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LESSONS IN LEARNING

The cultural divide in science education for Aboriginal learners

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"The First Nations people view themselves not as custodians, stewards or having dominion over the Earth, but as an integrated part in the family of the Earth. The Earth is my mother and the animals, plants and minerals are my brothers and sisters."

—F. Henry Lickers
Biologist, member of the Turtle Clan of the Seneca Nation

"The greatest challenge to face mankind is upon us. We, as humans, have initiated one of the greatest episodes of mass extinction the world has ever seen. If we are to survive, not only is our way of living going to change drastically within our generation, but we also must take control now to better manage our natural resources, decrease current extinction rates, and so conserve a large portion of our biodiversity. We MUST do this immediately."

—Royal Ontario Museum
Centre for Biodiversity and Conservation Biology

Aboriginal people in Canada are sharply under-represented in science and engineering occupations; more can be done to increase the relevance of learning and engagement of Aboriginal students in science and technology. Choosing careers in science and technology will benefit Aboriginal students directly through employment, but more importantly they can make a tremendous contribution to Canada from the unique perspectives to science and technology based on the values implicit in Aboriginal knowledge and ways of knowing. Past experience has shown that filling positions in science and technology with Aboriginal people is highly desirable, as non-Aboriginal people hired by Aboriginal organizations typically remain in their positions for less than two years. In contrast, Aboriginal professionals remain in their positions much longer and bring stability and pride to their communities.[1,2,3,4,5]

Issues in science education

A cultural mismatch, between the values and philosophy of Western science (particularly as these are typically exemplified in the classroom) and the values and philosophy held by many Aboriginal people and communities, makes the issue of increasing Aboriginal participation in science and technology a particularly thorny one. These cultural differences are nicely illustrated by the quotes given at the beginning of this artilce. The Aboriginal world view (captured by the Lickers quote) sees people, landscape and living resources as a spiritual whole. In contrast, the Western science approach seeks greater understanding through breaking apart the whole and analyzing it into its smallest parts.[6] These cultural differences can create difficulties for Aboriginal students in classrooms dominated by the Western science perspective.

G.S. Aikenhead has described most Aboriginal students' experience with science education "as an attempt at assimilation into a foreign culture."[7] This culture can be particularly foreign to Aboriginal students "whose world views, identities

and mother tongues create an even wider cultural gap between themselves and school science".[8] For example, these world view differences were explored among Kickapoo Indian children studying in off-reserve schools.[9] The work revealed a number of ways in which Kickapoo and Western world views conflict, interfering with Kickapoo children's ability and motivation to learn in Western science classrooms. Kickapoo students prefer cooperative learning rather than the competitive learning environment fostered in Western classrooms. They tend to think holistically about the natural world, whereas the Western science approach is reductionist in that it tends to explain things by reducing complex systems down to the simpler parts. Kickapoo students view time and space as cyclical in nature while these concepts are treated more linearly in Western science. Kinship, harmony, cooperation and spiritualism with respect to the natural world are highly valued by Kickapoo students, while the corresponding Western values are more exploitative, competitive, decontextualized, rational and materialistic. The researchers also found that, in Western science classrooms, Kickapoo students were unengaged and showed little evidence of learning; however, the very same students faced with the very same lessons in a different context (i.e., in their own village) were active, engaged and showed evidence of learning by enthusiastically answering questions.

Aboriginal legend

The Australian Aborigines have a legend about a prehistoric volcanic eruption. The people of Mount Wilson had joined together with the Hawkesbury River and Hartley tribes to cooperate in repelling the attacking tribes of the Hunter River Valley. One night, there was a great earthquake and fire from the volcanic activity rose up from the earth, threatening the lives of the tribes people. The legend tells of one clever young man who covered himself with waratahs and extinguished the volcanic fire.

The story contains information that is interesting and relevant from a Western science perspective: geologically interesting information about ancient volcanic activity and botanically interesting information about the heat and fire resistant properties of the waratah plant. As tempting as it may be from a Western science perspective to focus on these facts to the exclusion of the legend as a whole, it is important to keep the information within its narrative context. Otherwise the connections between various elements (e.g., the connection between seismic activity and the unusually long petiole on the waratah leaf) are lost, as are important social and historical lessons (e.g., about heroism, intertribal cooperation and warfare).

As a result of the cultural mismatch between Aboriginal and Western science world views, many Aboriginal students find themselves forced to choose between three problematic strategies for coping with science education.

1. Students can learn Western science by adopting a Western science world view and abandoning or allowing the marginalization of their Aboriginal values and ways of knowing.[10,11]
2. Students can acquire enough surface knowledge of the material presented in science classes to achieve a passing grade without acquiring a meaningful understanding of the concepts—thus avoiding potential threats to their Aboriginal identity.[12,13]

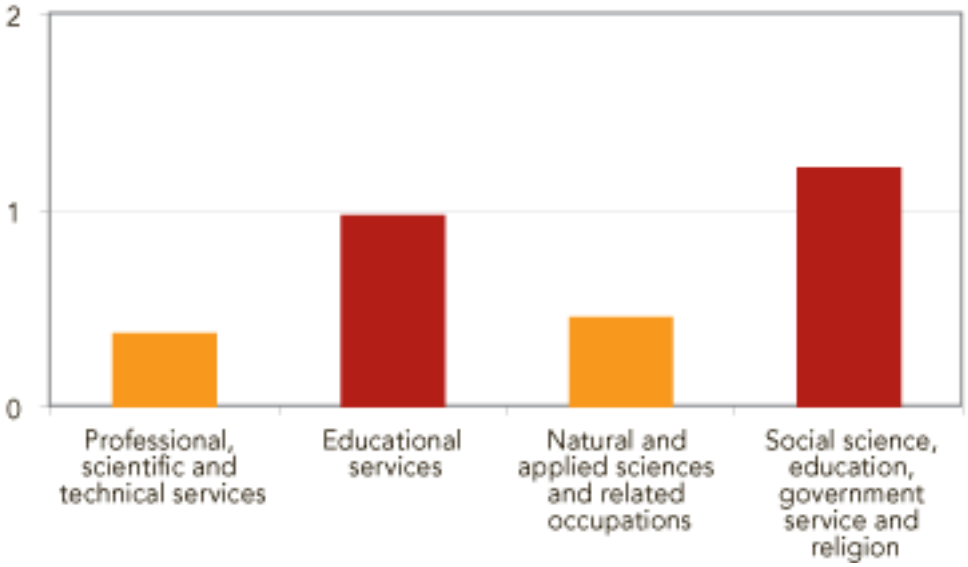
3. Students can avoid learning any science at all and accept the consequent failing grades and/or lack of participation in science education.

None of these strategies is likely to lead to exciting and engaging experiences with science education which may explain the low Aboriginal participation rates in science and engineering occupations, and post-secondary programs.

Under-representation in science and technology occupations and fields of study

There is abundant evidence that Aboriginal people are under-represented in science and technology occupations and educational programs—possibly as a result of the cultural mismatch issues described above.

Figure 1:
Ratios of Canadian Aboriginal to non-Aboriginal participation rates in science and non-science occupations

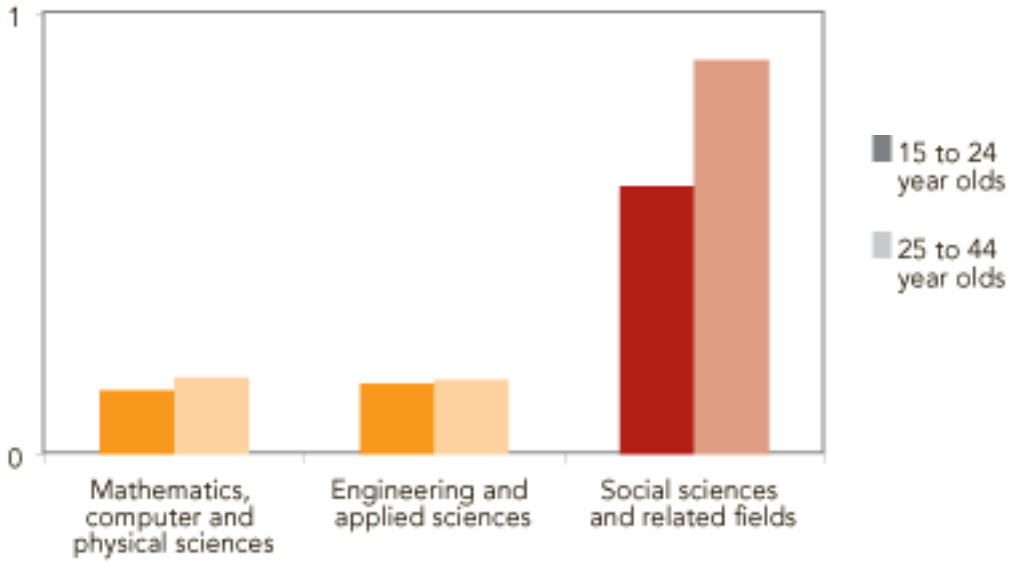


Source: 2001 Census of Canada

The UBC Fisheries Centre, UBC First Nations House of Learning, and the BC Aboriginal Fisheries Commission jointly commissioned a study to explore the causes underlying Aboriginal underrepresentation in fisheries employment. They noted that, despite the prominent role played by fisheries in Aboriginal treaty negotiations, economic activity and cultural identity, in 2002 there was not a single PhD level Aboriginal fisheries biologist in British Columbia. The study identified a number of issues; however, the primary problem seems to revolve around the failure to validate and incorporate Aboriginal values and knowledge at all levels of fisheries training and education.

Aboriginal under-representation in most areas of science and technology is evident both in the workforce and in education. Figures 1 and 2 below, from the 2001 Census of Canada, express as a ratio the proportions of Canadian Aboriginal and non-Aboriginal populations engaged in various occupations and fields of study. Each ratio is the Aboriginal proportion in a given occupational category divided by the non-Aboriginal proportion in the same category. Ratios equal to one indicate that Aboriginal people and non-Aboriginal people participate at the same rates. Ratios less than one indicate under-representation among Aboriginal people.

Figure 2:
Ratios of Canadian Aboriginal to non-Aboriginal participation rates in science and non-science fields of study.

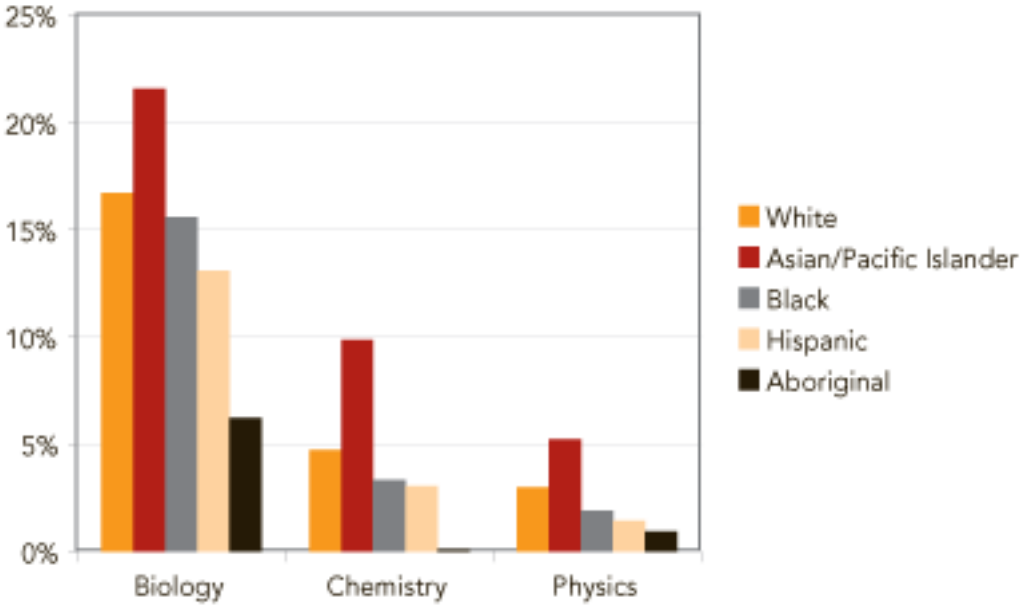


Source: 2001 Census of Canada

The data in Figure 1 indicate that Aboriginal people are significantly underrepresented in both of the categories for science occupations but not in corresponding non-science occupations. Figure 2 indicates that Aboriginal people are significantly under-represented in scientific fields of study but less so in corresponding non-science fields of study.

According to data on the Status of Native Americans in Science and Engineering, in the U.S. of the 3.4 million working scientists and engineers only about 10,000 (0.3%) were Aboriginal people, whereas Aboriginal people comprise 1.5% of the total U.S. population. Also in the U.S., Aboriginal high-school students participate in advanced science courses at a much lower rate than do non-Aboriginal students. Figure 3 shows the percentage of American Aboriginal and non-Aboriginal students taking advanced high-school science courses in 1998 (the most recent year in the High School Transcript Study tabulations). These proportions are significantly lower for Aboriginal than for non-Aboriginal students. Furthermore, Aboriginal participation in these courses is also significantly lower than for other U.S. minority groups, such as Blacks and Hispanics. The available evidence suggests that the situation is no different in Canada.

Figure 3:
* American students taking advanced high-school science courses, by ethnic group



Source: 2001 Census of Canada

Performance on science testing

The results of various types of standardized tests indicate that, in addition to lower rates of participation, Aboriginal people are experiencing lower rates of success in science education. In the 2000 PISA results for science testing, Canadian students were ranked 5th among 32 countries; only Korea, Japan and Finland achieved

* Note: This section represents the language used in the U.S. reports

significantly higher scores than Canada. Non-Aboriginal Canadian students posted a mean science score of 531; however, the corresponding Aboriginal score was 489—dramatically lower than the non-Aboriginal score and also lower than the international average (PISA scores are normed so that the international average is 500). Aboriginal students' performance on the math and reading sections of the PISA tests was similarly lower than non-Aboriginal performance. However, there is some evidence that Aboriginal people experience learning difficulties uniquely associated with science education.

In the U.S., where detailed data from the results of standardized tests are available, Aboriginal students do not appear to develop significant difficulties with their science courses until later in their schooling. In fourth grade testing, Aboriginal students achieve lower scores than their White classmates on standardized science tests, but score higher than Black and Hispanic students. By the eighth grade, however, Aboriginal scores drop further below White scores and remain only slightly higher than Black and Hispanic scores. This trajectory is unique to science. In math and reading, Aboriginal students' scores match Black and Hispanic scores from the earliest testing periods and onward. Furthermore, the science data indicate that Aboriginal children's scores are getting worse over time—falling further below White children's scores and closer to Black and Hispanic children's scores. This trend is particularly strong in the eighth grade science data.

Lessons in learning

Overall, the data suggest that Aboriginal participation in science and technology occupations is unlikely to improve until strategies can be found for producing successful experiences with classroom science among Aboriginal students.

Combining traditional knowledge with Western sciences

Cree hunters and their organizations have held management authority over beaver in northern Quebec since 1975. The Cree hunters have been able to combine their own traditional approach to monitoring beaver populations with a complementary Western science approach in order to generate accurate beaver population measures covering enormous geographic areas. The Cree hunters are skilled at determining the proportion of beaver lodges in a given area that are occupied. On their own, though, they have no way of generalizing this information over the full expanse of their vast territory. Conversely, the provincial resource managers can provide aerial survey data giving an accurate count of the number of beaver lodges over a large area, but these data provide no information concerning the number of lodges actually occupied. Combining these two approaches to population monitoring yields precise counts over large areas.

In New Zealand, Rakiura Maori harvest titi chicks every fall. Through years of observation, Rakiura Maori *titi* harvesters have noticed that chicks tend to be fat during years of high abundance and thin during years of low abundance because chick size and abundance both depend on the adult birds' ability to feed their chicks. Recently, however, *titi* harvesters noticed surprising occurrences in which there were small numbers of fat chicks. When the harvesters drew attention to this event, Western scientists began using state-of-the-art technology to track adult titi over their transequatorial migrations in order to identify the causes of the event. Combining Aboriginal knowledge of normal *titi* patterns with Western technology for studying aberrations in these patterns allowed scientists and titi harvesters to discover that titi were suffering from the effects of global climate perturbations.[24]

A number of lessons relevant to Aboriginal science education can be drawn from a new model or successful Aboriginal education currently being implemented by Antioch University in Washington State. The model is centred on Early College High Schools for Native Youth. High-schools, Aboriginal groups and colleges collaborate to establish these early college high-schools where high school students earn up to two years worth of post-secondary credits while completing their high school diplomas.

In British Columbia, forensic science and traditional ecological knowledge have been used in tandem to explore and validate Aboriginal treaty claims. Within the Gitksan-Wet'suwet'en oral history is a story of how a grizzly bear roared down a mountainside and raised the level of a lake. Rolf Mathewes, a paleoecologist studied sediment cores from the bottom of the lake and concluded that a landslide had occurred as described by the oral tradition. This finding validated the Gitksan-Wet'suwet'en people's claim that they had inhabited their land for over 3,500 years.

Early college high schools incorporate a number of features designed to foster academic success among Aboriginal students. The early college approach bypasses remediation options in favour of setting high standards and challenging students to meet them—while providing appropriate levels of support. Early college students begin taking college preparatory courses in the ninth grade and full college courses in the eleventh grade. Throughout, students receive academic support and individual advising. The schools are small, with no more than 400 students, and they engage family and community involvement while working to deliver culturally relevant curricula.

A small number of early college high schools have been established in Washington State and are showing early signs of success. For example, at the Ferndale Early College, Aboriginal student dropout rates fell from 69% to 16% in 2004-2005. At the Tulalip Early College, graduation rates for Aboriginal students reached 100% in the 2005-2006 school year. Along with higher retention and graduation rates, early college high-schools are also seeing higher student grade point averages, even with their students taking challenging college level courses.

Setting high standards is an important lesson to be drawn from the Antioch experiment. The early college approach is based on the understanding that focussing on high-school graduation "may actually reinforce negative stereotypes and eclipse goals for [post-secondary] degrees" among Aboriginal students. Similarly, a remedial approach that focusses on meeting the minimum science requirements for graduation may discourage Aboriginal students from pursuing post-secondary studies and careers in science and technology. It is important, then, to find ways to encourage Aboriginal students to pursue challenging goals including participating in advanced high-school science courses.

A second lesson involves the importance of providing culturally relevant curricula. One way to accomplish this is to include local Aboriginal values and knowledge in science classrooms. There is good evidence that Aboriginal students benefit from the inclusion of Aboriginal content, but to be effective, such inclusion should be done with care and deliberation.[14,15]

With respect to values, Aikenhead suggests an approach through which Aboriginal and Western science views are treated as valid cultural perspectives. Teachers can assist students in negotiating the cultural boundaries between Aboriginal and Western science values in the following groups:

- Establishing an Aboriginal science perspective that can stand in contrast to the Western science perspective without being treated as inferior to it.
- Making explicit the values that underlie the Aboriginal and Western science approaches to understanding the world. For example, Western science values knowledge for the sake of knowledge and therefore encourages the unravelling of the mysteries of the natural world. In contrast, the Aboriginal perspective places value on learning to live with the mysteries of the natural world for the sake of survival.[16,17,18,19,20]
- Maintaining the distinction between Aboriginal and Western science values, and consistently specifying which set of values underlies the information presented in science lessons.

In addition to facilitating Aboriginal success in science education, this approach can have a wider impact. First, including culturally relevant material within all curricula—not just science—will be broadly beneficial to Aboriginal students. Second, Aboriginal students are not alone in feeling the foreignness of Western science culture: the vast majority of students experience science education as an encounter with an alien culture and can benefit from knowledgeable assistance when crossing the border between their everyday culture and Western science culture.[21,22]

In addition to values, Aboriginal knowledge and ways of knowing can also be incorporated into science curricula. It is important to keep in mind, though, the enormous diversity in Aboriginal cultures across different communities: teaching materials developed in one community will not necessarily be transferable to another community.[23]

Any curriculum that includes Aboriginal content must be flexible enough to accommodate tailoring to fit local knowledge. It is also important to avoid trying to fit Aboriginal knowledge into a Western science framework. For example, the intricately detailed Aboriginal folk-taxonomies may easily lend themselves to a reductionist Western science understanding of the world. However, these taxonomies form the basis for understanding and explaining the workings of complex systems. Thus, much valuable knowledge is lost if they are reduced to isolated sets of facts about individual species. Similarly, many ancient Aboriginal narratives contain information that is likely to be of interest from a Western science perspective, but important dimensions of meaning are lost when these pieces of information are divorced from their narrative context. Aboriginal knowledge cannot, therefore, be blindly added into science curricula without some understanding of Aboriginal ways of knowing. One way to ensure that Aboriginal content remains meaningful is to consult with local Elders about how best to integrate traditional Aboriginal knowledge into school curricula. Elders "are the source for much of the retrieval of Native traditions and culture" (p. 108) and possess knowledge of how best to transmit these traditions to a new generation of learners.[25]

Further inspiration for ways to include Aboriginal content in Western science classrooms can be drawn from ongoing efforts to combine Aboriginal knowledge (or Traditional Ecological Knowledge) with Western science practices. These efforts often involve making use of the complementarities between the detailed, local, long term observations made by Aboriginal people and the quantitative and spatially extended observations made by Western scientists. Examples of successful uses of this complementarity can be brought into the classroom to demonstrate the relevance to everyone of the inclusion of Aboriginal content.

Aboriginal experts

Among his many accomplishments, Aboriginal biologist F. Henry Lickers co-chairs the Haudenosaunee Environmental Task Force, which has been developing strategies to address the environmental concerns of the Haudenosaunee Nations. The task force's recommendations were presented to the United Nations at the Summit of the Elders and the work has been singled out for recognition by the United Nations Environmental Program and the U.S. Environmental Protection Agency.

Chief Simon Lucas of the Hesquiat nation has made great contributions by raising public and government awareness of the vital role of traditional ecological knowledge in understanding marine ecosystems. Chief Lucas co-chairs the British Columbia Aboriginal Fisheries Commission and recently received an honorary degree from the University of British Columbia for his lifetime contribution to fisheries conservation.

Promising starts

The British Columbia Ministry of Education has already begun the process of incorporating Aboriginal knowledge into K-12 curricula. The Aboriginal Knowledge and Science Education Research Project has contributed to the considered and informed integration of Aboriginal knowledge into K-12 science curricula. As well, Aboriginal educators from around the province have created Shared Learnings, a guide to help teachers bring Aboriginal knowledge "into the classroom in a way that is accurate, and that reflects the Aboriginal concept of teaching and learning."

Saskatchewan Learning funds the Aboriginal Elder/Outreach Program to bring Aboriginal Elders, cultural advisors and other Aboriginal resource people into schools and to link students to Aboriginal traditions and knowledge.

Researchers at the University of Saskatchewan have created and assembled teaching materials entitled Rekindling Traditions in consultation with Aboriginal Elders to integrate Aboriginal knowledge into science education for grades six through twelve and to foster students' understanding of both Aboriginal and Western science.

In 1997, the BC Aboriginal Fisheries Commission, together with the UBC Fisheries Centre and the UBC First Nations House of Learning, committed to making concrete efforts to include Aboriginal people in fisheries science and policy-making. These efforts include finding ways to increase enrolment of Aboriginal students in graduate programs, and exploring practical and respectful ways by which Aboriginal traditional knowledge can contribute to conservation and management.

Aboriginal scientists who can draw on the strengths of both traditional ecological knowledge and modern Western science stand to make tremendous contributions to Aboriginal and non-Aboriginal communities in Canada. The contributions already made by Aboriginal experts provide clear evidence that Aboriginal people can bring an important and unique perspective to science and technology and all Canadians will be well-served by the increased participation of Aboriginal people in science and technology careers.

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