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Neo-colonialism in Our Schools: Representations of Indigenous Perspectives in Ontario Science Curricula

Le néocolonialisme dans l'environnement pédagogique : la représentation des peuples indigènes dans les programmes des sciences en Ontario

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Résumé de l'article

Motivé par la sous-représentation marquante des étudiant(e)s indigènes dans les domaines de science et de technologie, le Ministère de l'Éducation d'Ontario essaya d'intégrer des perspectives autochtones dans leur programme officiel dans l'espoir de créer un environnement plus représentatif des particularités culturelles des étudiant(e)s indigènes. En employant l'analyse du contenu herméneutique, un encadrement de méthode mixte pour analyser du contenu, cette étude examina comment et jusqu'à quel point le contenu autochtone est représenté dans les documents officiels des programmes des sciences. Étant donné que très peu eut été publié dans ce domaine, la présente recherche fournit un éclairage sur l'état de la représentation des cultures autochtones dans les programmes contemporains des sciences canadiennes.

NEO-COLONIALISM IN OUR SCHOOLS: REPRESENTATIONS OF INDIGENOUS PERSPECTIVES IN ONTARIO SCIENCE CURRICULA

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ABSTRACT. Motivated by the striking under-representation of Indigenous students in the field of science and technology, the Ontario Ministry of Education has attempted to integrate Aboriginal perspectives into their official curricula in hopes of making a more culturally relevant curriculum for Indigenous students. Using hermeneutic content analysis (HCA), a mixed-method framework for analyzing content, this study examined how and to what extent Aboriginal content is represented in Ontario's official science curriculum documents. Given that very little has been published in this specific area, this research sheds light on the current state of the representation of Aboriginal cultures in contemporary Canadian science curriculum.

LE NÉOCOLONIALISME DANS L'ENVIRONNEMENT PÉDAGOGIQUE: LA REPRÉSENTATION DES PEUPLES INDIGÈNES DANS LES PROGRAMMES DES SCIENCES EN ONTARIO

RÉSUMÉ. Motivé par la sous-représentation marquante des étudiant(e)s indigènes dans les domaines de science et de technologie, le Ministère de l'Éducation d'Ontario essaya d'intégrer des perspectives autochtones dans leur programme officiel dans l'espoir de créer un environnement plus représentatif des particularités culturelles des étudiant(e)s indigènes. En employant l'analyse du contenu herméneutique, un encadrement de méthode mixte pour analyser du contenu, cette étude examina comment et jusqu'à quel point le contenu autochtone est représenté dans les documents officiels des programmes des sciences. Étant donné que très peu eut été publié dans ce domaine, la présente recherche fournit un éclairage sur l'état de la représentation des cultures autochtones dans les programmes contemporains des sciences canadiennes.

> "What is Indigenous knowledge?" No short answer exists, since this is a question about comparative knowledge and no legitimate methodology exists to answer it.... It continues to be a difficult question for non-Europeans to answer because Eurocentric thought has created a mysticism around Indigenous knowledge that distances the outsider from Indigenous peoples and what they know.
>
> (Battiste & Henderson, 2000, p. 35)

Over the past twenty years, discussions around integrating Indigenous perspectives into curriculum have become more predominant in the field of science education.[1] The educational values of Indigenous knowledges and practice are increasingly recognized as they offer a more culturally relevant (responsive) curricula / pedagogies for Indigenous students (Aikenhead & Elliot, 2010). In Ontario, the province with the largest population of Aboriginal peoples in Canada, the Ontario Ministry of Education put forth the *First Nations, Métis, and Inuit Education Policy Framework* (FNMI Framework) in 2007. This framework suggested a need for "curriculum that reflects First Nation, Métis, and Inuit cultures and perspectives" as a way to enhance Aboriginal students' learning in Ontario's schools (Ontario Ministry of Education, 2007b, p. 7). Moreover, the province's official science curricula (grades 1-8 published in 2007, and 9-10 and 11-12 published in 2008) formally acknowledged the educational value of Indigenous knowledges in science education and emphasized that "all students in Ontario will have knowledge and appreciation of contemporary and traditional First Nation, Métis, and Inuit traditions, cultures, and perspectives" (Ontario Ministry of Education, 2007a, p. 7). Given this recognition, one might expect that the Ontario science curricula reflect Indigenous-related content, including "contemporary and traditional" knowledge of Indigenous peoples in Ontario (Ontario Ministry of Education, 2007a, p. 7). However, no published study to date has examined the prevalence or representation of Indigenous-related content in Ontario's current official science curricula. Examining the ways in which Indigenous-related content is presented within official curricula is important as it demonstrates how policymakers view Indigenous cultures and knowledges, which in turn influences the ways in which teachers and students teach and learn. However, Indigenous scholars, notably Battiste and Henderson (2000), continue to show concern about the ongoing negative impacts of academic practices that promote the cultural appropriation of intellectual property from Indigenous communities. In this paper, I explore the current status (i.e., prevalence and representation) of Indigenous-related content in the official Ontario science curricula.

LOCATING MYSELF

My point of entry is as a Korean-Canadian science educator, who has mainly been trained under the dominant Western model of science teaching. I was introduced to the knowledges and practices of Indigenous peoples during my undergraduate degree in biology as well as through community work. Through these experiences, I came to understand the importance and value of Indigenous knowledges (IK) in the field of science. As a science educator who was trained and is certified in Ontario, I tried incorporating some Indigenous-related content in my high school science courses. However, I often found that students resisted seeing IK as a valid science. Students often perceived Indigenous-related content as relevant in history class rather than counting as scientific knowledge. In addition, Canadian science textbooks tend to highlight

the cultural, traditional, and historical aspects of IK while diminishing Indigenous peoples' contemporary contributions to science and technology (Ninnes, 2000). Recognizing my students' perceptions and the textbook portrayals of IK, I questioned whether the representations of IK reflected in the official curricula of the Ministry of Education were aligned with those constructed by textbook publishers. In Canada, textbooks used in classrooms usually correspond with the official curriculum documents published by ministries of education; teachers in Canada are expected to follow the official curriculum documents to plan their lessons and to evaluate students' learning process. Therefore, I focused study on Ontario's official science curriculum documents.

Snively and Corsiglia (2001) have asserted that "since Aboriginal cultures have made significant contributions to science, then surely there are different ways of arriving at legitimate knowledge. Without knowledge, there can be no science, thus the definition of science should be broadened" (p. 8). I concur with Snively and Corsglia's notion of science. I likewise reject the traditional ways of looking at science as a subject rooted only in Eurocentric values. Therefore, in this paper, *science* refers to methods that construct reality and that also consist of different sets of prior knowledge about the natural world and practices. When referring to the subject of science, I use the terms *science curriculum*, *school science*, or *science education*. This paper is based on Ogawa's (1995) "science education in multiscience perspective," which recognized that science is not universal but can exist in different forms stemming from the cultures and worldviews of different people (p. 583). Ogawa (1995) stated that "science in science education normally refers to Western modern science, which is only one of the sciences that civilization has produced" (p. 583). Therefore, I use the term *Western modern science* (WMS) to address the type of science that is anchored in Euro-Western cultures. To describe the form of science and knowledges that arise from culturally distinct groups of Indigenous peoples, I use the term *Indigenous knowledges* (IK). To refer to people of First Nations, Metis, and Inuit ancestry, the preferred collective name established by Indigenous scholars and the United Nations is *Indigenous* (Cajete, 1993; Saskatoon Public School Division, 2014). Meanwhile, current education documents in Ontario, including science curriculum documents, use the term *Aboriginal*. Therefore, I use the terms *Aboriginal*[2] and *Indigenous* interchangeably in this paper. I also use the plural form when addressing Aboriginal peoples and their cultures and knowledges in Canada to acknowledge their diversity. I am not Indigenous nor a true expert of IK, but an ally. Here, a true expert refers to a knowledge holder and a community member who has received teaching directly from Elders and is recognized by Aboriginal communities. Before delving into the representation of Indigenous content within curricula, and in an attempt to provide a larger social and historical context for this study, I first provide a brief history of Indigenous education in Ontario as well as different perspectives on integrating IK into science education.

HISTORICAL CONTEXT: INDIGENOUS EDUCATION IN ONTARIO

The federal government of Canada has used education systems as an instrument of assimilation and oppression of Indigenous peoples in Canada since the early 1800s, when European missionaries established residential schools for Aboriginal children (Ledoux, 2006; Neegan, 2005). These residential schools were tools to attempt to eliminate worldviews, languages, and cultures of Aboriginal children "in a combination of powerful forces of cognitive imperialism and colonization" (Ledoux, 2006, p. 269). The perpetuating effects of these residential schools (e.g., loss of sociolinguistic knowledge, parenting skills, etc.) have been thoroughly discussed and echoed by various scholars and survivors (Battiste & Henderson, 2000; Cherubini, 2010; Grant, 1996). The education of Canadian students became the responsibility of provincial jurisdictions with the enactment of the British North America Act in 1867. However schooling systems and education for Aboriginal children remained a federal responsibility and the attempted assimilation of Aboriginal children continued through residential school systems in Canada (Ledoux, 2006). In 1963, Hawthorn, an anthropologist, was commissioned by the federal government to examine the well-being of Aboriginal peoples in Canada. In his report (1966-67), he identified the destructive effects of assimilation education policies (especially residential schools) on Aboriginal peoples and demanded for a change in Aboriginal education policies.

In the 1960s, even though the education of Aboriginal students on reserves remained the responsibility of the federal government, a substantial number of Aboriginal students attended public (provincially funded) schools. In 1967, the Ontario government introduced legislation permitting school boards to appoint an Indigenous member to represent Aboriginal students attending provincially funded schools (Gidney, 1999/2002). In addition, other policy initiatives, focused on curriculum and classroom issues, shifted from an approach of assimilation by segregation to assimilation by integration. This new approach emphasized creating more positive images of Aboriginal peoples in textbook and learning material, in which Indigenous peoples had previously routinely been portrayed as "savages" or "heathens" (Gidney, 1999/2002). However, the curriculum remained Eurocentric, forcing Western ways of thinking and knowledge on Aboriginal students (Battiste, 1998; Neegan, 2005). There has also not been enough (if not a complete absence of) consultation with Aboriginal peoples in regard to curriculum development, which has led to a lack of preparation of teachers and curriculum that accommodates Aboriginal students' learning in class (Ledoux, 2006). The integration approach to education — without proper involvement of Aboriginal peoples — continued to play a role in assimilating Aboriginal children and youth into Eurocentric culture and ways of thinking. When the 1969 federal White Paper advocated provincial control of Aboriginal affairs, including (and especially) education, Indigenous peoples responded quickly and, in 1972, First Nations groups in

Canada obtained the right to operate their own schools. However, one of the funding criteria required that Indigenous-governed schools follow provincial curriculum (Battiste, 1998; Ledoux, 2006).

Since 2008, the federal government of Canada has signed tripartite education memorandums of understandings (MOU)[3] with some Canadian provinces, not including Ontario (Aboriginal Affairs and Northern Development, 2014). Meanwhile, the numbers of identified Aboriginal peoples in Canada surpassed the one million mark in 2006, over one fifth (21%) of whom resided in Ontario, making the Indigenous population in Ontario larger than that in any other province or territory. In turn, in 2006, there were over 50,000 Aboriginal students enrolled in public schools across Ontario (Ontario Ministry of Education, 2011). Considering the growing population of Aboriginal students and the need for better education for Aboriginal students in the province, the McGuinty government published the *Ontario's New Approach to Aboriginal Affairs* report in June 2005. Even though the Ontario government never signed a MOU, the McGuinty government expressed its commitment to building a relationship and collaborating with Aboriginal communities. The report also suggested various strategies and principles to "improve educational outcomes among Aboriginal children and youth" and the development of curricula to "create a positive learning environment at both the primary and secondary school levels" (Ontario Native Affairs Secretariat, 2005, p. 12).

In 2007, the Ontario Ministry of Education (2007b) stated that they had collaborated with the Aboriginal Education Office in Ontario to publish a policy framework document for Aboriginal education, entitled *the First Nation, Métis, and Inuit Education Framework*. This framework also echoed the Ministry's stated commitment to provide "a curriculum that facilitates learning about contemporary and traditional First Nations, Métis and Inuit cultures, histories and perspectives among all students and that also contributes to the education of school board staff, teachers and elected trustees" throughout elementary and secondary science education in Ontario (Ontario Ministry of Education, 2007b, p. 8). Indeed, the Ministry stated in their official science curriculum documents from 2007 that their science curricula have been integrated with content related to "the perspectives and worldviews of various cultures, including Aboriginal cultures, as they relate to scientific issues" (Ontario Ministry of Education, 2007a, p. 37). Statements from the FNMI policy framework as well as official science curriculum documents of Ontario have highlighted the Ministry's commitment to integrating IK and practices into the curriculum. However, the integration of Indigenous-related content, including IK in science curricula, continues to be a subject of debate in the field of education, especially from the perspective of universalism versus multiculturalism in science education.

INTEGRATION OF IK IN SCIENCE EDUCATION

Integrating Indigenous perspectives into conventional WMS-focused science education has fuelled a fierce debate between universalists and multiculturalists in science education. Universalists argue that science is universal and is culture-, gender-, and ethnicity-free, thus the culture, gender, race, ethnicity, or sexual orientation of the knower does not influence the construction of scientific knowledge (Matthews, 2000; Siegel, 2001). In contrast, multiculturalists (i.e., pluralists) challenge the notion of universalism and suggest that science is socially constructed and thus can exist in different forms in different cultures (Lewis & Aikenhead, 2001; Snively & Corsiglia, 2001). The debate between universalists and multiculturalists in science education is part of a wider critique of science based on Kuhn's (1970) arguments about the structure of scientific revolutions, accompanied by the emergence of poststructuralist and postmodernist philosophies (McKinley, 2005). Through a multiculturalist lens, scholars such as Cajete (1993), Snively and Corsiglia (2001), and Aikenhead and Michell (2011) underlined the legitimacy of IK and Indigenous ways of knowing nature (IWKN) as types of science that are different from conventional WMS.

IK, considered to be distinctive knowledge, have their own place in science education (Kimmerer, 2012). First, IK help create a better learning environment for Indigenous students. Studies have shown that many Aboriginal students have a better grasp of Western-based school science when it is complemented by Aboriginal perspectives (Hatcher, Bartlett, Marshall, & Marshall, 2009). Hampton (1995) and Snively and Corsiglia (2001) suggested that a framework of integrative science (including both IK and WMS) would create a better learning environment for Aboriginal students to succeed in "both the white and the Native worlds" (Hampton, 1995, p. 7). The First Nations and Inuit lifelong learning models also emphasize learning both WMS and IK (Canadian Council on Learning, 2007b).

Moreover, IK play important roles in contemporary science and technology education and careers. The World Commission on Environment and Development (1987) pointed out the importance of locally developed IK, as such knowledges can offer potential solutions for ever-increasing contemporary and future environmental problems, including global warming. Derived from long-term observational data and maintained through an oral tradition, IK systems build upon the experience of earlier generations and adapt to new technological and socioeconomic changes (Omura, 2005; Tsuji & Ho, 2002). The knowledges and experiences of Indigenous peoples provide insights on the relationships between living things in nature that are currently absent in WMS and that can be complemented with WMS and technology to provide a more holistic understanding of nature (Kimmerer, 2002).

In particular, there is a growing recognition of the knowledges and practices of Indigenous peoples on sustainable development around the globe (Kimmerer, 2012; Nadasdy, 1999). In turn, environmental education that includes "activities that are by, with, or about Indigenous peoples, their environments, and the peoples' relations to the living and non-living things around them" (Reid, Teamey, & Dillion, 2004, p. 238) is being increasingly promoted. For instance, UNESCO created the Teaching and Learning for a Sustainable Future: A Multimedia Teacher Education program as part of its Educating for a Sustainable Future project. This program underscored that when integrated in curricula, IK can enhance learning attitudes and values for a sustainable future. These recognitions from the UN and UNESCO are also reflected in the Council of Ministers of Education of Canada's (CMEC, 2010) report, *Educating for Sustainability*, which stated that "Canada may want to play a role in the implementation of this [UNESCO's sustainability project]" (p. 6).

CURRENT STATUS OF IK IN CANADIAN SCIENCE EDUCATION

Despite their educational value, IK carry less importance than WMS in the field of science education (Omura, 2005). IK continue to be represented as primitive, wild, and natural, and evoke condescension from Western observers (Dei, Hall, & Rosenberg, 2000; Semali & Kincheloe, 1999). Historically, IK have been excluded from the school curriculum or offered minimal course time in lower status optional courses (Alsop & Fawcett, 2010). The results from a textual analysis on two key Australian and Canadian textbooks (used in grades 7-9 classes) suggested that these textbooks covered a substantial amount of IK (Ninnes, 2000). However, there are issues of essentialism and misrepresentation of Indigenous identities. Indigenous-related content was often associated with antiquity or primitive terms and was subordinated to or treated as peripheral in relation to Western knowledge (Ninnes, 2000). Kimmerer (2002) also pointed out that IK are unknowingly or knowingly ignored in curricula. Indeed, my previous study (Kim & Dionne, 2014) revealed that many Canadian jurisdictions showed either a lack of Indigenous-related content in their grades 7 and 8 science curricula (i.e., evidence of ignoring) and/or evidence of essentialism and appropriation of IK in their science curricula. However, unlike the other Canadian provinces and territories, Nunavut and Saskatchewan have made some headway in integrating IK into science curricula (Kim & Dionne, 2014). For example, rather than treat IK as add-on curricula, as Figure 1 shows, the official science curricula of the Saskatchewan Ministry of Education recognized IK "as a legitimate way to understand the physical world" along with disciplines developed by WMS (i.e., life science, physical science, earth and space science) (Aikenhead & Elliot, 2010, p. 329).

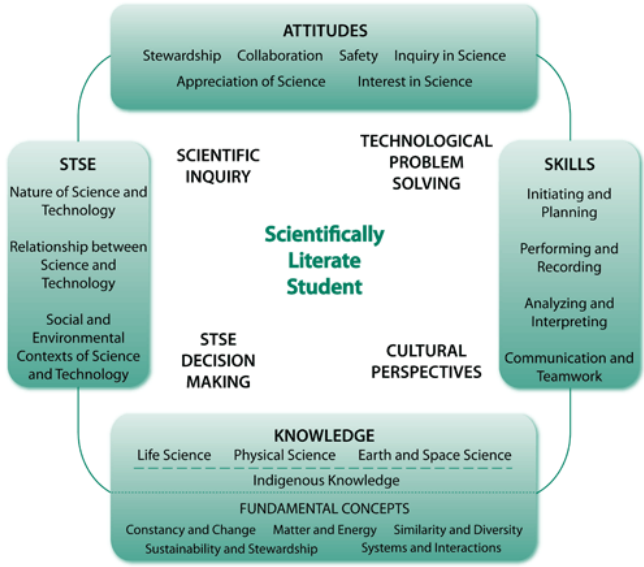

FIGURE 1. *The renewed Saskatchewan Science Framework (reproduced from Aikenhead & Elliot, 2010).*

Aikenhead and Elliot (2010) specified that the Saskatchewan curriculum renewal process required collaboration with Indigenous groups and scholars to ensure "the cultural and political validity of Indigenous knowledge[s] included in the curriculum"; in the process, Indigenous groups in Saskatchewan helped find connections between IK and the Pan-Canadian Science Framework[4] published by the Canadian Minister of Education Canada (CMEC) in 1997 (Aikenhead & Elliot, 2010, p. 330). In turn, IK content was integrated throughout four foundation pillars of the Pan-Canadian Framework: 1) science, technology, society, and the environment (STSE); 2) attitudes; 3) skills; and 4) knowledge, with the goal of avoiding tokenism of IK within curricula (Kim & Dionne, 2014). Indigenous scholars, including Battiste and Henderson (2000), Simpson (2004), and Deloria and Wildcat (2001), have underscored the importance of the participation and involvement of Indigenous scholars and Elders in reclaiming their epistemic identities and empowering their IK to gain social value and status as a system of knowledge in contemporary society. In this light, a meaningful integration of IK requires content that does not also tokenize the involvement of Aboriginal Elders and scholars in the curriculum development and teaching (Aikenhead & Elliot, 2010; Neegan, 2005). Indeed, the development of the Saskatchewan curricula included both the involvement of Aboriginal individuals and also the establishment of specific pedagogical tools for teachers to work with knowledge keepers / knowledge holders, individuals who are recognized from local Indigenous communities (Aikenhead & Elliot, 2010). The Saskatoon Public School Division (2014)

developed *Enhancing School Science with Indigenous Knowledge: What We Know from Teachers and Research*. This book offers different ways and the possibilities of the meaningful integration of IK into school science as a form of science rather than as cultural content.

METHODS

Research objectives

As mentioned above, the purpose of this paper is to examine the treatment of Indigenous-related content, including IK, in Ontario's official science curriculum documents. Here, treatment refers to the prevalence (i.e., the amount of coverage) as well as the representation (i.e., the portrayal of cultures, practices, and knowledge of Indigenous peoples). Johnston, Haines, and Wallace (2001) stated that the experience of students in secondary science classes has a significant impact on their perceptions and choices with regards to pursuing science and technology-related post-secondary studies. Recognizing this long-term impact of secondary science curriculum, I focused on the secondary (grades 7 to 12) curricula in this study, using the following guided questions:

1. What is the prevalence of Indigenous-related content within Ontario secondary science curriculum documents?
2. Within which learning domains (i.e., life sciences, physical sciences, and earth and space sciences) is Indigenous-related content found in the studied documents?
3. In what positive and negative ways has the Aboriginal perspective been represented in curriculum documents?

I used hermeneutic content analysis (HCA) — a mixed method framework of content analysis — to explore these questions, as researchers can employ HCA to consider studied content through both quantitative and qualitative lenses. In this way, the data from a HCA can bring a more complete contextualized interpretation of the documents (Bergman, 2010).

Data sources

Official Ontario science curriculum documents describe the knowledge and skills that students are expected to acquire, demonstrate, and apply in their classwork and investigations, on tests, and in various other activities upon which their achievement is assessed. The Ontario science curriculum consists of two sets of expectations: *overall* expectations and *specific* expectations (Ontario Ministry of Education, 2007a). Taken together, both sets of expectations make up the officially mandated science curriculum. While overall expectations describe "in general terms the knowledge and skills that students are expected to demonstrate by the end of each grade," specific expectations describe "the expected knowledge and skills in greater details" (Ontario Ministry of Educa-

tion, 2007a, p. 11). Specific expectations are usually accompanied by suggested examples, sample issues, or guiding questions in parentheses. These examples are not mandated curriculum but rather help teachers to elaborate their pedagogies to teach to the curriculum expectations. The overall and specific expectations of Ontario science curricula are both developed in ways that respect the interrelationship between the big ideas of science (i.e., fundamental concepts) as well as the three goals of science education in the provinces, as shown in Figure 2.

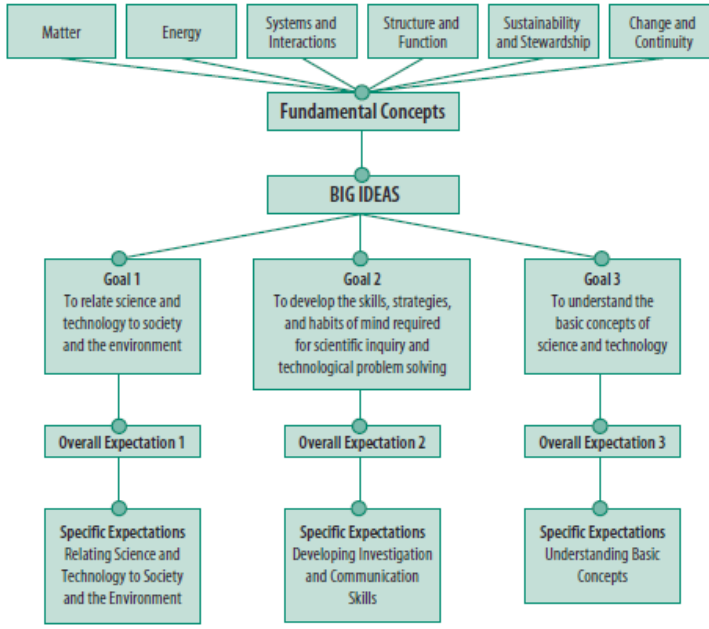

FIGURE 2. *The Ontario Science Curriculum Framework (Ontario Ministry of Education, 2008).*

Specific expectations in curricula are categorized into the disciplines of biology, chemistry, physics, and earth and space education, corresponding to the goals of the science program, which are: 1) to relate science and technology to society, 2) to develop the skills, strategies, and habits of mind required for scientific inquiry and technological problem solving, and 3) to understand the basic concepts of science and technology. In this study, I reviewed all the specific expectations through the mixed method framework of hermeneutic content analysis (HCA), focusing on its association with types of disciplines and the goals of the science program.

Hermeneutic content analysis (HCA)

I adopted Bergman's (2010) HCA framework, which consists of three steps (Figure 3):

1. A qualitative content analysis to identify meaningful codes according to the research question or theme;
2. A quantitative frequency analysis of themes and narrative components;
3. A qualitative re-contextualization of the quantitative data from step 2 through interpretation within the specific text and context.

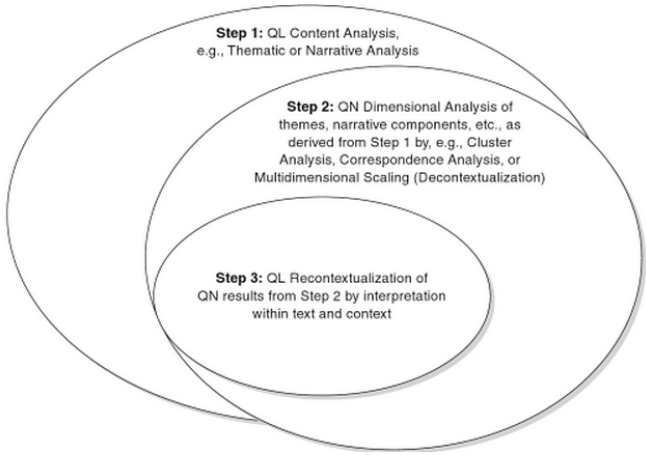

FIGURE 3. *Three-step analysis of sequential mixed methods content analysis (Bergman, 2010, p. 389).*

During the first qualitative phase, I reviewed curriculum documents and their contents. Here, the focus was twofold: 1) to identify specific expectations containing Aboriginal-related concepts and/or words and 2) to generate the descriptive categories (themes) that delineate the representations of Aboriginal topics and knowledge emerging from these specific identified expectations. Thereafter, I moved to the second (quantitative) phase, during which I conducted a frequency analysis on the identified concepts and words to investigate the prevalence of Aboriginal-related content categorized by the associated learning domains (e.g., biology, chemistry, physics, earth and space science and technology) as well as the frequency analysis of the appearance of generated themes throughout the documents. In the last phase, the results from the first and second phases were assembled to interpret (re-contextualize) the data for further discussion. Here, I also examined if any acknowledgement or recognition was given to local Aboriginal communities' involvement in the curriculum development. In the third stage, with all of the data combined, I attempted to identify the current state of IK in curricula. To do so, I referred to Afonso Nhalevilo's (2013) grounding framework (i.e., five stages of integration of IK systems) in science education (Table 1).

TABLE 1. *Five stages of the integration of IK systems*

1. Colonization	IK are not recognized as valued knowledge.
2. Decolonization	Awareness of the value of IK starts to take place in debates on curriculum policies in education (i.e., a conduit for the assimilation of IK into the Western paradigm).
3. Neo-colonization	Content integration: Process that undermines the cultural values of a society (e.g., integration that teaches Western science to Indigenous students and uses IK as a resource to clarify Western science).
4. Re-birth	Researchers and educators interrogate the lenses through which IK are communicated, argue for the inclusion of IK, and question the way in which IK have been included / integrated.
5. Theorizing	Researchers and educators are more concerned with justifying the claim for the co-existence of different discourses in school curricula and seek to address ontological, axiological, and epistemological issues in including IK in school curricula (i.e., how do we teach IK?).

This framework provides a tool that analysts can use to "reflect on curriculum changes and on programs of research into the cultural contextualization of science education and/or of Indigenous knowledge system inclusion in school curricula" (Afonso Nhalevilo, 2013, p. 25). Therefore, within this framework, I aimed to unveil embedded ideas that delineate the current representation of Indigenous-related content within the curriculum documents.

FINDINGS

Amount of coverage

The analysis revealed that an average of 1.8% of each grade's curricula was devoted to Aboriginal-related content and less than 5% of the content of all curricula across all grade levels was related to Aboriginal topics (see Table 2).

TABLE 2. *Total calculated percentages of textbook dedicated to Aboriginal content by grade*

Grade	Total number of specific expectations (i.e., learning outcomes) in documents	Number of specific expectations in curriculum with Aboriginal content	Estimated % of curriculum documents dedicated to Aboriginal content
Grade 7	66	1	1.5
Grade 8	57	1	1.8
Grade 9	118	5	4.2
Grade 10	126	3	2.4
Grade 11	383	8	2.1
Grade 12	463	4	0.9
Total	1,213	22	1.9

Once identified, the specific expectations were categorized by related learning domains: biology, chemistry, physics, earth and space science, and technology. The technology category consisted of the content related to the science field, such as current medical technologies, disease-related technologies, as well as technologies related to workplace hazards. Content in this category is from the grade 12 university / college preparation science and grade 12 workplace science courses. In relation to the learning domain, most of the Aboriginal content was presented in the context of teaching earth and space science, while none was found within the physics domains (see Table 3).

TABLE 3. *Total calculated percentages of curriculum documents dedicated to Aboriginal content in each teaching strand*

Learning domains	Total no. of specific expectations in documents	No. of expectations in curriculum with Aboriginal content	Estimated % of curriculum dedicated to Aboriginal content
Biology	244	8	3.3
Chemistry	299	1	0.3
Physics	306	1	0.0
Earth & Space Science	211	10	4.7
Grade 12 Science	58	2	3.5

With regard to the low level of Indigenous content in physics and chemistry, the Saskatoon Public School Division (2014) explained that these subjects are not aligned with the holistic nature of Indigenous worldviews. While physical science topics such as chemistry tend to require reductionism (i.e., analyzing and breaking apart the concepts into smaller parts), life science topics such as ecology tend to be based on holism (i.e., looking at the relationship to a whole system). Thus IK-related topics are more likely to appear in the topics of life sciences, such as biology, than physical sciences, including chemistry and physics.

I also examined the relationship between Indigenous-related content and the three goals of the science and technology program in Ontario. With regard to the goals of science and technology of the Ontario science curriculum (Table 4), Indigenous-related content found in the curricula was mainly associated with relating science and technology to society and the environment (STSE).

TABLE 4. *Estimated percentages of curriculum dedicated to Aboriginal content in relation to overall expectations*

Overall Expectation	Total no. of specific expectations in documents	No. of expectations in curriculum with Aboriginal content	Estimated % of curriculum dedicated to Aboriginal content
Relating science and technology to society and the environment	101	16	15.8
Developing investigation and communication skills	286	2	0.7
Understanding basic concepts	318	4	1.3

NOTE: Grade 11 and 12 Chemistry, Grade 11 and 12 Physics, and Grade 12 Earth and Space Science were not included as part of the quantitative analysis process since no Aboriginal content was found in the related documents.

This course content was mainly introduced in sample issues and questions related to an introductory activity or lesson to facilitate discussions around the topics of STSE rather than presented as a learning outcome. For example, one of the specific expectations from a grade 12 university prep biology course is to "evaluate, on the basis of research, some of the human health issues that arise from the impact of human activities on the environment" (Ontario Ministry of Education, 2008, p. 84). For this specific expectation, a few sample questions were given to teachers, such as: "In what ways have mining, forestry and hydroelectric developments affected the health of Aboriginal people in Northern Ontario?" and "What are the links between air pollution and respiratory disease such as asthma?" (p. 84). As seen in this example and as reflected throughout the official secondary curricula, Aboriginal topics were primarily discussed in the context of STSE, which shows the Ministry's attempts to integrate the cultures and issues of Aboriginal communities. However, as shown in Table 5, very little Indigenous-related content was introduced as scientific concepts (1.3%) or skills to acquire (0.7%). I will elaborate on the notion of tokenism further in the next section. Meanwhile, five themes emerged with regards to the representation of the cultures and knowledges of Aboriginal peoples upon exploring the identified contents in the documents (Table 5).

TABLE 5. *Estimated percentages of Aboriginal content for thematic categories*

Theme	No. of specific expectations	Estimated %
Aboriginal knowledge portrayed in antiquity terms or as primitive concepts	3	13.6
WMS as a solution to issues in Aboriginal communities	10	45.5
Aboriginal peoples' sciences and technologies portrayed as alternatives	4	18.2
IK recognized as concepts to learn	3	13.6
Aboriginal peoples seen as research subjects	2	9.1

Theme 1: Aboriginal knowledges portrayed in antiquated terms or as primitive concepts. The traditions and knowledges of Aboriginal peoples were often portrayed in the curriculum documents as primitive concepts or myths. They were often discussed in a pre-historic context, along with ancient Greek and Mayan civilizations. For example, in the grade 9 earth and space science strand, one of the specific expectations stated that students were required to

> describe various reasons that humankind has had for studying space (e.g., to develop calendars for agricultural purposes, to forecast weather, for celestial navigation, and for religious inspiration) and the conceptions of the universe held by various cultures and civilizations (e.g., Aboriginal cultures; ancient Greek and Mayan civilizations). (Ontario Ministry of Education, 2008, p. 55)

Unlike ancient civilizations, which are no longer in existence and thus no longer progress, the cultures and knowledges of Aboriginal peoples continue to evolve and adapt to the changes in environment and society (Dei et al., 2000; Tsuji & Ho, 2002). By associating Aboriginal cultures with the ancient Greek and Mayan civilizations, the curricula evoke the idea that Aboriginal cultures and knowledges are primitive and inferior, inadequate for solving current scientific problems, and superseded by conventional scientific ideas (Ninnes, 2000). When seen through a postcolonial lens, such a representation creates "fragmented, negative, and distorted" pictures of Aboriginal peoples, whereby Indigenous knowledges and technologies are characterized as "primitive, backward, or superstitious" (Battiste & Henderson, 2000, p. 86). Such representations of IK also evoke condescension from Western observers and the subjugation of IK in curriculum (Battiste & Henderson, 2000; Ninnes, 2000). In turn, curricula that emphasize such ideas play a role in devastating the self-confidence of Aboriginal youth while promoting the supremacy of WMS ideologies, which are based on the notion that European cultures, knowledges, and practices are superior to Indigenous ways of living and thinking (Hickling-Hudson & Ahlquist, 2003; Poonwassie, 1992). Jegede (1999) examined the effects of Eurocentric curricula in the learning context. His collateral learning theory supports the idea that learning through highly

Eurocentric content may impede the learning process of Aboriginal students because "learning something in one cultural setting that conflicts with their indigenous knowledge embedded in a different cultural setting (for example, Aboriginal students learning Western science)" could result in conflicting ideas in long-term memory of Aboriginal students (as cited in Aikenhead & Huntley, 1999, p. 5). Historically, Aboriginal-related content has been excluded from school curriculum or only offered in lower status optional courses (Alsop & Fawcett, 2010). While the educational and scientific value of IK is recognized to a certain extent in the policy framework and statements in Ontario curricula, the science curricula (rooted in the conventional WMS) continues to elicit antiquated images of Aboriginal peoples. In turn, this impedes teachers and students from understanding Aboriginal knowledges and technologies as potential tools to investigate current environmental problems.

Theme 2: WMS as a solution to issues in Aboriginal communities. As shown in Table 5, 45.5% of the studied content discusses current scientific and environmental issues within Aboriginal communities. These issues include concerns for safe drinking water in First Nations communities and the loss of traditional lifestyles for the Inuit peoples in Ontario. While these issues were framed as problems of Aboriginal communities, the curriculum nevertheless conveys the idea that conventional Western science has been, and continues to be, the answer to the problems. For example, one of the specific expectations for the grade 11 environmental science course requires students to "analyse grassroots initiatives that are intended to reduce the impact of environmental factors on human health" (Ontario Ministry of Education, 2008, p. 156). The particular sample issue given for the expectation was:

> People from the Grassy Narrows Reserve in Northern Ontario were experiencing chronic health problems. They commissioned a study which found that many animals and fish that were part of a traditional diet were contaminated with mercury and heavy metals. Guidelines were proposed to limit consumption of the affected animals and thereby improve people's health. (Ontario Ministry of Education, 2008, p. 156)

While the sample excerpt introduces a current scientific issue in the Aboriginal community, it ignores the causes of contamination. Free Grassy Narrows (2010) stated that the Ministry of Natural Resource has been permitting logging companies to obtain natural resources in Grassy Narrows without the consent of the community. These logging companies have left vast amounts of mercury in the land and the river, as a result of which high levels of mercury have remained in the community's water system. This problem stemmed from the government and the capitalist economic system, not from this Aboriginal community. However, by failing to mention the accurate cause of the problem, the curriculum gives the impression that the environmental problem first transpired from within the Aboriginal community. In addition, without mentioning non-WMS-based ways of healing that are currently being used in the community (e.g., holistic healing approach, herbal medicine) or any

initiatives governed by the community, the curriculum states that to improve the health of the people in the community, the provincial government created guidelines for people to follow in an effort to resolve the health and environmental issues. Here, Western science and guidelines are seen as the answer to the problems in Aboriginal communities, showing the ways that the discourse of the science curriculum — being highly political — is anchored in WMS. Within a postcolonial framework, such representation follows an assimilationist trajectory, leading Aboriginal students to devalue their traditional science and praise Western science, which is portrayed as the solution to the problems in their respective communities. Consequently, this leads to the disengagement of Aboriginal students in learning school science and has devastating impacts on the self-confidence of Aboriginal youth (Poonwassie, 1992).

Theme 3: Aboriginal peoples' sciences and technologies portrayed as alternatives. Nearly 18% of all identified Aboriginal content was dedicated to introducing the scientific contributions of Aboriginal peoples in Canadian society and environment. The Ontario curricula often ask students to assess the effectiveness of human activity on long-term sustainability or alternative technologies, including the technologies and knowledges of Aboriginal peoples. An example can be seen in the grade 12 university / college preparation science course, which asks students to "identify a variety of alternative technologies and therapies used to diagnose or treat human health conditions (e.g., biofeedback, acupuncture, homeopathy, chiropractic, and Aboriginal healing practices) and assess the effectiveness of one such therapy" (Ontario Ministry of Education, 2008, p. 228). Multiculturalist-based understandings of science education recognize that there are many solutions to scientific problems and that Western scientists have utilized the knowledges and technologies of Aboriginal peoples (Snively & Corsiglia, 2001). However, students are asked to assess "the effectiveness" of Aboriginal peoples' contributions and technologies (which are represented as "alternative"). This portrayal of Aboriginal knowledges and technologies as "alternative" and not yet validated by WMS conveys a message of uncertainty regarding the legitimacy of Indigenous knowledges and technologies. Battiste and Henderson (2000) stated that, in fact, the knowledges and technologies of Indigenous peoples are as, if not more, empirical and valid as Western scientific thought and technologies since Indigenous knowledges and technologies are continually being revised over time at the individual and community levels.

Theme 4: IK recognized as concepts to learn. As seen in Table 3, 13% of the analyzed Aboriginal content was described as concepts students need to learn. IK have been recognized internationally as valuable knowledge systems to study how the environment has changed over time as well as to promote environmental stewardship (Aikenhead & Michell, 2011; Kimmerer, 2002; McKinley, 2005; Tsuji & Ho, 2002). Through the lens of the universalist view of science, the knowledges and practices of Aboriginal peoples are incommensurable to number- and formula-based science (i.e., factual science), such as the chemistry of

physics (Siegel, 2001). Therefore, from this perspective, there seems to be no space for IK in current school science curricula. However, despite the argument that IK cannot be incorporated into physical sciences (such as chemistry and physics), the Ontario curriculum provides an example in the Grade 8 physics strand that introduced the Aboriginal clan system as a basic concept explaining the term *system*. It may seem to be a mere integration of IK but the concept of system is considered to be a "big idea" in science education and the application of the concepts and examples of Aboriginal clan systems in this example illustrates the possibility of integrating Aboriginal topics into the physical sciences.

Indeed, when integrating IK into WMS-based curriculum, it is important to focus on the similarities as well as the differences between WMS and IK to be able to illustrate how a synthesis of both knowledge systems can work together to solve problems (Hatcher et al., 2009; Snively & Corsiglia, 2001). While the differences between WMS and IK have been emphasized in the field, the similarities of these two systems have also been discussed (Agrawal, 1995; Aikenhead & Michell, 2011). Both WMS and IK are generated through systemic experimental approaches and both share intellectual processes that include observing, questioning, interpreting, looking for patterns, inferring, and classifying. They both originate from the human impulse to understand the environment, thus the knowledge is continually being revised based on new observation and new data (Aikenhead & Michell, 2011). Despite these similarities, much more emphasis has been placed on the differences, as a result of which IK have been made to be peripheral and WMS has been placed in the center of the curriculum — therefore reproducing the broader social status quo within the curriculum.

Scholars have suggested that these differences are due to political reasons rather than epistemic factors, as politics has played an important role in determining the status of IK in dominant Western society (Agrawal, 1995; Nadasdy, 1999; Tsuji & Ho, 2002). Omura (2005) affirmed that the perpetuated status quo and the differences between WMS and IK emphasized by scientists are "a result of the socio-political construction of otherness" (p. 339). The examples of constructing otherness are shown in theme 5.

Theme 5: Aboriginal peoples seen as research subjects. Some learning outcomes involved sample cases that include Aboriginal peoples and communities as a subject to study. For example, one of the expectations for developing investigation and communication skills in the Grade 12 biology university preparation course requires that students study Aboriginal peoples by researching "the increase of Aboriginal compared to non-Aboriginal populations and the significant difference in average age between the two groups" (Ontario Ministry of Education, 2008, p. 12). As many Indigenous scholars such as Smith (2012) and Battiste and Henderson (2001) have suggested, Indigenous peoples often have been the subject of study. By studying "them" (Indigenous peoples), it

often has been the case that Indigenous peoples' knowledges and practices have been represented as primitive or inferior and needing to be advanced to the standards of Eurocentric values. Such representations have been a result of research conducted without consultation with Indigenous peoples.

Without providing a possible context of study (e.g., Aboriginal peoples are the fastest growing population in Canada as suggested by Aboriginal Affairs and Northern Development Canada, 2010), the purpose of the above-mentioned comparative analysis between Aboriginal and non-Aboriginal population growth using "laboratory inquiry or computer simulation" can be questioned. The purpose of the choice of two populations, Aboriginal and non-Aboriginal (Ontario Ministry of Education, 2008, p.12), is also not clear. Is the comparison between these two groups the most effective way to either learn science-related concepts (e.g., population dynamics) or develop science-related skills (e.g., investigation and communication skills) suggested in the curriculum document? This inclusion of Aboriginal peoples in the curriculum does not serve any educational role but rather tokenizes Aboriginal peoples. Also, the curriculum expectations create a discourse of "us and them" and provide an example of othering the Aboriginal population and separating this specific population from the rest of the Canadian population.

This is particularly poignant as Canada is often recognized as a "mosaic" consisting of many different cultures, including those of Aboriginal peoples. While the non-Aboriginal population includes diverse ethnic and linguistic populations including recent immigrants to Canada, Aboriginal peoples are put in a separate category despite the distinctiveness and diversity within Aboriginal communities. Indeed, there was also evidence of essentializing Indigenous peoples in the curriculum in Ontario. There was no mention of the diversity of the Aboriginal cultures and knowledges, and when Indigenous-related content was included, it represented Indigenous peoples as a homogenous population. The Mohawk people are referred to as "people from the Grassy Narrows reserve" in the earlier example (Ontario Ministry of Education, 2008) without giving the proper nation name associated with the people in the community. As such, the curricula not only fail to recognize the diversity existing within Aboriginal peoples but also other them from the rest of multicultural Canada.

Here, *other* is defined by difference, typically marked by outward signs, such as race and gender, where *difference* indicates "some kind of weakness or superior strength or intellect depending on the sympathies of the dominant [i.e., Western] cultural voice" (Onbelet, 2012, p. 3). Learning through curricula that separates Indigenous cultures from the rest of Canada as well as silences or devalues Indigenous scientific knowledges and practices, Aboriginal students may feel excluded from broader Canadian society, which often leads to the disengagement of these students from science learning (Canadian Council on Learning, 2007a).

Moreover, Aboriginal communities have their own way of examining that is not rooted in "laboratory inquiry or computer simulation," as illustrated by Ferguson and Messier's (1997) studies on IK about the population of Arctic tundra caribou. Such comparative analysis using only WMS-based technology to study Aboriginal peoples without recognizing the possibility of Aboriginal ways of studying a population is an example of educational and academic practices that perpetuate the asymmetric power relationships that exist between WMS and IK. Providing more detailed contexts and rationales as to why the comparison between the two groups is significant to learning either science concepts or skills and including examples of Aboriginal ways of studying populations would have helped to avoid tokenization and othering within the curriculum.

CONCLUSION

Based on their commitment to creating a more integrative science curriculum, as highlighted in the *First Nation, Métis, and Inuit Education Policy Framework*, the Ontario secondary science curricula included Aboriginal-related content to a certain extent (see Table 2). Considering the amount of coverage and representation within the documents, the Ontario secondary science curriculum is at Afonso Nhalevilo's (2013) stage of neo-colonization in regard to the integration of IK. In the neo-colonization stage, IK are included in the curriculum but are "decontextualized, expropriated and objectified" (Afonso Nhalevilo, 2013, p. 27). Traditionally, colonization refers to the occupation, control, and economic exploitation of one nation by another (Asher, 2010). Neo-colonization, in the context of curriculum, is a new form of colonization — "a process that undermines the cultural values of a society" (Ryan, 2008, p. 673).

The neo-colonial stage of the integration of IK in curricula is further illustrated by Afonso Nhalevilo (2013). She suggested that content integration is a typical practice used in the neo-colonial stage where curricula include IK but fail to consider the paradigm associated with the knowledge. In turn, IK are included to "teach WMS to indigenous students... as a resource to clarify WMS, [and/or] to name the subject IK but teach it within the Western science framework" (Afonso Nhalevilo, 2013, p. 28). Therefore, within neo-colonial curricula, IK are being assimilated into WMS. The integration of IK is based on the WMS agenda. As such, IK continue to be subjugated and misrepresented based on the WMS framework. The five themes generated from the representation of Aboriginal-related content suggest the presence of embedded salient colonial ideas within the Ontario curriculum, which in turn does not accommodate Aboriginal students' learning and creates a stereotype of Aboriginal knowledge as antiquated.

Carter, Larke, Singleton-Taylor, and Santos (2003) effectively illustrated the neo-colonial process within the science community. These authors referred to the science community as a special kind of "club" that has its own rules. If individuals or scientists are not willing to play by its rules, they are not

welcome to join or even remain. In this way, rules and regulations are based on the traditions of Western science and universalism. An individual who wants to become a member of this "club" is expected to be an expert on the values, culture, and content of Western science. Based on findings from this study, I argue that Ontario's secondary science curriculum has played a role in creating this exclusive "club" within their science education. Such curricula indoctrinate students to believe that WMS is the only valid way of constructing the world, while othering IK (Carter et al., 2003). Afonso Nhalevilo (2013) challenged the discourse and the context that frames this discourse of integrating IK within neo-colonial curriculum, stating that IK "is not just about artifacts or the phenomena occurring in the hearth or beyond. It is rather about the discourse we have in relation to these occurrences" (p. 29).

Therefore, the context in which IK are introduced or integrated in science curricula must consider not only the WMS-based paradigm but also IK paradigms to avoid "epistemological dependency, viewing IK as dependent on the lens of Western Science" (Afonso Nhalevilo, 2013, p. 29). The integration of IK within IK paradigms must be done by Indigenous people. The Ontario curriculum documents (e.g., Ontario Ministry of Education, 2007b, 2008) made no mention of the participation of Indigenous scholars or educators in the curriculum development nor did any pedagogy suggest the involvement of community members. Here, I echo the importance of the involvement of Indigenous scholars and Elders, as this is an essential element of integrating IK. As mentioned in the literature review, collaborating with Aboriginal scholars and local knowledge keepers in regard to curriculum design and instruction would help avoid the misrepresentation of knowledge and create a curriculum that better serves Aboriginal students' learning.

As seen in Saskatchewan's successful case (Aikenhead & Elliot, 2010; Kim & Dionne, 2014; Saskatoon Public School Division, 2014), the meaningful integration of IK can be accomplished by consulting with local Aboriginal knowledge holders and experts. Instead of being used as a tool to tokenize IK, the contributions and knowledges of Aboriginal peoples can be introduced across all teaching strands and grade levels in a respectful manner towards Indigenous peoples without misrepresenting them as primitive or inferior. Moreover, curricula should include pedagogies that involve community members. Cherubini (2010) problematized the current situation whereby non-Aboriginal educators "translate Aboriginal education curricula initiatives by their own understanding of pedagogical content and therefore situate their teaching from a personal narrative context" (p. 21). If ministries of education decide to integrate Aboriginal perspectives in curricula, Aboriginal scholars and members should be involved from the start, in the development as well as the delivery of the content. When integrating and teaching about Indigenous-related content, non-Indigenous people must recognize their role as allies rather than experts. In such a way, the effects of neo-colonialism within science teaching can be diminished and a more meaningful integration of IK within science curricula can be achieved.

NOTES

1. I would like to thank the reviewers for their critical and constructive comments, which helped strengthen this article.
2. The term *Aboriginal* includes First Nations, Métis, and Inuit peoples. First Nations, Métis, or Inuit students are referred to specifically where appropriate to the context.
3. While there are some variations, each MOU represents an important long-term commitment to collaboration regarding K-12 education and frames joint initiatives pursued by the parties (Aboriginal Affairs and Northern Development, 2014).
4. The Pan-Canadian Framework (1997) listed specific content and skills for science classrooms for each grade level; all Canadian curricula are required to follow this framework.

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