Chapter 3 - “Coming to Know”: A Framework for Indigenous Science Education

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In developing a framework for Indigenous Science education, we explore the assumptions and beliefs that form the basis of an Indigenous worldview. The concept of “coming to know” is a term used to describe the process of developing understanding in Indigenous Science (Cajete, 2000; Colorado, 1988; Peat, 1994). Peat describes coming to know as “entering into relationship with the spirits of the people” (p. 65). Coming to know reflects the idea that understanding is a “journey, a process, a quest for knowledge and understanding” with all our relations (Cajete, 2000, p. 66) and there are responsibilities attached to the application and sharing of this deep understanding.

“Coming to know” requires the individual to personally reflect upon and conceptualize the balance between his or her own Indigenous Knowing and the views presented in Western Science. The personal reflection is consistent with Ermine’s (1995) description of an Aboriginal epistemology:

> “In their quest to find meaning in the outer space, Aboriginal people turned to the inner space. This inner space is that universe of being within each person that is synonymous with the soul, the spirit, the self or the being. (p. 103)

The journey to understand the reality of existence and harmony with nature is obtained by calming the mind, turning inward, and achieving an inter-play of human and more-than-human consciousness. Sheridan & Longboat (2006) connect the journey to achieving harmony with nature with long-resident cultures in vast territories, “The sacred ecology of mind is a consequence of long residence in traditional territory and enduring spiritual and intellectual relationships between people, clans, and landscape” (p. 365). From a Haudenosaunee or Mohawk perspective, we notice that the traditional territory was a bountiful reality:

> “… the territory or ecosystem was itself a longhouse, with the sky as its roof, the Mother Earth as the floor and the setting sun and the rising sun as the doorways of the Longhouse …. Thinking with and believing in the diverse minds that assemble ecosystems allows humans to understand what their animal teachers and spiritual helpers guide and instruct, in the ways of ‘being’ of the continent. (p. 368)

Coming to know the use of fire, agriculture, the ancient fish wheel, key migration routes of the many types of salmon and developing sustainable harvesting technologies and practices were among the first elements of science. For example, as the salmon travelled their migration route, each salmon species was dried for preservation in a different way because of the varying fat content and with the different wind conditions. Humans live in relationship with nature and with plants, animals, forests, mountains and oceans. Humans need to pay attention to

key "ecological" relationships and responsibilities to the natural world, including an understanding of the order and cycles of nature and having a sense of how things began and how things are in the natural order:

> From this view, science becomes essentially a story, an explanation of the how and why of the things of nature and the nature of things. The human mind as an extension of nature and as Creator of story becomes the fertile ground where myth, science, and our human perception of reality meet. (Cajete, 2000, p. 13)

Thus, knowledge is contained in the web of stories told to children during family and community gatherings, stories that span time from when the world was coming to be.

Sutherland and Henning (2009) describe how explanations of Aboriginal epistemology must be applied to school science education, "Indigenous students need the latitude to reflect upon multiple dimensions of the world in which they live in order to develop the advanced critical thinking necessary for a greater understanding of the nature of Western Science and Indigenous knowledge" (p. 176). In fact, all students and perhaps all of us need to have this opportunity.

Indigenous Worldview

A key to understanding IS and WS is the concept of worldview. Cajete (2000) defines worldview as "a set of assumptions and beliefs that form the basis of a people's comprehension of the world" (p. 62). Although Indigenous peoples come from diverse cultural contexts, there is a shared worldview, in which humans are intricately connected to the natural world (Michell, 2007; Michell, et. al., 2008; Battiste, 2000, 2002; Kawagley & Barnhardt, 1999). An Indigenous worldview provides the filter, the lens from which place-based epistemologies, methodologies, and pedagogies can be articulated.

A fundamental attribute of Indigenous worldviews reflects a belief in the innate consciousness and spirituality of all things in the environment. Because of this central concept, respect for other life forms is an essential component of an Indigenous worldview, both biological and non-biological. Respect is expressed in words of praise, acknowledgement, and thanks offered to plants and animals as they are harvested and during their preparation and use (Turner, 1997, 2005). Taken together, we are all one family.

Indigenous worldviews are conveyed via stories, symbols, models, and metaphors and expressed unconsciously or consciously through family, community, art, the media, spirituality, and educational institutions; all of which guide the people in respectfully caring for each other and all their relations. The stories contain the historical events that transformed the earth over time, and the guiding principles for good relational living. The stories metaphorically relate central ideas of interdependence and respect for plants, animals, places, and for those behaviours that each generation must learn in order to maintain a reciprocal relationship with the natural world.

Principles of Indigenous Science Education

Outlined below are six principles or themes that we believe characterize the cultural forms of Indigenous discourse and, thus, represent the nature of science from an Indigenous worldview. We believe that these principles

would be applicable in any Indigenous Science program or curriculum. Because IS is holistic and not easily subject to fragmentation, all of the principles discussed here are interrelated and can be considered in delivering all curriculum. In the words of Nuu-chah-nulth Elders *"hishuk ish tsawalk"* (everything is one) (Turner, 1997, p. 276). The first four principles are outlined in Snively and Williams, (2006, p. 122-123).

Place-based Knowledge

According to Christie (1991), "the most fundamental principles taught by Indigenous Elders is that our subject matter is to be examined and interpreted only as it is found embedded within its context. This is in marked contrast with WS where environmental influences are considered confounding" (p. 29) and where scientists do their most serious work most often in an indoor laboratory. Indigenous peoples closely identify with their ancestral lands because of their deep associations with their resources and because of their long-term occupation of particular areas—probably thousands of years (Turner, 1997, 2005). Everything is connected in a web of relationships. Nothing exists in isolation. Indigenous people over millennia have strived to live in harmony with all living things in their environments. They learned the rhythms of each being in their ecosystems and how each life form, including their own, depends on each other and becomes another. Science knowledge amongst Indigenous people is not taught as a pre-planned lesson, but learned through working and walking alongside the older more experienced family or community members.

Multiple Perspectives

A second principle the Elders teach is that we are not so much meant to discover the one true picture of reality, but rather we are meant to construct the fullest and clearest picture of the situation we can by integrating our best collective knowledge. The more viewpoints and ideas included the more complete and meaningful the picture will be. Knowledge embedded in context and interpreted from a network of perspectives has the opportunity to be rich in metaphors. It is not only the perspective of the people engaged in the dialogue whose views must be taken into consideration, but ideas are always examined against views of the ancestors embedded in peoples' memory and in the stories, songs, and dances. Equally, the viewpoints include future generations and how current decisions will affect them and their world. Each member of the group finds the best place to contribute to the overall fabric of the combined work. All contributions are seen to be of value, which in turn encourages individuals to be thoughtful and respectful in their contributions.

A Living Conscious Universe

In the Indigenous world, everything of Mother Earth possesses a spirit. This spirit is conscious and has awareness—the wind, water, stars, frogs, rocks, smoke, people, cedar trees, salmon, and killer whales possess a spirit. Everything in the universe lives and has its own place (Cajete, 1999, 2000; Deloria, Jr., 1995; Kawagley, 1999; Little Bear, 2009). In the Andean life-world, the relationship between nature and humans is familial and full of feeling: "Everything in the world is alive, everything is a person, everything speaks. Nature has a voice. Nature expresses itself through signs" (Ishizawa & Rengifo, 2009, p. 68). If you are going to gain knowledge over something you have to look after it; to make yourself ready to have that knowledge, you must form a respectful and positive relationship with self and everything around you. This expression of the relationship between humans

and nature is shared with Indigenous peoples on every continent. Humans cannot place themselves before or above other life forms.

As Nancy Turner (1997, p. 278) explains, "there are also imperatives to share resources—and for the other life forms to share themselves with humans." Turner quotes Nuu-chah-nulth scholar Richard Atleo:

> Ceremonial preparations for Nuu-chah-nulth whaling and other forms of hunting, for example, were intended to supplicate the animal being hunted to recognize and acknowledge the needs of humans and yield itself willingly to the hunters. (personal communication, to Turner, 1994)

The concepts of relationships and interconnections cannot be taught without acknowledgment of the spirit, as outlined in the document, *Aboriginal Perspectives into the Teaching and Learning of Science Education: Beginning the Conversations in Southern Saskatchewan* (Sammel, 2005):

> The concept of spirituality for Aboriginal cultures is similar to that of many of the world's cultures, in that the spiritual infuses the person's entire existence and underpins how one relates to the world. Saskatchewan Aboriginal cultures acknowledge that a spiritual person cannot make sense of anything in isolation from their spiritual path, which is why the philosophy of interconnectedness cannot be taught without acknowledgement of the spirit. (p. 22)

The philosophy of a conscious living universe encourages the individual to move towards experiencing connections to themselves, their family, the community, societies, and the earth.

Focus on Balance and Harmony

The Elders teach that plants, animals and the elements are embraced by Indigenous peoples as kin and are given an active role in the production of knowledge. Amongst the Nisga'a of British Columbia (BC), for example, if you observe the Bear Teacher in the woods, you will know what you can eat and what you cannot eat. It turns out that the physiology of bears is similar to that of humans, so if a bear will not eat a particular berry, it is likely also poisonous to humans. Taking more than you need upsets the balance of nature. Unlike WS, which tends to emphasize dominion and control over nature, IS de-emphasizes one's sense of self-importance in the web of life. Indigenous people give thanks for all life, to the sun, water, wind, earth, animals, plants, and minerals. This simple practice helps humans live in harmony and balance. If everything is interconnected, what you do to the part affects the whole. A common practice before entering the forest to hunt or dig roots or before setting out in a boat on the water is to stop and consciously remove feelings of anger, all negative feelings, so that those negative energies don't upset the balance. Humans have a role and responsibility in maintaining the balance within themselves, the family, the community, the earth and the cosmos.

Cycles and Circles

According to Hanohano (1999), the journey towards harmony and balance in Indigenous education begins with the sacred circle. Cycles and circles can be seen in the relationships of all things: seasons, migrations, life cycles, food chains, tidal cycles, interdependence of all life, the movement of the sun and moon in relation to the earth, and the earth in relation to the universe. Time is perceived as cyclical rather than linear. The predictive value of cyclical time permeates Indigenous Science. Turner (1997) explains how close observation of the life cycle and seasonality of plants and animals allows the use of ecological indicators to determine harvesting readiness.

For the Sliammon, the arrival of sandhill cranes in March indicated the onset of herring spawning. The full blooming of ocean spray, usually in late June, announced the peak of plumpness and flavor of butter clams (Elizabeth Harry, personal communication, 1993).

The circle of life speaks of the interconnectedness and the interrelationships of all life. All beings are viewed as interdependent and part of a greater whole. Wholeness is the perception of the undivided unity of life forms.

Interactive and Reciprocal Relationships

When Indigenous people practiced seasonal travel throughout their lands, they took only what they needed from each place of their lands, carefully harvesting so that the resource could continue to regenerate itself; and the harvesting encouraged health and well-being. Humans observed how all life on the land was impacted by climate, weather, soil, and available water and harvesting. If an area became over harvested, they let that land heal itself. The stories people told and continue to tell are of the conditions observed as they travel the land. Humans learn to live in harmony with the land; nurturing and protecting the land as the land nurtures and protects them. Turner (1997) explains how Indigenous ideologies enforce sustainable use of resources:

> The concept of interactive relationships is expressed in the recognition that the plant, animal (or object) has the power to influence the life of a person using it. If appropriate respect is not shown, the person might be harmed; if praise and gratitude are expressed, the person can expect to receive help and good fortune. Nothing is regarded as mere food and nothing more. Not a single plant or animal or object is looked upon as something the harvester has secured for himself by his own wit and skill. He regards it rather as something which has been voluntarily and compassionately placed in his hands by the object itself. (p. 278)

As described in Corsiglia and Snively (1997), the Nisga'a people of BC developed procedures for maintaining the ecological integrity of their valley:

> One such caution instructs novice salmon fishers to consume all edible parts and return all unused wastes to the river Nass. Nisga'a people explain that the fish need the smell of the salmon remains in order to have a proper scent trail to find their way home from the open ocean. If we do not return the salmon remains to the river, the fish will feel insulted and will not come back …. Later, when a cannery was allowed to

> operate on the Nass, the Nisga'a required the cannery operators to return the wastage to the sandbars in order to create a natural "scent trail"…. This practice, along with the Nisga'a persistent petitioning of governments to address problems associated with White economic activities in the valley—is quite likely to have contributed to the survival, to date, of all the Nass River fishes that return from the sea to spawn. (p. 24)

To guarantee that the quality of sharing is deep-rooted the practice of sharing is embedded in everything such as ceremonies, food distribution, and work distribution. Giving and receiving are both practiced, just as to nurture and to be nurtured by the land is a reciprocal relationship. From an early age and every stage of life people are encouraged to give easily and not to hoard.

Components of an Indigenous Science Education Model

A review of the literature on First Nations, Inuit, and Métis learning identified several attributes of Indigenous teaching and learning. The six cultural themes or principles that characterize the cultural forms of Indigenous thought, or worldview, were placed alongside the attributes of Indigenous learning identified in the literature and explored with culture keepers. These principles and attributes stand tall in their own right as coming from an Indigenous worldview. The following is an overview of what we conceptualized as the key components of learning science from an Indigenous perspective.

Elders are Keepers of Knowledge

Elders and knowledge keepers play a key role as facilitators of lifelong learning. They teach responsibilities and relationships among family, community and creation, reinforcing intergenerational connections and identities (Canada Council on Learning (CCL), 2007a & b; Córdoba, 2006; Little Bear, 2000, 2009; Michell et al., 2008). Elders and knowledge keepers are without question the source of Indigenous knowledge and teaching and are highly respected because of a lifetime of acquiring wisdom and knowledge through continuous experiences and apprenticing with their forebears. They are the keepers of wisdom, the libraries of Indigenous communities, and repositories of knowledge (Hanohano, 1999). Elders are distinguished from the elderly, although both are highly respected, by the roles they assume in the Indigenous communities. From an IS perspective, Elders are custodians of knowledge because they identify the contributions of Indigenous people to science (e.g., ecology, biology, agriculture, medicine, astronomy, navigation and sustainability); and are responsible for passing this knowledge and related wisdom practices to succeeding generations.

Elders are especially attuned to stories, ceremonies, and values; and bear important responsibilities to the community as teachers, community leaders, and spiritual guides. Elders and knowledge keepers can identify methods of teaching and learning according to an Indigenous worldview, can help students see themselves in the school curriculum, and help set goals for future generations.

Learning is a Community Activity

The Report of the Royal Commission (1996), noted the central role of family and community as lifelong educators:

Traditional education prepared youth to take up adult responsibilities. Through apprenticeship and teaching by parents, grandparents, aunts and uncles, skills and knowledge were shaped and honed. In the past, the respective roles of men and women in community life were valued and well established, with continuity from generation to generation, so that youth saw their future roles modeled by adults and Elders who were respected and esteemed within their world (CCL, 2007a, p. 7).

> Thus, while growing up, learning is mediated by parents, grandparents, and community Elders. When preparing to go to the mountaintop, the young person is mentored and prepared by knowledgeable and caring Elders. While on the mountain, he might have thought he was alone, but he was never alone, his Elders and ancestors were there with him. Amongst the Lil'wat, as practiced when Wanosts'a7 Lorna Williams was a child, during puberty young women spent their days making implements like berry picking baskets as well as dolls, and beading and buckskin work. As they were completed, these articles were hung on bushes or rope lines drawn along walking trails. Anyone walking along the trail could take these articles. The purpose of this practice was to train young women to have strong, nimble, sure hands, have patience and persistence, approach tasks with a kind and loving heart, practice what they had observed their Elders doing, develop their own way of doing things and practice giving and gratitude. As well, narratives and stories told over and over to children are a highly important mode of communicating traditional knowledge and wisdom practices. And any one individual does not own what you learn; it is for and from the community seven generations back and forward (D. Donald, personal communication to Lorna Williams, February 6, 2013).

Learning is Holistic

The learning process simultaneously engages and develops all aspects of the individual—emotional, physical, spiritual and intellectual. Individual learning is viewed as but one part of a collective that extends beyond the family and community to Creation itself (Archibald, 2008; CCL, 2007a). Hence, IS is recognized as holistic and not easily subject to fragmentation. When teaching in the sciences, the themes presented are inextricably linked and interrelated to other learning disciplines.

In Indigenous education, knowledge is not classified into hierarchical competencies or disciplinary specializations. All knowledge, including knowledge of language, culture and tradition, and all existence (humans, animals, plants, cosmos, etc.) are related by virtue of their shared origins—Creator (Literacy and Learning, 2003). Information tends to be framed around relationships such as the interconnectedness of humans, animals, plants, water—all aspects of the environment, and Creator.

According to Battiste (2007), the silence on spirituality in the classroom has left a gap in learning which reduces education to understanding content and developing certain skills, and removes the factor that fuels our passion for our work—love and meaning making. Exploring traditional spirituality is not about putting forward a religious agenda. It is about calming the mind and developing an awareness of one's wholeness and interconnectedness.

Learning is Relational

More than any other single concept, it is the notion of respect for all life forms and the land itself that characterizes Indigenous belief systems. Vine Deloria, Jr., noted Lakota scholar (1986), discussed the principle of power and place relationships:

> Here, power and place are dominant concepts—power being the living energy that inhabits and/or encompasses the universe, and place being the relationship of things to each other … the universe is alive, but it also contains within it the very important suggestions that the universe is personal and, therefore, must be approached in a personal manner …. The personal nature of the universe demands that each and every entity in it seek and sustain personal relationships. Here, the Indian theory of relativity is much more comprehensive than the corresponding theory articulated by Einstein and his fellow scientists. The broader Indian idea of relationship, in a universe very personal and particular, suggests that all relationships have a moral content. For that reason, Indian knowledge of the universe was never separated from other sacred knowledge about ultimate spiritual realities. The spiritual aspect of knowledge about the world taught the people that relationships must not be left incomplete. There are many stories about how the world came to be, and the common theses running through them are the completion of relationships and the determination of how this world should function. (as cited in Colorado, 1988, p. 52)

As Deloria, Jr. says, "the universe is alive." Therefore, to see a child speaking with a tree does not carry the message of mental instability. On the contrary, this is a child engaged in coming to know the connections of the universe and to feel empathy with another living entity. The ability of teachers to introduce multiple sensory experiences and understandings of how people make sense of the interconnections of the planet allow opportunities for all students to explore and discuss the cultural or environmental aspects of science, which is often missing in the teaching of science.

In the Indigenous world, human relationships are acknowledged and any changes in those relationships are acknowledged and affirmed in ceremonies through songs, stories, dances, and witnessing. Also, in relation to the ecosystem where the state of plants or animals has been altered by humans or by nature; these changes would be referred to in songs, stories, and dances. Gratitude and requesting assistance from plants, ancestors, or Creator to maintain or achieve balance and harmony is central to all of ceremony.

Hence, Indigenous education attempts to develop qualities and values in students such as modesty, generosity, resourcefulness, integrity, wisdom, courage, compassion for others, and living harmoniously with the environment. A classroom setting can be established that encourages working on class assignments for the benefit of others more

than only benefitting the self. These values can be confounded by the current demands of the curriculum to compete for grades at the expense of other members of the class.

Learning is Carried in Language

Through language, Indigenous peoples make sense of the world and transmit cultural knowledge from one generation to another. Language comes from the land and contains the unique knowledge and life-rhythms of each place (Battise, 2002; Battiste & Henderson, 2000; McKinley, 2005; Sutherland & Henning, 2009). Language is the vessel and application of knowledge. It acts as a repository for all of the collective knowledge and experiences that a people, a society, or a nation has (Little Bear, 2009). For example, the names of places can describe the unique characteristics of a place or the history of a place. In Lil'watul, a favourite fishing spot is called Scet' describing a large rock that became lodged in the river after a rockslide. The place is a favoured fishing spot because the salmon must rest below the rock and then gather in abundance before making the effort to jump upstream to continue on their journey to their spawning grounds.

In Canada, Indigenous cultural diversity is represented in 53 different First Nations languages belonging to eleven different language families (MacIvor, 1995). Understanding a worldview comes from the language. Indigenous languages connect Indigenous peoples to their culture's system of values about how they ought to live and relate to each other (Nickerson, 2005). For example, Wanosts'a7 Lorna Williams, provides the following:

> The word for family in Lil'wat, my language, is snukw'nukwa7, however it is not confined only to a human birth family, it extends to all who are related—humans, plants, animals, ancestors, friends, groups, no one is excluded; the root of the word in 'nukw'—meaning to care for.

As Indigenous languages encode unique ways of interpreting the world, they are seen as critical to the maintenance of Indigenous knowledge systems (Herbert, 2000).

From an Indigenous perspective, all languages are born on a piece of land and are connected to identity and culture. They act as repositories for all of the collective knowledge and experiences that a people, a society, or a nation has (Little Bear, 2009). For Indigenous communities, "it is language that unifies everything, linking environmental practices with cultural knowledge, and transmitting everything synchronically among members of the community as well as diachronically between generations" (Crystal, 2000, p. 47). Edōsdi Judy Thompson, a Tahltan scholar emphasizes that:

> Language and land are interconnected—language is a connection to the land through our ancestors. Our ancestors have named our land—in our language. Through our language we can hear the voices of our ancestors and their teachings about our culture and our relationship with the land." (2012, p. 19)

Thus, for many Indigenous peoples, loss of language is often associated with loss of spirit (Cajete, 1999, 2000; Deloria, Jr., 1986, 1995; Little Bear, 2009).

Language is perhaps the most challenging aspect of cross-cultural IS and WS education because the ability to communicate in the languages of each knowledge system is needed to access both systems (Sutherland & Henning, 2009). In Canada, for the most part, science education takes place in the official languages (French and English) and the majority of Indigenous children do not speak their mother tongue language. Therefore, a framework that looks at lifelong learning in science education for Indigenous students needs to consider many approaches that involve Elders, knowledge keepers, and language examples.

Learning is Rooted in Home Place

The importance of home place is a predominant theme in Indigenous Science education (Cajete, 1999, 2000; CCL, 2007a & b; Chinn, 2007; Corsiglia & Snively, 1997; Little Bear, 2000, 2009; Michell, 2005; Michell et. al, 2008; Snively & Williams, 2006; Sutherland & Henning, 2009). As Cajete (2000) states, "native people interacted with the places in which they lived for such a long time that their landscapes became reflections of their very souls" (p. 183). Indeed, Indigenous Knowledge is created through experience. The subject matter is to be examined and interpreted as it is found embedded within its context. In contrast to WS where environmental influences are often considered confounding, and scientists do their work often in indoor laboratories; the land is the place, the base of its knowledge. In some nations when a child was born its parents cut the umbilical cord and buried it on the land, or put it in a rock or tree crevice so that the child would always be connected and smell, taste, and hear the sights and sounds of its home place and would be able to find the way home.

Indigenous peoples are diverse and cannot be treated as a single entity. Each Indigenous people have their own unique economic, practical, spiritual, political, and historical relationships to their homeland. By caring for the land, walking feeling and seeing the trees, rocks, plants and animals every day they gain an intimate and accumulated knowledge about the land. They know what animals and how many reside on the land, and they learn how each animal family fares over a winter. They are familiar with all the places certain plants favour. They know the plant communities that grow together; feeding each other. They know the wind, water, and soil patterns of each part of the land. Hence, IS education involves numerous activities that take place outside the classroom and on the land.

Learning is Experiential

The traditional Indigenous classroom consists of the community and the natural environment. It is the experiences that a people have on their land that gives a place its meaning (Cajete, 1999, Cōrdoba, 2006; Kawagley, 1995; Michell, 2005, 2007; Michell, et. al, 2008). Each adult is responsible for ensuring that each child learns the specific skills, attitudes, and knowledge they need to function in everyday life. Experiential learning is seen as connected to "lived experience," as in learning by doing, through observation and imitation that occurs as part of daily family and community activities such as clamming, trapping, harvesting berries and medicines, fishing, and working alongside Elders to cut up the fish.

Experiential learning is structured formally through regular community interactions such as sharing circles, songs, dances, ceremonies, meditations, or storytelling. Talking circles give individuals the opportunity to express their thoughts on an issue in both large and small groups; by continuing to go around the circle, recognizing the value of each speaker, until a collaborative consensus is reached on an issue, or until each speaker has had an opportunity to express a viewpoint.

Although experiential learning is most often associated with activities that occur outside the formal classroom, it is a purposeful and essential mode of learning for First Nations, Métis, and Inuit (Canadian Council on Learning, 2007b). The lack of practicality and experiential approaches are often cited as the major inhibitors of Indigenous students' success in the classroom (Cajete, 1999; Kawagley, 1995; Kawagley & Barnhardt, 1999; Snively, 1995). To learn IS in schools, learners must actively participate in the natural world, a process that can be transferred to formal, curriculum based science education. Students at all levels respond well to activity-centred inquiry based experiences that are hands-on, tactile, concrete and manipulative, which is consistent with experiential and inquiry learning in science education.

Learning is Ecological

Indigenous Science is in every sense an expression of the interrelationships, the ecology, of Indigenous people with nature. Hence, IS is grounded on an understanding that all things are related and interconnected at all times—this understanding is necessary to comprehend what Indigenous people do as they relate to living in a particular place on the Earth.

One of the leading scholars in IS education is Gregory Cajete, a Tewa from New Mexico. His book, *Look to the Mountain: An Ecology of Indigenous Education* (1994), provides a personal synthesis of tribal educational principles of ecology and sustainability principles for contemporary education. Cajete explores traditional universal concepts such as self-knowledge, wholeness, reciprocity, spirituality and the willingness to accept our interconnections with the earth and the cosmos. Cajete believes that "a contemporary application of Indian education must creatively integrate the orientation of economic survival and ecological sustainability if it is to serve the needs of Indian people living in contemporary times" (Cajete, 1994, p. 215-216).

In North America, Indigenous resource management was carried out through a value system that enforced practices of sustainability, expressed as respect for all life forms, and sanctioned individuals who were wasteful. Children continue to be taught never to play wastefully with animals or plants that are perceived as giving themselves up for the benefit of humans (Turner, 1997, 2005). Thus, humans think at their best when they realize they are totally dependent on everything else.

Ecology and environmental ethics is based on the notion that all of creation is connected and unified. As the naturalist John Muir said, "When we try to pick out anything by itself, we find it hitched to everything in the universe (quoted in Knapp, 1989, p. 5). Similarly, Theodore Roszak developed a philosophy that resists the dehumanizing forces of industrial society by exploring the emerging congruency between environmental enlightenment and spiritual need. Roszak claimed in the book, *Person/Planet* (1979) that "the needs of the planet are the needs of the person." Therefore, "the rights of the planet are the rights of the person." It is interesting that this view, which is traditional in Indigenous peoples' thought, has most recently been emerging primarily through the work of scientists. From biology we learn that there is virtually no significant genetic differences between all humans, and the genetic differences between all living organisms is relatively minor. From ecology, we learn of the subtle interconnections within and between ecosystems. The view that the world is a functioning system, and not composed of discrete entities to be described and treated individually is not new in Western culture, even though many of the scientific facts which support it have come to light only recently. As Callicott (1982) states:

> The basic concept of ecology is that the myriad of nonhuman natural being—soil and water, plants and animals—are functioning members of a single natural community to which we also belong and upon which we utterly depend for the means to live. (p. 41)

Callicott knew that consciousness is central to our experience as living beings and latent in the emerging science of ecology were vast implications for religion and philosophy.

We are seeing the limitations of the view that the earth is a dead planet made of inanimate rocks, oceans, and atmosphere merely inhabited by life. A root metaphor is the Gaia hypothesis that sees the planet as a living organism that carries on many of the same functions as an animal or plant (Lovelock, 1988). The theory is that our planet is, itself, a gigantic living organism composed of organs (oceans, forests, and tectonic plate motion). Although most scientists balked at the idea taken to such an extreme, during the past few years scientists in a variety of fields have elevated Gaia to the status of respectable paradigm that may prove useful in analyzing past and future conditions on the Earth.

By becoming aware of these universal connections, we gain what is called environmental consciousness or environmental identity. Mitchell Thomashow (2002) has described this identity as getting people to "perceive themselves in reference to nature, as living breathing beings connected to the rhythm of the earth, the biochemical cycles, the grand and complex diversity of ecological systems."

Thus, IS can enrich environmental and science education by engendering respect for and feelings of attachment to home-places. It also dovetails nicely with many fields of contemporary study based on "knowing home"—environmental education, eco-feminism, bioregionalism, deep ecology, and the emerging popularity of the study of "place" in geography, eco-philosophy, social justice, environmental psychology, and environmental law.

Summary and Future Directions

Canadian education systems will need to create new models of teaching and learning which are grounded in Indigenous traditional knowledge and values, but can facilitate the development and understanding of WS disciplines as well. Indigenous Science education must be seen to be more than an add-on topic and more than a process for discovering remedies for ecological problems and environmental crises. IS education must take its rightful place as a wealth of science knowledge, wisdom and processes encompassing ecology, biology, medicine, astronomy, agriculture, geology, meteorology, architecture, metallurgy, and horticulture, to name a few. IS education must also be viewed as a philosophy of education to produce healthy individuals, communities and environments.

What is interesting about IS is that when Indigenous people were still living their traditional way of life, there was no physical separation between school and home. There was no set time or place that learning occurred; teaching, and learning happened all the time. Now that the Indigenous students spend most of their days in school, as with non-Indigenous students, it will be a challenge to include ample place-based ecological learning activities on the land, which is of vital importance to the future of the earth.

The main purpose of this chapter is to show that there exists a framework, a place and a way for IS education. We have not attempted to show specifically what should be taught, how changes might come about, or how learning might be assessed, only that changes are necessary and to point a general direction. As with any change, it will take

time before significant changes in the participation of Indigenous students in science takes place, but change is on the way.

In our journey to adapt and modify provincial curriculum to include an Indigenous perspective, teachers can "come to know" the knowledge, wisdom, metaphors and practices of Indigenous peoples. Teachers can see themselves as representing different worldviews and cultural constructions from within their worlds. We must be open to seeing the limits of our own boundaries of knowing. "Coming to know" in the Indigenous world is about utilizing the wisdom and knowledge gained by ancestors. It is approaching each task with an open and kind mind, heart, and spirit. We have no doubt that the work we will do as teachers to create learning experiences in science that allow for success of Indigenous students without expecting a form of cultural assimilation would be work that many teachers find of personal value. In the final analysis, grounding our teaching on the needs of a particular population is of significant benefit to all. Certainly, most teachers who do participate in such work find it both inspirational and liberating.

SUGGESTIONS FOR TEACHING

- Reflect on the idea that everything is connected and has a spirit. What impacts on the planet might this philosophy have over the long term compared to an education void of this philosophy?
- When studying the water cycle in the region, one learns that in some Indigenous perspectives the river contains not only rainfall and runoff from the land, but also the "tears of the people." How could the discussion of the emotion help in exploring the water cycle, and the history and culture of Indigenous people?
- Key questions that guide curriculum and pedagogy (not necessarily with an exclusive focus on science) are:
  - Where is here?
  - Who am I that I am here?
  - Who else is here alongside me?
  - What gives and sustains life here?
  - How can I participate in the life that is here?
  - How can we live well together here?

Key questions provided by Dwayne Donald, University of Alberta (personal communication, January 23, 2013).

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