Towards Decolonizing the Pan-Canadian Science Framework

Glen S. Aikenhead
College of Education
University of Saskatchewan
Saskatoon, SK, S7N 0X1
Canada

glen.aikenhead@usask.ca

Published in the *Canadian Journal of Science, Mathematics and Technology Education*, vol. 6, no. 4, pp. 387-399.

Canada is facing a key issue: The *under* representation of Aboriginal students in high school science and mathematics courses leads to economic, resource management and sovereignty problems for First Nations, Inuit and Métis communities (collectively, Aboriginal communities); and this under representation defines an ethical problem of equity and social justice for the rest of Canada (Battiste, 2002; DIAND, 2002; Ignas, 2004; MacIvor, 1995; RCSP, 1996). The under representation of Aboriginal students has two main causes: the disproportionately high level of poverty in Aboriginal communities, and the foreign nature of school science and mathematics for many (but not all) Aboriginal students due to the culture clashes they experience when they move from their home culture to the culture of school science and mathematics (Aikenhead, 1997, 2002; Battiste, 2002; Cajete, 2000b; Kawagley, 1995; Sutherland, 2005). Science educators have clear and direct jurisdiction over the problem of culture clash, but we ought not to ignore other sources of discouragement, such as racism in classrooms or occupations (St. Denis, 2004).

Conventionally, school science has attempted to enculturate students into taking on a Western scientific way of knowing, replete with its canonical knowledge, techniques, and values. In short, many science teachers want students to think like a scientist (AAAS, 1989). This often means that positivistic notions of scientific knowledge are combined with ontologies of realism and Cartesian duality, to feed on reductionistic and mechanistic practices in order to celebrate an ideology of power and dominion over nature. Science is not value neutral.

To participate in school science, an Aboriginal student is often expected to set aside their Indigenous way of knowing, including its alternative notion of knowledge as action and wisdom, which combines the ontology of spirituality with holistic, relational and empirical practices in order to celebrate an ideology of harmony with nature for survival. When school science does not nurture students' Aboriginal identities or strengthen their resiliency, most students are not inclined to participate or achieve in these courses (Cajete, 2000a; MacIvor, 1995; Kawagley, Norris-Tull, & Norris-Tull, 1998; Sable, 2005; Sutherland, 2005). The culture clash between Aboriginal identities and Western science ideologies is severe for these students. Many feel unwelcome in school science.

By trying to force a Eurocentric science curriculum on all Aboriginal students, we continue the colonization of the past, a process today called “cognitive imperialism” (Battiste, 1986, p. 23) and “neo-colonialism” (Ryan, 2006, p. 179).

In Canada, the conventional science curriculum is best represented by the influential *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum* (CMEC, 1997). This *Framework* outlines the Council of Ministers of Education of Canada (CMEC)’s vision for scientific literacy and the Council’s aims for science education (listed in the Appendix). This vision assumes a particular cultural context for school science: canonical Western science content embedded in the predominant Euro-Canadian culture. This assumption has worked well for students who embrace the dominant culture of Euro-Canada and the cultures of Western science and school science. These students are well represented in school science and mathematics. However, it has not worked well for the vast majority of Aboriginal students who experience this conventional context as neo-colonialism.

In addition to having our current Anglo- and Franco-culture versions of CMEC’s (1997) *Framework* available to guide the development of provincial science curricula across Canada, we require a third cultural version that is responsive to students of First Nations, Inuit and Métis ancestry. The challenge for science educators is to decolonize the pan-Canadian science framework, by engaging Aboriginal communities (prime stakeholders in their children’s education) in developing an enhanced pan-Canadian science framework.

We need to strengthen students’ Aboriginal self-identities as they learn to master and critique Western scientific, technological and mathematical ways of knowing without, in the process, sacrificing their own culturally constructed ways of knowing, that is, their Indigenous knowledge (Kanu, 2005). We must eschew tokenism, indoctrination, and neo-colonialism. Our aim is to nurture Aboriginal students’ scientific literacy so they can successfully “walk in both worlds,” Aboriginal and Euro-Canadian (Battiste, 2000, p. 202, 2002; Cajete, 1999; MacIvor, 1995). Our aim is also to nurture non-Aboriginal students’ understanding of Indigenous knowledge held by Aboriginal communities (Saskatchewan Learning, 2005, pp. 6-7).

The purpose of this article is to explore the challenge of creating an enhanced science curriculum framework amenable to Aboriginal students living in many nations across Canada.

Enhancing the Pan-Canadian Science Framework

In addition to the *Framework*'s (CMEC, 1997) vision, aims, and foundation statements (Appendix), its curricular details are organized into five groups: (1) science-technology-society-environment (STSE) content, (2) processes (inquiry, problem solving, and decision making), (3) skills common to these processes, (4) canonical science content (designated as "knowledge" in the *Framework*), and (5) attitudes. These details themselves are listed in the *Framework* in terms of "general or specific learning outcomes" which represent the Anglo- and Franco-Canadian (Eurocentric) contexts in which the *Framework*'s vision and aims are enacted in most science classrooms. A different context, one responsive to Aboriginal self-identities, is required if the *Framework* is to be accessible to most Aboriginal students.

The first step towards establishing an accessible science curriculum is to *recognize* Indigenous knowledge as a knowledge system that describes and explains nature in culturally powerful ways. The survival of Aboriginal peoples for tens of thousands of years, based on each nation's Indigenous knowledge, already legitimizes its content validity (Cajete, 2000b); Aboriginal elders have accomplished that. We need to recognize Indigenous knowledge in the *Framework* as a foundational element to school science.

We can begin to accomplish this by conceiving "science" in a multi-science context (Ogawa, 1995) so the meaning of "science" is more encompassing than its Eurocentric meaning. A broader concept for "science" is the following: a rational, empirically based description-explanation of nature. This concept includes, among others, the Eurocentric cultural perspective (Western science) and Aboriginal cultural perspectives (Indigenous knowledge) held by First Nations, Inuit and Métis peoples in Canada.

The political history of the word "science" in England privileges a very narrow meaning (the canonical Western science content taught in universities), which today can act in a neo-colonizing way. The word "science" was deliberately chosen in 1831 when some natural philosophers founded the British Association for the Advancement of Science and thereby professionalized natural philosophy into a new social institution, which they called "science" for very political reasons (MacLeod & Collins, 1981). Equally political, we can decolonize school science by extending its purview to all three founding nations of Canada: Anglo, Franco, and Aboriginal. This pluralistic multi-science perspective leads us towards decolonizing the Canadian *Framework*.

Based on a pluralistic re-reading of the phrase "science and technology" in the CMEC's vision for scientific literacy in Canada (Appendix), we can discern its new meaning inclusive of Aboriginal students' self-identities. For instance, inquiry, problem solving and decision making all take place within Indigenous knowledge, but students' abilities are anchored in a different cultural worldview. Life-long learning and a sense of wonder about the world are cherished priorities in both Aboriginal and Eurocentric cultures, but in different culture-based ways. Advancements in *Western* science and technology play an increasingly significant role in everyday life for Aboriginal students, but so too does the present day wisdom of Indigenous knowledge in many communities. In short, the CMEC's vision for scientific literacy in Canada can effectively apply to both Eurocentric and Aboriginal cultural contexts, once Indigenous knowledge is recognized as foundational. The *Framework* can be expanded (enhanced) to embrace Canada's three founding nations.

Similarly when we recognize Indigenous knowledge as one of several culture-based science and technologies, the statements identifying CMEC's five aims for science education (Appendix) can be re-read equally for Aboriginal and Eurocentric cultural worldviews. For instance, on the one hand, a sense of curiosity held by Aboriginal students may differ in some ways from their Euro-Canadian counterparts; while on the other hand, careers in Western science-related occupations hold greater similarities. A word of caution: The variation in interests and abilities within an Aboriginal group of students is greater than the variation between Aboriginal and non-Aboriginal groups of students. Stereotyping students is a neo-colonial strategy.

By recognizing Indigenous knowledge as a foundational component to school science for all students (Aboriginal and non-Aboriginal), we create an additional cultural context for school science amenable to Aboriginal students and valuable to non-Aboriginal students, in which to enact the CMEC's vision and aims for science education in Canada. These expectations are clarified below.

Moving Forward

As a non-Aboriginal Canadian, it is not my place to reformulate the *Framework* so it embraces an Aboriginal perspective. That responsibility belongs to Aboriginal communities and their leaders. They must articulate Indigenous knowledge for a culturally responsive science curriculum framework (Battiste, 2002; Battiste & Barman, 1995), and they must negotiate appropriate modifications to the *Framework* or to their province's science curriculum in order to develop an enhanced document. Consultation with Aboriginal elders is a key feature of policy development if we want to achieve cultural relevance, sensitivity and support in an Aboriginal community (ANKN, 2004a; Inuit Subject Advisory Committee, 1996; Kawagley et al., 1998; McKinley, 1996; Riggs, 2005; Sutherland & Tays, 2004). Elders and community members must be seen as authoritative stakeholders in any negotiation over an enhanced science curriculum.

Because the validity of Indigenous knowledge is delimited by its geographic and ecological setting for those who hold it, it is called "place-based" knowledge (Battiste & Henderson, 2000; Hampton, 1995; Kawagley & Barnhardt, 1999; Michell, 2005).

> Indigenous knowledge thus embodies a web of relationships within a specific ecological context; contains linguistic categories, rules, and relationships unique to each knowledge system; has localized content and meaning; has established customs with respect to acquiring and sharing of knowledge (not all Indigenous peoples equally recognize their responsibilities); and implies responsibilities for possessing various kinds of knowledge. (Battiste, 2002, p. 14)

Consequently an enhanced *Framework* will vary in some specific ways from community to community across Canada (Aikenhead & Huntley, 1999). It is important that an enhanced science curriculum be framed by the epistemology, ontology and axiology of Indigenous knowledge. These features are characterized by place-based empirical knowledge, holism, relationships, and a strong value for harmony with Mother Earth (Cajete, 2000b).

The process of curriculum negotiation in Canada between Aboriginal communities and provincial ministries of education can be accelerated by science educators whose Eurocentric self-identities have privileged them in science and mathematics (i.e., science educators who enjoy an abundance of cultural capital [Apple, 1997] in their Eurocentric lives), but who have transformed themselves into cross-cultural science educators who respect Indigenous knowledge and are reasonably conversant with it (Snively & Corsiglia, 2001). A science educator's role in accelerating curriculum negotiations must be a collaborative one. Aboriginal colleagues will determine the goals of education for Aboriginal students (Hampton, 1995; MacIvor, 1995), and cross-cultural Western science educators will invest their Eurocentric cultural capital in these negotiations to help develop an enhanced *Framework*. The result will be a science curriculum that conveys both Indigenous and Western ways of knowing about nature.

Current Achievements

An enhanced science curriculum framework is for all students, Aboriginal and non-Aboriginal; although the degree of emphasis on Indigenous knowledge will vary in accordance with a school's community. This culturally enhanced framework is much closer to being achieved than most people might realize because it is educationally feasible at the present time. This feasibility is summarized here, drawing upon only a small portion of the research literature. In Canada and internationally, Aboriginal groups have articulated features of Indigenous knowledge they would like to see taught in their schools.

The Federation of Saskatchewan Indian Nations (FSIN) organized an elder's group to establish an ideology and worldview for teaching First Nations students about nature. These principles guided the development of *Practising the Law of Circular Interaction* (Saskatchewan Indian Cultural Centre, 1993), a publication that provides a clear vision for curriculum negotiation and provides some teaching materials (video tapes included) for school science instruction that nurtures a holistic continuity between Aboriginal students' everyday life and their science classrooms.

In British Columbia, the project *Forests for the Future* integrates Indigenous knowledge and Western science, based on the ideology and worldview of the Tsimshian community (Ignas, 2004). Teaching materials were developed in a way that linked the community's ways of knowing and ways of learning with emergent anthropological research. In a different approach to integrating Indigenous knowledge and Western science in Northern Saskatchewan, key Aboriginal community members were engaged in producing and helping to teach cross-cultural school science units. The project, *Rekindling Traditions*, illustrated how this could be done in remote Cree, Métis and Dëne communities (Aikenhead, 2000, 2002). The units gave students access to Western science and technology without requiring them to adopt the worldview endemic to Western science (Gagné, 2004). For students who had a gift or talent for Western science, the units lay the foundation and encouragement for further study. Similarly in a northern Manitoba village, three Cree teachers developed their own culturally responsive science lessons (Sutherland & Tays, 2004).

Sable (2005) conducted research in collaboration with Mi'kmaw students attending Eel Ground First Nations School in New Brunswick, where the Mi'kmaw people rely on their Indigenous knowledge for economic and cultural survival (Berkowitz, 2001). By discovering the complex nature of students' learning school science, Sable was able to develop culturally sensitive lessons ("Chemical Change: Entering Science through the Language") that integrated Mi'kmaw knowledge of nature into a science textbook unit. Her research is transferable to other Aboriginal nations.

The Inuit and Yupiaq nations of the far north have published their Aboriginal perspectives that they expect to be incorporated into their science curriculum (ANKN, 1998, 2004a; Inuit Subject Advisory Committee, 1996; Kawagley, 1995). A case study into the integration of the Canadian document *Inuuqatigiit: The Curriculum from the Inuit Perspective* (Inuit Subject Advisory Committee, 1996) in a grade 7 science classroom identified advantages and challenges when the integration was the sole responsibility of the teacher (DeMerchant, 2002).

Successful integration has been achieved by the Alaska Native Knowledge Network's *Spiral Pathway for Integrating Rural Alaska Learning* (ANKN, 2004b), where Aboriginal students' standardized science test scores uniformly improved over four years to meet with national averages, in classrooms where teachers implemented ANKN science modules (Barnhardt, Kawagley, & Hill, 2000). Increased interest and achievement in school subjects have also been documented in Canada for similar projects (Kanu, 2002).

Aotearoa New Zealand enjoys an enhanced science curriculum. A Mäori version of their country's science curriculum came about through negotiations between Elders of the Mäori nation and science educators (McKinley, 1996; Stewart, 2005). This Mäori version, called "pütaiao," was recognized by the country's ministry of education for a network of Mäori language schools and Mäori bilingual and immersion classrooms in elementary and high schools, including grade 12 (McKinley, 2005; McKinley, Stewart, & Richards, 2004). "As an Indigenous science, pütaiao offers the opportunity to develop a uniquely local critical science education curriculum" (Stewart, 2005, p. 866). Teacher candidates are being educated to produce lesson plans to fit pütaiao (Barker, 2004).

In Australia, national policies explicitly support Aboriginal versions of school science (Michie, 2002; Purdie et al., 2000). This support inspired a non-Aboriginal science educator to collaborate closely with three different Aboriginal family groups across Australia (Read & Rose, 2001) to produce a high school textbook, *The Kormilda Science Project* (Read, 2002).

It is clear from the Aotearoa New Zealand and Australian experiences that when Indigenous knowledge is recognized as foundational to school science, appropriate curricula, teacher education programs and instructional materials can ensue.

In summary, several curriculum projects have illustrated appropriate ways to integrate Western science into an Aboriginal framework enriched by Indigenous knowledge. *Integration is demonstratively feasible*. These achievements, however, have been isolated projects rather than provincial initiatives to enhance provincial science curricula or enhance the pan-Canadian *Framework*.

The remaining barrier to overcome now, by and large, is the collective political will to recognize Indigenous knowledge as a foundational component to school science and the will to support Aboriginal students with a cultural context for their school science.

Challenges

First Nations, Inuit and Métis communities seek to move beyond a colonial past into a postcolonial present, and to forge a sovereign future (Battiste & Henderson, 2000; Binda & Calliou, 2001; Menzies, Archibald, & Smith, 2004). “Postcolonial” does not mean that colonialism has ended, but rather, it means that colonialism is interrogated and critiqued for the purpose of diminishing and extinguishing its power (Ryan, 2006). An enhanced science *Framework* needs to reflect this postcolonial goal. This entails a number of challenges that will take time to work through. Challenges include the articulation of Indigenous knowledge for school science and the development of teachers’ professional capacities to ensure students learn Indigenous knowledge.

But first, how will we know when we have made progress? To help answer this question, I draw upon Bennett’s (1986, 1993) “developmental model of intercultural sensitivity” (DMIS). As shown in Table 1, one-half of the DMIS describes decreasing degrees of ethno-centrism while the other half captures increasing degrees of ethno-pluralism. The indicator’s six categories begin at the one extreme of ethno-centrism in which Indigenous knowledge is denied, and ends at the other extreme of ethno-pluralism, integration, which represents the goal of an enhanced science *Framework*.

Table 1 fits here

Progress towards this integration goal can be monitored. As an illustration, I shall apply the DMIS to a science curriculum recently developed by Saskatchewan's ministry of education, Saskatchewan Learning. Here are a series of excerpts from a short section in the *Science 10 Curriculum Guide* (Saskatchewan Learning, 2005) entitled "Indian and Métis Content and Perspectives." The following data suggest a particular category in Table 1.

> It is an expectation that Indian and Métis content and perspectives be integrated into all programs related to the education of kindergarten to grade 12 students in Saskatchewan, whether or not there are Indian and Métis students in a particular classroom. … Integrating Indian and Métis perspectives into the science program requires a multi-faceted approach. (p. 6)

Five facets to this multi-faceted approach are then clarified:

1. …understanding and respecting Indigenous knowledge and ways of knowing …[that] often seem at odds with contemporary, scientific ways of knowing. …An inclusive science curriculum respects the variety of worldviews that various cultures use to understand and explain their relationships with the natural world. (p. 6)
2. …the responsibility and authority of teachers to adapt instruction in order to be responsive to the interests and needs of their students and local communities, while still respecting the [Eurocentric] foundational and related learning objectives. …All of the units in Science 10 should be addressed from a personal, local, and community perspective. (p. 6)
3. …by bringing in Indian and Métis role models (may or may not include Elders), identifying Indian and Métis contributions towards our understanding of the natural world, and equally valuing Indigenous perspectives and understandings of the natural world along with scientific perspectives. (p. 7)
4. …the creation of cross-cultural units of study. This approach requires teachers to work collaboratively with members of the Indian and Métis communities … . (p. 7)

5. The final responsibility for accurate and appropriate integration of Indian and Métis content and perspectives into science instruction rests with teachers. … (p. 7)

This multi-faceted approach represents, I believe, an enlightened viewpoint in its rejection of an ethno-centric position. Saskatchewan's grade 10 science curriculum has achieved at least a ranking of "acceptance" in the DMIS.

The onus, however, is clearly on science teachers to accomplish an enhanced science curriculum (with the help of another Saskatchewan Learning document, *Diverse Voices*, mentioned in the curriculum guide). The curriculum enacted in the classroom (i.e., the provincial curriculum translated by teachers) requires the process of adaptation (a category in the DMIS) by teachers before the integration of Indigenous knowledge and Western science can be realized. Therefore, I would place Saskatchewan's grade 10 science curriculum in the "acceptance" category of the DMIS because its adaptation clearly rests with teachers rather than with provincial curriculum developers.

This placement defines an evolutionary trajectory for Saskatchewan Learning to follow. The science curriculum needs to proceed through the stage of adaptation and enter the stage of integration. In other words, to achieve success in schools, Saskatchewan Learning needs to recognize Indigenous knowledge as foundational to school science, and then it needs to facilitate the development of an enhanced science curriculum (in collaboration with First Nations and Métis communities, as mentioned above) and to facilitate the development of culturally responsive school science programs and resources, along with the development of more culturally sensitive science teachers.

The CMEC's (1997) *Framework* is silent on the issue of Indigenous knowledge. As described above, it required a culturally conscious re-reading of its vision and aims before Indigenous knowledge became present in the document. Although this silence might be interpreted as "denial" in the DMIS in the context of school science, its silence most definitely places the *Framework* in the ethno-centrism portion of the DMIS.

Classroom success (i.e., a more equitable representation of Aboriginal students in science and mathematics courses) does require more than providing teachers with instructional resources. The challenge is to provide science teachers with opportunities to effect professional change in accordance with Bennett's (1986) DMIS. Decolonizing school science *begins* at the stage of "acceptance" and succeeds at the stage of "integration." Concomitantly, teacher education programs must select and instruct more teacher candidates to become cross-cultural science teachers. Some universities embrace this goal already. We can be encouraged by recent action-research studies worldwide (e.g., Barker, 2004; Chinn, 2004; Sutherland & Tays, 2004).

The development of instructional resources for teachers and students raises challenging questions, for instance: What is Indigenous knowledge? and How does one learn it? Besides being a placed-based, empirical, holistic, and relational description-explanation of Mother Earth, Indigenous knowledge resides in Aboriginal languages (Battiste, 2002; McKinley, 2005). These languages are dramatically different from our Indo-European languages such as French and English. In fact, the prevailing Eurocentric concept of school "knowledge" (an accumulation of specific information, concepts, and skills within a school subject) has no direct translation into most Aboriginal languages because the Eurocentric concept of knowledge is largely foreign to most Aboriginal worldviews. The best English expression for what Aboriginal peoples learn as knowledge is "ways of living," for which the word "learn" means "coming to knowing" (Ermine, 1998), a concept closely related to Dewey's (1916) participatory learning. "Knowledge is not a commodity that can be possessed or controlled by educational institutions, but is a living process to be absorbed and understood" (Battiste, 2002, p. 15).

Thus, the challenge of learning Indigenous knowledge is to engage in an Aboriginal community's activities in order to participate in coming to knowing new ways of living (Michell, 2005). Knowledge outside of this domain is deemed irrelevant within a worldview of Indigenous knowledge. The phrase "in-school instruction of Indigenous knowledge" is almost, but not necessarily, an oxymoron.

This analysis reveals a tremendous educational advantage to all students, Aboriginal and non-Aboriginal, who learn a multi-science (ethno-pluralistic) perspective about nature, because in a "two-world" perspective these students will enjoy a far richer array of relevant knowledge / ways of living.

Unfortunately the term "Indigenous knowledge" itself is embedded within a Eurocentric epistemology. In the "integrated" stage in Bennett's DMIS, the term "Indigenous knowledge" may be replaced by a more appropriate phrase devised by Aboriginal communities, for example, "Indigenous ways of living."

Outcomes

By attempting to rectify the under representation of Aboriginal students in high school science and mathematics courses, all Canadians stand to benefit in several ways. First, there will be more Aboriginal scientists, engineers, technicians, and health professionals. As a result, Canadian R&D, industry, business, resource management and health sectors will function with people who are not necessarily imbued with Eurocentric thinking. Their alternative values, ideologies, and intuition hold promise for sustainability, biodiversity, holistic creativity, and Aboriginal sovereignty and cultural survival (Cajete, 2000a; ICSU, 2002; Knudtson & Suzuki, 1992; Settee, 2000; Snively & Corsiglia, 2001).

Second, a Eurocentric dominated world is an ontologically impoverished world. Even for non-Aboriginal students who plan a career in science and engineering, learning Indigenous knowledge can expand their perspective on nature and on problem solving, thereby creating better scientists and engineers for the future. “Indigenous knowledge fills the ethical and knowledge gaps in Eurocentric education, research, and scholarship” (Battiste, 2002, p. 5).

Conclusion

I attended a recent meeting of Saskatchewan educators invited from various groups who have a strong stake in the science curriculum (e.g., Federation of Saskatchewan Indian Nations, provincial School Boards, Tribal Councils, Saskatchewan Learning, and universities). At this informal meeting, people discussed the issue of Indigenous knowledge in the school science curriculum. Two main outcomes were achieved. First, the group posed some key questions:

- How can we make a difference in classrooms?
- How do we expect teachers to teach science in an Indigenous knowledge approach without showing them what Indigenous knowledge is?
- How can we involve science teachers in developing a curriculum that includes an Indigenous knowledge approach to science teaching?
- What does it mean to understand Indigenous knowledge?
- What does Indigenous knowledge in the science curriculum look like?
- How do we put Indigenous knowledge in the science curriculum?
- What might the role of Saskatchewan Learning be?
- Can the two ideologies of Indigenous knowledge and Western science be symbiotic?

- How can we utilize both ideologies for all students?

Second, the group committed themselves to continuing what they had begun, and they made specific plans to meet again with even more stakeholders involved. The challenges defined by their questions are worthwhile to these people because they foresee the positive consequences for Aboriginal communities. Such stories from across Canada must be told so they can inspire the political will to enhance the CMEC's (1997) current *Framework* into a postcolonial *Framework*.

"Canadian administrators and educators need to respectfully blend Indigenous epistemology and pedagogy with Euro-Canadian epistemology and pedagogy to create an innovative Canadian educational system" (Battiste, 2002, p. 21). Battiste's broad recommendation can easily be transposed into a specific case for science education: Political leaders and science educators, both Aboriginal and non-Aboriginal, need to decolonize our pan-Canadian science framework.

Acknowledgement

I am indebted to a number of colleagues in Saskatchewan whose contributions to a discussion over Indigenous knowledge in the science curriculum helped clarify my thinking, and as a result contributed to this paper: Marie Battiste, Susan Beaudin, Terrina Bellegarde, Dean Elliott, Brenda Green, Elder Simon Kytwayhat, Darren McKee, Darlene Speidel, Jim Taylor, Lee Wilson, Melody Wood, and Yvonne Vizina.

References

AAAS. (1989). *Project 2061: Science for all Americans*. Washington, DC: American Association for the Advancement of Science.

Aikenhead, G.S. (1997). Toward a First Nations cross-cultural science and technology curriculum. *Science Education*, *81*, 217-238.

Aikenhead, G.S. (2000). *Rekindling Traditions: Cross-cultural science & technology units*. Retrieved March 17, 2006, from http://www.usask.ca/education/ccstu/.

Aikenhead, G.S. (2002). Cross-cultural science teaching: *Rekindling Traditions* for Aboriginal students. *Canadian Journal of Science, Mathematics and Technology Education*, *2*, 287-304.

Aikenhead, G.S., & Huntley, B. (1999). Teachers' views on Aboriginal students learning Western and Aboriginal science. *Canadian Journal for Native Education, 23*, 159-175.

ANKN (Alaska Native Knowledge Network). (1998). *Alaska standards for culturally-responsive schools*. Fairbanks, AK: Alaska Native Knowledge Network, University of Alaska Fairbanks.

ANKN (Alaska Native Knowledge Network). (2004a). *Alaska Native Knowledge Network*. Retrieved November 24, 2004, from *http://www.ankn.uaf.edu/*.

ANKN (Alaska Native Knowledge Network). (2004b). *Spiral pathway for integrating rural Alaska learning*. Retrieved November 24, 2004, from *http://www.ankn.uaf.edu/*.

Apple, M. (1997). What postmodernists forget: Cultural capital and official knowledge. In A.H. Halsey, H. Lauder, P. Brown, & A.S. Wells (Eds.), *Education: Culture, economy, and society* (pp. 595-604). Oxford: Oxford University Press.

Barker, M. (2004, July). *Indigenous cultures and the culture of science: The dilemma of being and knowing*. Paper presented to the 11th International Organization for Science & Technology Education (IOSTE) symposium, Lublin, Poland.

Barnhardt, R., Kawagley, A.O., & Hill, F. (2000). Cultural standards and test scores. *Sharing Our Pathways*, *5*(4), 1-4.

Battiste, M. (1986). Micmac literacy and cognitive assimilation. In J. Barman, Y. Herbert, & D. McCaskell (Eds.), *Indian education in Canada, Vol. 1: The legacy* (pp. 23-44). Vancouver: University of British Columbia Press.

Battiste, M. (Ed.). (2000). *Reclaiming Indigenous voice and vision*. Vancouver, BC: University of British Columbia Press.

Battiste, M. (2002). *Indigenous knowledge and pedagogy in First Nations education: A literature review with recommendations*. Ottawa: Indian and Northern Affairs Canada.

Battiste, M., & Barman, J. (Eds.). (1995). *First Nations education in Canada: The circle unfolds*. Vancouver, Canada: University of British Columbia Press.

Battiste, M., & Henderson, J.Y. (2000). *Protecting Indigenous knowledge and heritage*. Saskatoon, SK, Canada: Purich.

Bennett, M. (1986). A developmental approach to training for intercultural sensitivity. *International Journal of Intercultural Relating*, *10*, 179-195.

Bennett, M. (1993). Towards ethnorelativism. In M. Paige (Ed.), *Education for the intercultural experience* (pp. 21-72). Yarmouth, ME: Intercultural Press.

Berkowitz, P. (2001). Western science meets Mi'kmaq knowledge. *University Affairs*, *42*(December), 16-21.

Binda, K.P., & Calliou, S. (Eds.) (2001). *Aboriginal education in Canada: A study in decolonization*. Mississauga, Ontario, Canada: Canadian Educators' Press.

Cajete, G.A. (1999). *Igniting the sparkle: An Indigenous science education model*. Skyand, NC: Kivaki Press.

Cajete, G. (2000a). Indigenous knowledge: The Pueblo metaphor of Indigenous education. In M. Battiste (Ed.), *Reclaiming Indigenous voice and vision* (pp. 181-191). Vancouver, BC: University of British Columbia Press.

Cajete, G.A. (2000b). *Native science: Natural laws of interdependence*. Santa Fe, NM: Clear Light.

Chinn, P.W.U. (2004, July). *Moving Native Hawaiian knowledge from the margins to the center: The transformative potential of place and standards-based, culture-science professional development*. Paper presented to the Culture Studies in Science Education (CSSE) meeting, Kobe University, Japan.

CMEC (Council of Ministers of Education, Canada). (1997). *Common framework of science learning outcomes: Pan-Canadian protocol for collaboration on school curriculum*. Ottawa, Canada: Author.

DeMerchant, R.V. (2002). *A case study of integrating Inuuqatigiit into a Nunavut junior high school classroom*. Unpublished master's thesis, University of Saskatchewan, Saskatoon, Canada.

Dewey, J. (1916). *Democracy and education*. New York: Macmillan.

DIAND (Department of Indian Affairs and Northern Development). (2002). *Our children: Keepers of the sacred knowledge*. Ottawa: Author.

Ermine, W.J. (1998). Pedagogy from the ethos: An interview with Elder Ermine on language. In L.A. Stiffarm (Ed.), *As we see … Aboriginal pedagogy* (pp. 9-28). Saskatoon, Canada: University Extension Press, University of Saskatchewan.

Gagné, M-C. (2004, April). *Valuing identity and knowledge: "Rekindling Traditions" as an exemplar for minority education*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Vancouver, Canada.

Hampton, E. (1995). Towards a redefinition of Indian education. In M. Battiste & J. Barman (Eds.), *First Nations education in Canada: The circle unfolds* (pp. 5-46). Vancouver, Canada: University of British Columbia Press.

ICSU (International Council for Science). (2002). *Science and traditional knowledge: Report from the ICSU study group on science and traditional knowledge*. Paris, France: Author.

Ignas, V. (2004). Opening doors to the future: Applying local knowledge in curriculum development. *Canadian Journal of Native Education*, *28*, 49-60.

Inuit Subject Advisory Committee. (1996). *Inuuqatigiit: The curriculum from the Inuit perspective*. Yellowknife, Canada: Northwest Territories Education, Culture and Employment.

Kanu, Y. (2002). In their own voices: First Nations students identify some cultural mediators of their learning in the formal school system. *Alberta Journal of Educational Research*, *48*, 98-121.

Kanu, Y. (2005). Teachers' perceptions of the integration of Aboriginal culture into the high school curriculum. *Alberta Journal of Educational Research*, *51*, 50-68.

Kawagley, A.O. (1995). *A Yupiaq worldview*. Prospect Heights, IL: Waveland Press.

Kawagley, O., & Barnhardt, R. (1999). Education indigenous to place: Western science meets Native reality. In G.A. Smith & D.R. Williams (Eds.), *Ecological education in action* (pp. 117-140). Albany, NY: SUNY Press.

Kawagley, A.O., Norris-Tull, D., & Norris-Tull, R.A. (1998). The indigenous worldview of Yupiaq culture: Its scientific nature and relevance to the practice and teaching of science. *Journal of Research in Science Teaching*, *35*, 133-144.

Knudtson, P., & Suzuki, D. (1992). *Wisdom of the elders*. Toronto, ON: Stoddart.
MacIvor, M. (1995). Redefining science education for Aboriginal students. In M. Battiste & J. Barman (Eds.), *First Nations education in Canada: The circle unfolds* (pp. 73-98). Vancouver, BC: University of British Columbia Press.
MacLeod, R., & Collins, P. (Eds.) (1981). *The parliament of science*. Northwood, Midx., UK: Science Reviews.
McKinley, E. (1996). Towards an indigenous science curriculum. *Research in Science Education*, *26*, 155-167.
McKinley, E. (2005). Locating the global: Culture, language and science education for indigenous students. *International Journal of Science Education*, *27*, 227-241.
McKinley, E., Stewart, G., & Richards, P. (2004). *Mäori knowledge, language and participation in mathematics and science education*. (Final Report). Hamilton, Aotearoa New Zealand: University of Waikato, School of Education.
Menzies, C.R., Archibald, Q.Q.J., & Smith, G.H. (2004). Editorial: Transformational sites of indigenous education. *Canadian Journal of Native Education*, *28*, 1-7.
Michell, H. (2005). Nēhîthâwâk of Reindeer Lake, Canada: Worldview, epistemology and relationships with the natural world. *Australian Journal of Indigenous Education*, *34*, 33-43.
Michie, M. (2002). Why Indigenous science should be included in the school science curriculum. *Australian Science Teachers' Journal*, *48*(2), 36-40.
Ogawa, M. (1995). Science education in a multi-science perspective. *Science Education*, *79*, 583-593.
Purdie, N., Tripcony, P., Boulton-Lewis, G., Fanshawe, J., & Gunstone, A. (2000). *Positive self-identity of Indigenous students and its relationship to school outcomes*. Canberra: Legislative Services, Commonwealth of Australia.
RCAP (Royal Commission on Aboriginal Peoples). (1996). *Gathering strength: Report of the Royal Commission on Aboriginal Peoples*. Ottawa: Canada Communication Group.
Read, T. (2002). *The Kormilda science project: An indigenous perspective on the earth sciences*. Mount Eliza, Australia: Author.
Read, T., & Rose, D. (2001). The Kormilda science project: The earth sciences with an Australian Indigenous perspective. *Australian Science Teachers' Journal*, *47*(2), 44-45.
Riggs, E.M. (2005). Field-based education and indigenous knowledge: Essential components of geoscience education for Native American communities. *Science Education*, *89*, 296-313.
Ryan, A.E. (2006). *"Dancing yet to the dimdims' beat": Dilemmas in postcolonial science curricula: The case of Papua New Guinea*. Unpublished doctoral dissertation. Monash University, Clayton, Australia.
Sable, T. (2005). *Emerging identities: A proposed model for an interactive science curriculum for First Nations students*. Unpublished doctoral dissertation, University of New Brunswick, Fredericton, Canada.
Saskatchewan Indian Cultural Centre. (1993). *Practising the law of circular interaction*. Saskatoon, Canada: Author.
Saskatchewan Learning. (2005). *Science 10 curriculum guide*. Regina, SK, Canada: Author.
Settee, P. (2000). The issue of biodiversity, intellectual property rights, and Indigenous rights. In R.G. Laliberte et al. (Eds.), *Expressions in Canadian Native studies* (pp. 459-488). Saskatoon, Canada: University of Saskatchewan Extension Press.
Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science Education*, *85*, 6-34.

St. Denis, V. (2004). Real Indians: Cultural revitalization and fundamentalism in Aboriginal education. In C. Schick, J. Jaffe, & A. Watkinson (Eds.), *Contesting fundamentalisms* (pp. 35-47). Halifax, Canada: Fernwood.

Stewart, G. (2005). Mäori in the science curriculum: Developments and possibilities. *Educational Philosophy and Theory*, *37*, 851-870.

Sutherland, D.L. (2005). Resiliency and collateral learning in science in some students of Cree ancestry. *Science Education*, *89*, 595-613.

Sutherland, D.L., & Tays, N. (2004, April). *Incorporating indigenous culture into school science*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Vancouver.

Appendix

Common Framework of Science Learning Outcomes:
Pan-Canadian Protocol for Collaboration on School Curriculum
(For Use by Curriculum Developers)
1997
Council of Ministers of Education, Canada (CMEC)
252 Bloor Street West, Suite 5-200
Toronto, ON, M5S 1V5

CMEC's Vision for Scientific Literacy in Canada

Students need:
- to develop inquiry, problem-solving, and decision-making abilities;
- to become lifelong learners;
- to maintain a sense of wonder about the world around them;

because "advancements in science and technology play an increasingly significant role in everyday life" (p. 5).

CMEC's Aims for Science Education

a. to develop a critical sense of curiosity about scientific and technological endeavours;
b. to use science and technology to acquire new knowledge and to solve problems, for the purpose of improving the quality of their own lives and the lives of others;
c. to critically address science-related societal, economic, ethical, and environmental issues;
d. to create opportunities to prepare for science-related occupations;
e. to convey the wide variety of careers related to science, technology, and the environment. (p. 5)

CMEC's Foundation Statements

1. Students will develop an understanding of the nature of science and technology, of the relationships between science and technology and of the social and environmental contexts of science and technology. "STSE" (Science-Technology-Society-Environment)
2. Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions. "Skills"
3. Students will construct knowledge and understandings of concepts in life science, physical science, and earth and space science, *and apply* these understandings to interpret, integrate, and extend their knowledge. "Knowledge"
4. Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment. "Attitudes" (p. 6)

Table 1. A Developmental Model of Intercultural Sensitivity (after Bennett, 1986)

denial defence minimization	*decreasing ethno-centrism*
acceptance adaptation integration	*increasing ethno-pluralism*