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We connected youth of the Mushkegowuk Territory (specifically Fort Albany First Nation) with environmental science and technology mentors in an outreach program contextualized to subarctic Ontario that addressed some of the environmental concerns identified by members of Fort Albany First Nation. Most activities were community-based centering on the general theme of understanding a changing environment (e.g., long range transport of contaminants, global warming, and postglacial isostatic rebound); however, our initiative also included an annual trip for Grade 8 students to the Ontario Science Centre and the Royal Ontario Museum in Toronto, Ontario, to expose students to science in an interactive, fun setting. We found that informal educational settings, resources that relied on spatial/visual cues, group activities, and hands-on and experiential teaching were effective in engaging the schoolchildren. Our hope is that some of the students that attend our community-based camp will pursue a postsecondary education in the environmental sciences.

Substantial progress has been made within the last three decades to improve the state of North American Native education. Improvement has been attributed, at least in part, to the establishment of Native-administered primary and secondary schools as well as postsecondary institutions (Barnhardt, 1991; Brady, 1991; First Nations University of Canada, 2007; Kleinfeld, McDiarmid, & Hagstrom, 1989; McCarty, 1989; Reyhner, 1993), the establishment of Native counselling services and support groups (First Nations University of Canada, 2007; Kirkness & Barnhardt, 1991; Wright, 1998), the training of more than 3,500 Native teachers, some in their own communities through special outreach programs (Barnhardt, 1991; Hampton, 1993; Queen's University, 2007), and the use of more culturally relevant curricula (Dick, Estell, & McCarty, 1994; Feurer, 1993; First Nations University of Canada, 2007; Lipka, 1990; Wilson & Wilson, 1995). Nevertheless, there is an under-representation of Native post-secondary graduates in environmental science and technology (CASTS, 2007). More Native professionals in these fields are required now and will be required in the future (Hampton, 1993; Krebs, Hurlbert, & Schwartz, 1988)—to deal with a rapidly changing environment—as the fates of Aboriginal people are more intimately intertwined with the environment than that of non-Aboriginals (McDonald, Arragutainaq & Novalinga, 1997). In the past, indigenous knowledge was used to predict environmental phenomena, such as, weather (McDonald et al., 1997); however, anthropogenic activities have changed the environment to the extent where the use of either "science" or indigenous knowledge individually is inadequate to address complex environmental issues (Tsuji & Ho, 2002). These knowledge constructs must be used as complementary systems (Tsuji & Ho, 2002). Thus, there is a need to train a generation of First Nations students who are skilled in both knowledge systems.

To take the first step in engaging/interesting schoolchildren from Fort Albany First Nation of the Mushkegowuk Territory in environmental science, we organized a community-based science and technology camp for First Nation students employing culturally appropriate educational strategies. We use the term culturally appropriate educational strategies to identify any factor related to curricula, resources, instructional practices or learner characteristics that have been shown to lead to greater academic success of Native students. In this paper, we address the question, "How can we make university-based scientific knowledge relevant in an Indigenous context?"

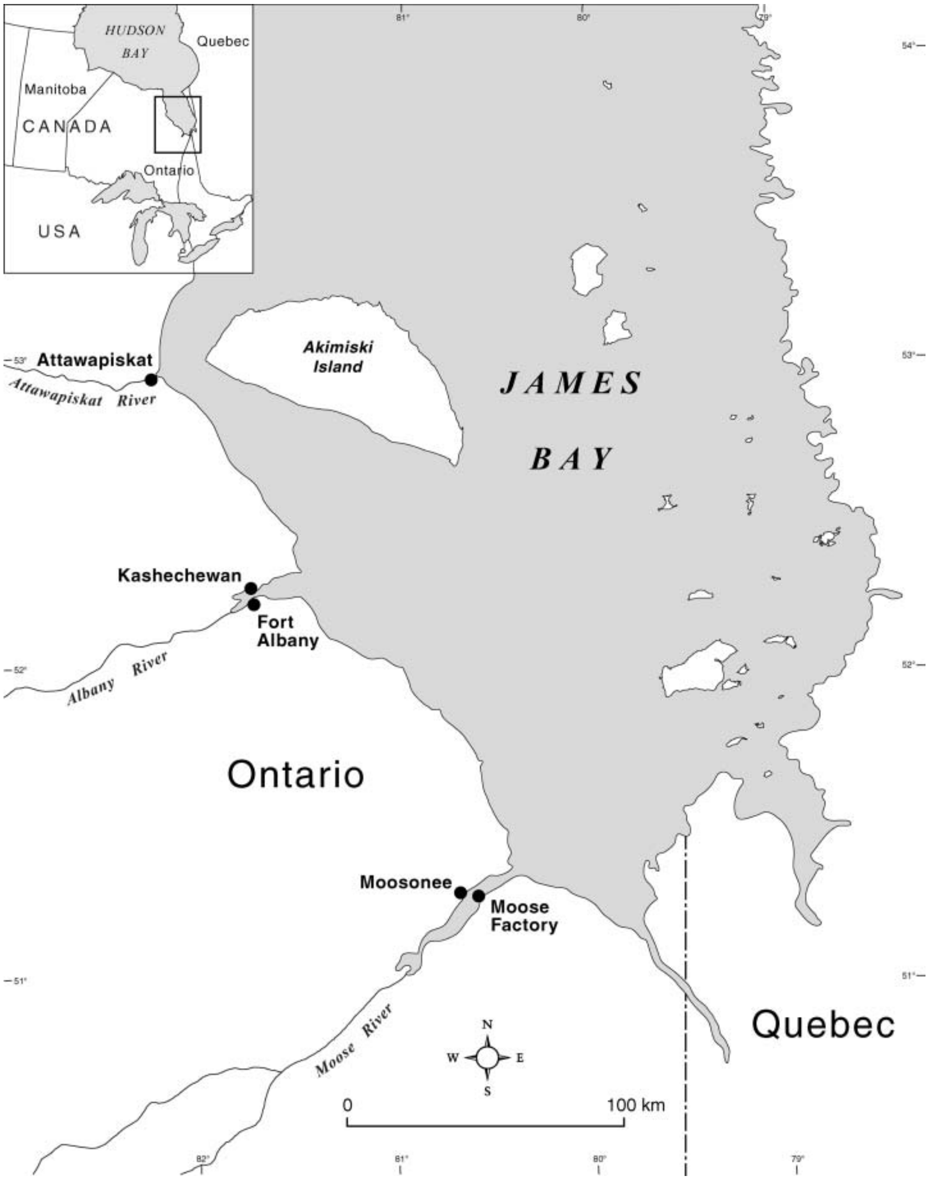

Fig. 1. Map of the Mushkegowuk Territory in western James Bay, Ontario, Canada. The study was undertaken in Fort Albany First Nation, a community of about 850 people.

PROJECT DESCRIPTION

The Mushkegowuk Territory

Approximately 10,000 Omushkego Cree reside in the western James Bay region (approximately 52°N and 81°W in Ontario, Canada) of the Mushkegowuk Territory, in four coastal First Nations (Moose Factory, Fort Albany, Kashechewan, and Attawapiskat; Fig. 1), and the community of Moosonee. Fort Albany is a community of about 850 people, situated on the south bank of the Albany River about 15 km west of James Bay. The Mundo Peetabeck Education Authority is the administrative wing of Fort Albany First Nation that deals with educational matters related to Peetabeck Academy, the community elementary and secondary school.

Connecting Youth of the Mushkegowuk Territory with Environmental Science Mentors

Successful programs in First Nation communities require continuity (Tsuji & Katapatuk, 2007). The outreach program described in this study ran from 2006–2009 and all mentors associated with this project have a long association with the Mushkegowuk Territory with respect to environmental science issues. For example, mentors have been involved in environmental contamination research (e.g., Tsuji et al. 2005; Tsuji & Karagatzides, 1998), ornithological research (e.g., Tsuji & De Iuliis, 2003; Tsuji & Karagatzides, 2001), global warming research (e.g., Gough, Cornwell, & Tsuji, 2004), and postglacial isostatic rebound research (Tsuji, Gomez, Mitrovica, & Kendall, 2009). Continuity played an important part in establishing familiarity and trust and the outreach initiative strengthened already established linkages.

Engaging Youth in Grades 6 to 8 in the Fort Albany First Nation

Noncommunity members of the outreach team visited Fort Albany in August 2006, 2007, and 2008 to conduct the science camps. Twenty students were registered each year although ~12 students actually participated each year. In addition, a total of ~20 Grade 8 students from Fort Albany traveled to Toronto in June 2007, 2008, and 2009 to visit the Ontario Science Centre and the Royal Ontario Museum (ROM).

The science and technology camp primarily targeted Grades 6 to 8 First Nation students. We targeted this group of schoolchildren after community consultation because high-school drop-out rates are high in Fort Albany First Nation; thus, we had to consider that targeting high school students may have been too late as many students may have already left the school-based educational system. An objective of our program was to keep students interested in school (and environmental science) long enough for them to make informed decisions about postsecondary education.

The types of educational strategies that we employed were adapted to be culturally-appropriate to optimize the learning experience and engage the youth (Table 1). Each activity in our outreach program was contextualized to the Ontario region (and more specifically to subarctic Ontario) and addressed environmental concerns identified by Fort Albany First Nation with direct relevance to their culture. In addition, each activity was an extension of research being conducted in the Ontario region by members of our outreach team. Hopefully, First Nation youth saw the relevance and direct relationship of environmental science to their way of life; that is, the students were introduced to applied science in a natural setting rather than a didactic construct.

Table 1
Educational strategies shown to result in greater Native student success

- the use of informal educational settings
- the use of resources that rely on spatial/visual cues
- the outreach team acting as guides/facilitators
- the use of group activities
- stressing of collaborative learning rather than competitive
- peer teaching and learning
- the use of hands-on and experiential teaching
- the use of relevant resource material
- decreasing the amount of formal lecturing time
- avoidance of "spotlighting" (i.e., not singling out a student)
- the use of multimodal instruction

(Dick, Estell & McCarty, 1994; Dumont, 1972; Feurer, 1993; Foreman, 1991; Irwin & Reynolds, 1992; Leith & Slentz, 1984; Miller & Thomas, 1972; Moore, 1987; Pepper & Henry, 1986; Rhodes, 1988; Sawyer, 1991; Wilgosh & Mulcahy, 1993; Wilson, 1992; Wright, 1998; Zwick & Miller, 1996).

A DESCRIPTION OF OUTREACH ACTIVITIES: UNDERSTANDING A CHANGING ENVIRONMENT

Long Range Transport of Contaminants and Effects on Whole Ecosystems

During summer camp, long-range transport of contaminants was discussed with particular emphasis on acid rain. Carnivorous pitcher plants (*Sarracenia purpurea*) living in muskeg around Fort Albany (and throughout Canada and the eastern United States) provided a model microecosystem to examine the effects of acid rain in an entire food web. Pitcher plants are long-lived perennial carnivorous plants that grow as rosettes of leaves. The leaves are modified into pitfall traps (pitchers) that fill with rainwater, in which captured arthropod prey drowns. The water-filled leaves are inhabited by detritus-based food webs consisting of bacteria, protozoa, and invertebrates. This food web decomposes captured prey in *ca.* 2-wk and the mineralized nutrients are released for uptake by the plant.

There were two field and one laboratory component to the outreach activities of carnivorous plants. First, students established pit-fall traps in three different ecosystems to examine insect communities in relation to vegetation structure. Second, students examined sample pitcher plants in a laboratory setting to obtain a basic sense of plant morphology (leaf size and shapes) and food web structure. *Sarracenia* provides immediate information about the health of the environment in that keel size (pitcher morphology) is a strong bioindicator of environmental conditions and acid rain whereby plants in acid rain-stressed environments have a large keel size and small openings in the pitcher. This reflects the added nitrogen obtained from acid rain and a smaller investment to trap prey (Ellison & Gotelli, 2002). Students began to understand the importance of food webs and that long-range transport is a source of contaminants especially in the north. Each student was provided with a pitcher plant that had a full, intact food web in multiple pitchers. Students learned that there exists "worlds within worlds." Students were allowed to compare their observations with other students in the group to illustrate variation in food webs between plants. This was followed by a field trip to a local bog which allowed the students to examine pitcher plants and their associated food webs in situ. Students also found evidence of plant herbivory by moths that feed on the pitchers, underground tubers and flowers. The laboratory and field survey also included sundews (*Drosera* spp.), another carnivorous plant but with a different trapping mechanism (sticky pads vs. water-filled pitcher-shaped leaves of *Sarracenia*). Students examined the interaction between the carnivorous-plant species and learned that both types of carnivorous species compete for prey. Indeed, students observed a sundew trap growing right at the mouth of a *Sarracenia* pitcher indicating competition for the same prey.

Paleontology

An introductory lecture in the classroom provided a background to paleontology (e.g., osteology, anatomy, stratigraphy), so that students understood the basics of this scientific discipline. A discussion followed on how paleontology can be used to understand not only how environments have changed over time but also how animals have changed. The lecture helped build a picture of the interactions of flora and fauna with the physical environment. Students gained a broader appreciation of biology especially in the historical framework of life and earth history. Thus, the central unifying concept of environmental change was incorporated into our consideration of science. Students were then asked if they or their families had found either fossils and/or bones.

Paleozoic fossil localities were prospected with the students, mainly on natural outcrops along the Albany River but also in quarry sites being used for gravel production. The typical fossils of the region provided the basis for discussing environmental change, evolution, and the main groupings of organisms. The types of fossils collected by the student illustrated that the Mushkegowuk Territory was once covered by a large inland sea; marine fossils were collected by students in present day areas devoid of water or where only fresh water was nearby. Students had to relate their introductory experiences in the field, to what they learned inclass. Hands-on fossil activities also took place under a laboratory setting at the school where students used air scribes to remove fossils from their stone matrix. Students particularly enjoyed the fossil-related activities:

> I like going up the dikes to look for fossils. It was fun. I found three fossils. I also liked learning about the fossils. I liked going to science camp because my friends went there too. (Grade 6, female student)
>
> In summer camp, I really liked learning about fossils, collecting them and cleaning them. I liked using my hands and helping out others drilling out the fossils. (Grade 7, male student)

The summer science camp and field work experience prepared youth for the site visit to the ROM and contextualized the experience. At the ROM, Grade 8 students were able to view fossil collections behind the scenes to examine material not open to the public. Students continued to develop an understanding of the scientific method by learning how fossils and specimens they collected during their summer fieldwork experience were analyzed and investigated by ROM scientists. Youth spoke with ROM academics about their work, examined fossil material, and other ROM specimens. ROM academics Dave Rudkin and Janet Waddington kindly gave presentations and also acted as guides.

Post-glacial Isostatic Rebound

During science camp, a slide show using pictures and animations introduced students to geophysical processes in the James Bay region. In particular, we discussed continental drift, structure of the Earth, plate tectonics, the last ice age, and post-glacial isostatic rebound to illustrate how the land beneath Fort Albany has moved since the distant past and how it might evolve in the future.

The land rebounding after the weight of the ice sheets had been removed results in sea-level change and shoreline movement which has been well been known since time immemorial, by the indigenous people of the Hudson and James Bay region (McDonald et al., 1997). It was explained to the students that post-glacial isostatic rebound was the reason why they found marine fossils so far inland and why shoreline ridges can be found inland. It was also discussed and shown how islands in James Bay will become part of the mainland (Tsuji et al., 2009). Each student was also given a piece of Silly Putty® so that they could manipulate the putty in their hands to emulate the different ways in which the materials of the Earth's crust can behave. In 2008, this module culminated in a special field trip to James Bay during low tide where some had never been during summer and none during low tide, as this type of trip usually depends on the tides and water levels in the river. This trip was used to reinforce to students and mentors the flatness of the region and that even a small amount of uplift in the vertical direction makes a huge difference in the horizontal direction. That is, the amount of land that becomes exposed due to postglacial isostatic rebound is immense.

Migratory Birds, Avian Flu, and Global Warming

The wildlife and habitat of the James Bay region has the potential to be greatly impacted by recent changes in climate, namely global warming and the spread of pathogens such as the H5N1 strain of avian flu. How these environmental changes may affect the traditional way of life is of importance to First Nations. Topics that we covered included: (a) Identification of bird species and bird-habitat associations in the James Bay region, emphasizing the importance of breeding and staging areas to bird populations. (b) Warmer temperatures were discussed with respect to the time of spring snow-melt, length of growing season, freeze and thaw dates, and winter temperatures. Warmer temperatures were related to earlier migration and advanced breeding schedules of birds in North America. The harvest of migratory game birds is a way of life in the Mushkegowuk Territory; thus, understanding the changing game bird migration pattern is a growing concern. (c) Avian flu was discussed in the context that this virus is expected to reach North America through the mingling of North American and Asian migratory bird populations. Avian flu has the potential to drastically affect North American waterfowl, which are important sources of food for First Nations of the James Bay region. In-class instruction included illustration of the major migratory flyways of birds (namely the East Asia/Australian, Pacific Americas, Mississippi Americas, and Atlantic Americas flyways) which showed how the H5N1 virus may be carried around the world.

Field trips by boat to the mouth of the Albany River and into James Bay allowed students to observe migratory birds. The wetlands of the western James Bay are one of the largest in the world and host to a variety of migratory birds during the late summer-fall migration. Students were expected to apply what they learned during the class lecture to the field experience. Also, shorebirds were emphasized as the children know less about the general biology of these species as these birds overwinter around the world, unlike waterfowl.

Satellite Imagery

Remote sensing and mapping are powerful tools that help quantify and analyze components making up more complicated systems. Remote sensing and mapping is an applied science that may be appealing to students more concerned with practical applications than with theoretical constructs and to students with a sense of spatial relationships.

The first lessons examined the orientation of satellite imagery from small-scale coarse resolution imagery showing the general region of South-Western James Bay down to high resolution imagery showing sharp detail of the Fort Albany First Nation community. Next, the basics of mapping were introduced such as orienting the imagery with north at the top of the image map, proper labeling, and concepts of scale. The students were asked to locate features of interest in the imagery such as their house, a friend's house, and distances to school, stores, and the hospital. The lessons were concluded with an overview of multispectral imagery where the color infrared band was used to help determine types of vegetation as well as the relative health of vegetation. Vegetation growing under stressful conditions was identified and associated with soil disturbances adjacent to the refuse dump and prior excavation and containment of polychlorinated biphenyls. Students and Elders (who visited the summer camp) quickly oriented themselves with satellite imagery and easily identified features of interest using color, texture, and proximity cues.

DISCUSSION

We believe that we incorporated in our outreach initiative the four Rs that Kirkness and Barnhardt (1991) believe necessary for success in Native education: respect for Native cultural values and traditions; relevance to Native perspectives and experiences; reciprocity in relationships; and student empowerment by taking responsibility for their own education. We showed respect for First Nation culture by making university-based scientific knowledge matter in an Indigenous context rather than vice versa. The learning environment for schoolchildren was made more congruent to the traditional learning environment by having activities in familiar outdoor surroundings (Brewer, 1977; Rohner, 1965; Swisher, 1990). In addition, we showed respect for First Nations traditions by taking into account *when* something was presented as this factor is as important as the *"what"* and *"how"* factors (Butterfield, 1983; Tafoya, 1995; Tsuji, 2000). For example, our component on migratory birds had to be coordinated to the rhythm of the seasons and not the school calendar; Elders teachings typically follow the rhythm of the seasons (Couture, 1985; Tafoya, 1995; Taylor, Crago, & McAlpine, 1993). With input from the First Nation, we contextualized our outreach activities to the home community and surrounding region. Research in cognitive psychology suggests that knowledge is better remembered in the context it was originally learned (e.g., Godden & Baddeley, 1975).

The outreach initiative was relevant in that many of the activities were related to issues the community identified as being of importance (e.g., environmental contamination, avian flu, and postglacial isostatic rebound). Further, as the issues are covered in more depth in each subsequent year, reflective thinking is stimulated. Reflective thought or the spiral learning process has been described as culturally important for Native people (Moore, 1987; Rhodes, 1988). As described by Tafoya (1995), content material (e.g., Native stories or legends) do not change but a persons interpretation does change, dependent on changing experiences of the person. Prior experience was given relevance with our program.

Reciprocal relationships existed between mentors and students in that students learned from the mentors, but mentors also learned from the students. This was especially true on the field trips when student knowledge about the environment was often quite extensive. Also, academics have long been criticized for taking from Native communities without ever giving anything back (Medicine, 1995); it was our opportunity to give back to the community in a more meaningful way.

It should be stressed that summer camp outreach activities occurred during late summer when school was still not in session. Thus, students who registered for the outreach camp did not have to attend as this was their holiday time; students chose to attend the camp. Students took responsibility for their own learning and enjoyed themselves. As discussed by Leo Loone (former Deputy Chief of Fort Albany First Nation), who accompanied the children during some of the activities:

> I think it is really constructive for our young people that are taking the science camp, experiencing that, seeing different things that they can learn about out on the land . . . [the camp] is a good thing. Because we are so isolated up here, kids do not have the opportunity to learn about different stuff. It is good to have people come in [to the community] to do that sort of thing . . . I think in time, they [the students] learn more that sets a seed in their mind to pursue that career where they can become a scientist or whatever—a really positive thing for our youth and our community—it is really good. I really appreciate what is being done for the kids . . . my grandchildren are always keen on attending . . . I think the hands-on approach to learning is very helpful for these kids, especially the ones that are problematic in school. It is not that they are a problem, but just that they want to really grasp the tools to begin to learn. When they are sitting in class with just paper and pen, I think it gets too boring for them. And now they have the experiential technique to learning . . . I heard Elders say the best way to learn is from actually doing things.

Even in the urban setting, the students enjoyed the hands-on approach to learning and the freedom given to them, as is evident from the following passage:

> At the Toronto Science Centre, I liked best touching stuff and learning. I also liked that I got to do things without people telling me what to do. (Grade 8, male student)

We believe that student interest in our outreach initiative was high because of our adherence to the four Rs of Kirkness & Barnhardt (1991): respect, relevance, reciprocity, and responsibility. Indeed, if you refer to our website (www.leonardtsuji.ca and select the "science outreach" link and select one of the photographic folders), you will see photographs of engaged, motivated students enjoying themselves. During the outreach initiatives, students became more aware that the environment is ever changing through both natural and human processes, and how these environmental changes might impact their traditional way of life and communities in general. It is our hope that in ten years, we will see some of the schoolchildren who attended our outreach initiative presenting their work at the Canadian Aboriginal Science and Technology Society conference.

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