to examine how traditional Indigenous Knowledge and Western science interact.*

Despite her resourcefulness, Saiqa also discussed a lack of it in RN#6. Regardless of acknowledging the importance of resourcefulness, she was unable to bring a knowledge keeper (Elder) to her

classroom. We need to establish collaboration with local Indigenous organizations and Elders, so that we can offer authentic learning experiences to PSTs.

R5 - Reasonableness

Family structures, responsibilities attached to family and extended family members, and emotional ties within families and communities vary from culture to culture. Similarly, PSTs' work-related schedules also sometimes differ based on their opportunities to work with certain communities. Culturally responsive teachers need to be realistic and reasonable with regard to expectations, teaching strategies, and the assessment tools available. From this perspective, a reasonable teacher will carefully and thoughtfully design curriculum experiences that diverse students can make sense of and respond to. In the following excerpt from RN #5, Saiqa shared her thoughts and efforts to provide options for the representation of new learning for IBED students that can fit into their busy and family oriented life-styles.

> *I also decided to be more inclusive regarding students' representations of their learning. I have been engaged in inclusive teaching practices and started challenging the written format for assessment evidence, and I started being more open to accepting another form of representation of knowledge as acceptable evidence of their learning. So, one big change [in course assignment] was to accept audio and video recordings, art, or a combination of any of these forms, as an acceptable form of assignment submission in addition to writing up an assignment.*

Karen responded to the above segment and shared her ideas around Universal Design of Learning (UDL) as a means to provide differentiating instruction and assessment to our science learners.

> *Like you Saiqa, I have been incorporating this notion into my courses. I want to provide a range of options for students to represent their learning. It could be traditional formats, multimedia formats, performances, etc. Also, I am experimenting with letting students design their own assessment tools. This aligns with the broad UDL principle providing multiple means of action and expression.*

In a reflective exchange of ideas regarding reasonableness, a characteristic of CRT, we found similarities between UDL principles and CRT, as both demand us to understand the learners' specific needs and provide pathways for their learning that fit within their realities.

T1 - Theory (T)

To become a culturally relevant teacher through maintaining rigor, there is a need to include 'conceptual and theoretical approaches' to learning and teaching that are evidence-based for engaging all students. One of the hindrances to making science accessible for all students, and particularly for students of Indigenous heritage, is cultural inequality, which is widespread in existing science curriculum and science teacher education programs. Many Aboriginal students distance themselves from science because they find science to be representative of a foreign culture, and hence they do not believe in it (Aikenhead, 2001; Aikenhead & Ogawa, 2007). Therefore, Aikenhead and Ogawa (2007) considered science teaching as cultural border-crossing which allows students to develop connections between science and their home culture. Saiqa revealed in her RNs the importance of using theory-based instructional strategies to engage science learners. In the following excerpt from RN#3, Saiqa justified her decision to use two socio-scientific issues related to water.

> *The Socio-scientific Issue (SSI) approach may provide a counterpoint for culture-free science, and a way to engage aboriginal youth with science content through the use of*

> *current and relevant socio-scientific issues faced by their communities, bringing the concept of 'place' within the SSI approach. SSI is a link between relevant social issues and science (Kolsto, 2001), as these have become important topics in science education*.

Karen responded to this segment and further reinforced the idea of using the SSI approach for effective science teaching while introducing other similar approaches.

> *Yes, the SSI approach not only allows students to access the content, but also permits them to see how science is relevant to individuals and their communities. In many subject areas, situating concepts and ideas 'in context' or 'in situ' is very important for students to make the learning relevant and personalized. Infusing students' own culture is needed. It also requires the teacher or teacher educator to be creative and responsive.*

This exchange of ideas allowed us to reflect on many theory-based approaches that we have used in our science methods course with the intent of making it culturally relevant for our PSTs. We also had an agreement that we should model these practices to help prospective science teachers use them effectively in their future classrooms.

4. Northern direction: Where are we going?

In this section, we position ourselves as science teacher educators who are making an effort to infuse Indigenous perspectives and ways of knowing into our future science methods courses. During our reflective journeys, it became apparent that self-study is a powerful tool for science teacher educators as they plan to learn together and from each other to transform their classroom pedagogies, which in this case means developing inclusive pedagogies. Here we reflect back on our learning journey and articulate a few guiding principles that will inform the design of our science methods courses and our practices as inclusive science teacher educators.

1. The first guiding principle is that diversity is a strength and CRT allows you to use this strength in science teaching in a number of ways. For example, providing multiple options for prospective science teachers to represent their learning ensures that multiple perspectives on learning can find their way into our classrooms. This strategy will serve all PSTs, but specifically, Indigenous student teachers, by facilitating the process of indigenizing the science methods courses. By modeling these strategies, we intend to decolonize these courses.
2. The second guiding principle is showing value and respect for diversity in order to help students feel respected, achieve a sense of belonging, and contribute to relationships that foster communities of learning. Respect and value for a particular culture can be achieved in many different ways, such as using words from other linguistic backgrounds in the classroom, using specific cultural practices such as talking circles to replace group discussions, and acknowledging established principles and respecting cultural values and traditions. As science teacher educators, we will continue to use these instructional strategies to model culturally relevant pedagogies in our science methods courses.
3. The third guiding principle is helping PSTs practice intercultural exchange by using specific examples and scenarios presenting the prevailing cultures within a classroom. Such inter-cultural exchanges can be introduced through science content: for example, teaching about friction in the context of snowshoes and snowshoeing experiences. We as science teacher educators can model such intercultural exchanges by organizing sessions on designing and making snowshoes, and especially by inviting Indigenous Elders. Also, an inquiry into the physics behind snowshoes and snowshoeing can be facilitated through placed-based learning by organising a science expedition. These pedagogical experiences may help prospective

science teachers learn about other cultures and cultural practices while developing inter-cultural awareness and understanding, thereby helping us to decolonize our teacher education practices and indigenize our science methods courses.

4. The fourth guiding principle is highlighting the socio-cultural perspectives of science to allow students to understand the role of cultural contexts and factors in shaping scientific knowledge. The cultural aspects of science may help PSTs explore Indigenous or native science ideas as they relate to a scientific phenomenon, such as weather or technology created by Indigenous people. These socio-cultural aspects of science may help us as science teacher educators to converge Western science and Indigenous science by using Two-Eyed-Seeing principle. For example, using Qulliq lamp video analysis, we could help IBED students to examine how Western science is the same or different from traditional knowledge, with an emphasis on applying a socio-cultural perspectives.
5. The fifth guiding principle is being reflective and advocating reflective practice for PSTs. Reflection is a powerful learning tool, and when implemented thoughtfully, can foster critical thinking skills and self-regulated learning. We, as science teacher educators, will continue to include critical reflections in our science methods courses, particularly written reflections on school-based lessons.

Conclusion

This self-study research is an addition to the scarce literature on preparing science teachers who understand CRT to effectively teach in Indigenous communities and engage Indigenous youth in urban science classrooms. There is a great need for effective teacher education practices as a response to the urgency of engaging Indigenous youth in science classrooms, helping them to be successful, and encouraging them to join STEM careers in future. The findings from this self-study research will guide the design of culturally relevant experiences for PSTs, as well as develop increased awareness about Indigenous peoples and cultures among non-Indigenous PSTs. The findings of this self-study research may be useful to other science teacher educators when developing and implementing their own culturally relevant pedagogies.

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Appendix A

Summary of the characteristics of CRT as reflected in classroom learning activities.

Reflective Narrative (RN)		CRT Characteristics
RN # 1	Building relationships through the use of Talking Circles	R1, R2, R3, R4, T1
RN # 2	Introducing scientific literacy: Using a video-analysis of a video about the Qulliq Lamp to develop an understanding of scientific literacy	R1, R2, R4
RN #3	Using relevant Socio-Scientific Issues (SSI): Engaging pre-service teachers and connecting with their community (a) Critical analysis of a scientific article to understand the local issue of a hydroelectric power project (b) Muskrat Falls hydroelectric project: A socio-scientific issue	R1, R2, R3, R4, T
RN #4	Water safety & inquiry into drinking water (a) Bringing to the classroom the inquiry into local drinking water to engage pre-service science teachers in discussions about safe drinking water, and inquiry (b) A visit to the local water treatment plant to understand the need to keep our water safe	R2, R3, R4, R5, T
RN #5	Modifying assignments to make culturally relevant curriculum	R1, R2, R3, R5, T
RN #6	Limitations and challenges	R1, R2, R3, R4, R5, T