2

Transforming Teacher Thinking about Indigenous Science through Cultural Experiences

Nan Kendy

My first teaching assignment, 30 years ago, was in the Witsuwit'en community of Witset, Moricetown in northern British Columbia, Canada. The elementary school overlooks some of the most spectacular beauty in BC, including the coastal mountain range, hectares of forested lands as far as the eye can see and a canyon where the Widzin Kwah, Bulkley River runs through. The Witsuwit'en peoples have travelled and harvested these lands, forests, and waterways for thousands of years. Like most reserves bordering settler communities many Witsuwit'en students living on reserve are bussed into the neighbouring town on their territory to attend school. The number of students of Indigenous ancestry enrolled in this school district increased from 10% in 1995 to 21% in 2005/2006 and again to 23% in 2014 (School District #54, 2013-2018). Indigenous student enrollment and achievement in the sciences for this northern school district is similar to that reported in the BC Provincial Required Examinations in 2010 and 2011 (Yore et al., 2014). Specifically, Yore et al. reported that Indigenous students' participation in biology, chemistry, and physics in BC continues to be proportionately lower than their non-Indigenous counterparts and there continues to be a performance gap between the two groups with the Indigenous students achieving lower scores on required provincial examinations. Statistics from a study by the Canadian Education Association show that Indigenous students continue to lag behind: "In Canada, there is a critical underrepresentation of Aboriginal [sic] peoples going into science-related programs at the post-secondary level. This has an impact on their ability to participate fully" (Murray, 2015, p. 21).

The Aboriginal Enhancement Agreements, the BC Ministry of Education's Integrated Science Resource Packages (IRP 2005, 2008), as well as the 2015 curriculum, encourage place-based learning experiences and Indigenous community involvement in schools, and suggests ways to include Indigenous Knowledge in the K-10 curriculum alongside the Western science model. These efforts by the BC Ministry of Education suggest that a new paradigm in science education needs to be traversed to attract and inspire Indigenous students to the sciences. The challenge inherent in this process of policy change is in transforming Western science teachers' view of science to include Indigenous Knowledge. Barnhardt and Kawagley's (1998) work details their efforts in trying to facilitate this change. They have identified the difficulty many Western educators and scientists have in understanding Indigenous Science (IS) knowledge.

> At the heart of the problem are different worldviews, values, traditions, and histories. These differences form a cultural disconnect that triggers and nourishes misunderstandings and misperceptions on the part of both groups. (p. 10)

For more than a decade we have witnessed a pedagogical shift away from attempting to change students' attitudes about learning Western science paradigms towards changing teachers' attitudes and to valuing Indigenous ways of knowing through teacher professional development.

Teachers as Change Agents

Before teachers can become effective change agents in an educational system that has worked to assimilate First Nations, Métis, and Inuit people for over a century we must be able to change our way of thinking. Becoming mindful of our pre-conceived notions, the thoughts and judgments, which impact our teaching practices is imperative. For Williams (2005) this means being able to "transform our frames of reference through critical reflection ... become aware of our habits of mind and points of view through reading, experiential activity, and interacting with others where we can compare new knowledge with past knowledge" (p. 70).

As a Canadian of European ancestry, participating in First Nations life-ways has transformed my life. My teaching experiences in the north and a spiritual life with my adopted Cree family, under the guidance of the late Joe P. Cardinal and his wife Jenny have played a major role in altering my Euro-centric worldview. Through the lived experience of First Nations ways of being I have come to ally myself with First Nations peoples, and work to honour their ways of knowing in educational practices. Kanu (2005) contends that learning experiences, which are transformational in nature, can lead to change in the classroom and ultimately affect individual students. Her study determined transformational experiences to be the incentive for both non-Indigenous and Indigenous teachers integrating an Indigenous curriculum into their science programs and argued for more transformative experiences to inform teacher practices. This chapter presents a brief summary of an experiential learning journey to encourage a transformational process that would deepen teacher thinking about (IS) knowledge while taking into account the knowledge and values of the Witsuwit'en people.

Introducing the Learning Experience

Methodologies

The teacher workshops and data gathering phase of this research project took place on the traditional territory of the Witsuwit'en people during the spring and summer of 2006. Aspects of Indigenous methodologies that were central to the lived experience of the Witsuwit'en people with whom I was conducting the research such as prayer, song, drumming, gifting and feasting were identified, integrated, and practiced (Kendy, 2007). Engaging in these traditional protocols demonstrated respect and reverence for the values and ethical practices of the Witsuwit'en people. "Ceremony focuses attention so that attention becomes intention.... Ceremonies transcend the boundaries of the individual and resonate beyond the human realm" (Kimmerer, 2013, p. 249). Another key component of the methodology was to bring the participants together in a dialogical process, which provided a forum for listening, reflecting, and sharing perspectives. The dialogue circles provided an opportunity for people of different cultures to listen and learn from each other. In order for authentic change to occur for non-Indigenous people, it often requires the suspension of their Euro-centric assumptions in order to listen deeply to another point of view. According to Williams and Tanaka (2007), dialogue can lead "to a space that allows for power balances to shift, and cross-cultural meaning making to occur" (p. 7). The dialogue circles helped deepen our understanding of IS enriched by a Witsuwit'en worldview. This chapter includes pre- and post-workshop questionnaires, an analysis of the participants' responses and an overview of the workshops.

Professional Development Model

The land, yin tah, is integral to the Witsuwit'en people and their way of life. Their holistic view of the land integrates all knowledge, including IS knowledge. The land, extending to the headwaters of the Widzin Kwah, Bulkley River was central to the teachers' learning experience (Figure 2.1). For that reason, Workshop 1 was conducted on Witsuwit'en traditional territories. Stories and lessons from the land told by the Elders and knowledge holders informed our learning in Workshop 2. The traditional lunch of oolichan, moose meat, salmon, and berries was gathered from the land (catered by Christine William). The dialogue and brainstorming sessions included discussions about activities on the land for youth and Elders. The two-way arrows indicate the reciprocal relationship of gratitude and reverence the people have with the land, the water, the plants, and the animals, which became the theme of our learning and understanding of IS knowing. Pre- and post-questionnaires addressed teacher knowledge of First Nations students and IS as it related to the people on whose traditional territories we live and work.

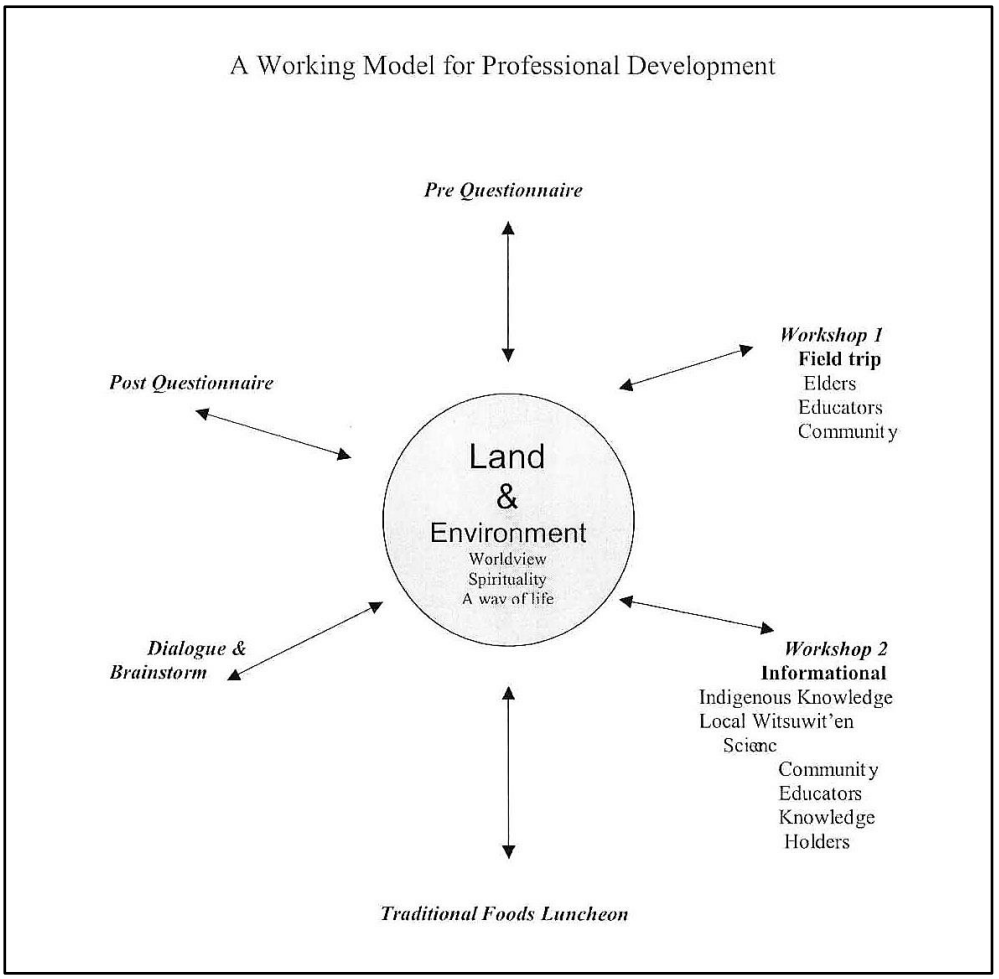

Figure 2.1 ▲ A working model for professional development. (Kendy, 2007, p. 205)

Participants

The Teachers

It became clear through the recruitment process that the teachers who agreed to become involved in this research were life-long learners who were willing to take risks and were open to new ideas. Cajete (1999) explains the elements necessary for science teachers to become change agents:

> Becoming open to the paradigm of Indigenous science has some prerequisites, which need to be considered. There must be an understanding and acknowledgement of the

> history of exploitation of Indigenous peoples by Western culture and science. There must be a willingness on the part of the non-Indigenous teacher to view science from a perspective that is 'inside out, upside down and the other way around' or, more simply put, without bias and with deep vision which allows for a deep examination of habitual thought processes. This means reflecting on Indigenous science based on its own terms and methodologies without stereotyping or trivializing its essential components. (p. 185)

Research participants included eleven elementary school teachers and six high school teachers of biology, chemistry, and physics initially representing Grades K-12. Teacher career experience ranged from 3 years to 44 years. As part of the data collection participants were given pre- and post-questionnaires with the option of anonymity in their responses. Where teachers were quoted, a letter of the alphabet (A-O) was used to protect the identity of the participant.

The Elders

Two respected Elders and Hereditary Chiefs from the Witsuwit'en Nation participated in the first workshop. At this time, Gisdewe (Alfred Joseph 1927-2014) was the Hereditary Chief of one of thirteen houses of the five Witsuwit'en clans. He was raised by his grandmother and had a lived experience on the territories. Gisdewe carried with him the historical knowledge of his people. He was instrumental in interviewing and documenting the Elders' oral histories for the famed *Delgamuukw v British Columbia* Supreme Court of Canada case (1997). In this landmark case the Supreme Court respectfully recognized Aboriginal land rights, including Aboriginal title (past and present), Aboriginal law and oral histories. According to Morin (2016) it meant that for the first time, "oral histories had been acknowledged and taken seriously by the courts and the Government of Canada" (p. 326). This case created a duty to consult the Hereditary Chiefs before industry and development could remove resources from their territories. In 2009 Gisdewe was awarded an honorary degree by the University of Northern BC for his life's work.

The second Chief Wigidimsts'ol, the late Dan Michell was a Wing Chief. He had been a hunter, fisher, and trapper on the territories all his life, and knew the political and environmental issues that surround these life-ways from a deeply personal and spiritual place. Both Elders were fluent in their language. Throughout the field trip they conversed in Witsuwit'en, teaching us names and phrases for places along the journey.

Other Participants

Personal face-to-face invitations were extended to the Aboriginal Support Services Educational Team (Asset) workers, the District Principal for Aboriginal Education 'Ilhdesinon Birdie Markert and the Curriculum Developer. These resource people were to guide, inform, and potentially gather materials to build culturally relevant resources. Additional guests in the second instructional workshop included Tsalik Mel Basil (a representative from The Friendship Centre) and Dr. Ross Hoffman (a professor from the University of Northern British Columbia First Nations Studies program). These invited guests discussed Indigenous Knowledge (IK) and Traditional Ecological Knowledge (TEK); and participated in the dialogue circles. Traditional Ecological Knowledge is best described by the Witsuwit'en people:

> TEK has no equivalent name in Witsuwit'en. Western science tends to break things down into parts, whereas our Ancestors viewed the world as a whole.
>
> The closest way to describe traditional ways of living and knowing comes from two terms: *yin tah* (earth, land, territory) and *'annuc niwh'it'ën* (our way of life, laws, knowledge). *Yin tah* ... is not just the land itself, but all the plants, animals, and people that inhabit it. *'Annuc niwh'it'ën* is determined by this view that all life is connected.
>
> In time, ecologists, biologists, archaeologists and other scientists started to realize that TEK and oral histories offer real longer-term observations about the environment, marking changes over thousands of years, which help confirm or refute scientific theories. (Morin, 2016, p. 74)

Teachers' Thinking before the Workshops

Pre-Workshop Questionnaire and Findings

The pre-workshop questionnaire inquired into non-Indigenous teachers' thinking about Indigenous student success and IS. What follows are sample questions from the pre-workshop questionnaire and the themes that emerged from the analysis:

1. How many Indigenous students are in your science classes and what Nations are they from?
2. Evidence suggests that Indigenous students are under-represented in the sciences. Why do you think this is the case?
3. Define what science means to you.
4. Do you include IS knowledge in your science program?

Theme 1 - Non-Indigenous teacher thinking about Indigenous students

a) Relationship building

Building relationships with Indigenous students was evidenced in two teacher responses. One high school biology teacher who was experiencing success with Indigenous students explained, "It's really about getting to know the students." One half of the teachers knew the number of Indigenous students in their class. One third of the teachers indicated they knew the Nations represented in their classes.

According to Ignas (2004) and Kanu (2005), lack of relationship between teachers and Indigenous students is consequential to student success. Kanu explains that a mismatch between a student's culture and the culture of the teacher and classroom sets the student up for failure if teachers aren't able to demonstrate tolerance or sensitivity to the cultural special needs of the child. Ignas has found the best way for Indigenous students to experience success in science is in teacher recognition of an Indigenous perspective in science education.

b) Systemic and Cultural Deficits

Teachers' responses to Indigenous students' under-representation in the sciences fell into two categories: systemic and cultural deficits. Systemic deficits included low self-esteem due to systemic racism, lack of subject relevancy, lack of relevant resources, and Indigenous students' lack of academic skills. The majority of teachers believed lack of student self-esteem is the reason for Indigenous students' under-representation in the sciences. One teacher explained:

> Aboriginal [sic] under-representation in the sciences is due to a lack of self-esteem, embedded racism within the system, where Aboriginal students [sic] may feel inadequate and not welcome or cannot identify with the teacher. (Participant D)

Many teachers believed the science curriculum lacked relevancy for Indigenous students. One teacher explained:

> My top student in Earth Science 11 is a Cree student. He is a very intelligent fellow and he was a good C+ and B student in Science 9 and 10, but he is an A student in Earth Sc.11. I know he spends a lot of time outside. He is attuned with the outside; he likes to learn more about the things that are relevant to him. (Participant A)

Cultural deficits were identified as lack of student motivation and included socio- economic factors. Teacher participants D, E, L, O indicated there was a lack of home and family support; "Students don't see science as important and education is not a priority for many Aboriginal [sic] families." "Since they don't

think science is important there is no focus or concentration. Because of lack of focus they end up with little or no skills and show little interest." "Students are dealing with alcohol, drugs, abuse, and neglect. They don't have time for anything else." Viewing Indigenous students' under-achievement as a cultural deficit in an education system modeled on a Eurocentric paradigm, shifts responsibility away from the teachers and further marginalizes Indigenous students.

Theme 2 - Non-Indigenous teachers' understanding of Western and Indigenous Science and the impact their thinking may have on Indigenous student success in science

a) Conflicting Views of Science

Teachers' definitions of science were mostly based in the Western scientific method construct. This perspective fosters one point-of-view, the Western worldview. A case in point is Participant B's comment in the post-questionnaire:

> I would like to emphasize the importance of terminology. I have no problem with 'Aboriginal knowledge' [sic] and 'Aboriginal technology' [sic]. For me 'Aboriginal science' [sic] and 'Native Science' [sic] are artificial terms that I would not use. Scientific thinking and methodology was not part of the Aboriginal [sic] way of thinking and should not be confused with knowledge.

This participant appears to have misinterpreted the holistic, interconnected, and inter-relational knowledge inherent within IS.

b) Contradiction

The data indicates that most of the teachers included aspects of Indigenous Knowledge in their science class although they weren't aware of the scientific implications specific to Indigenous Science. From their responses, many teachers appeared to be teaching something they didn't believe they knew much about. This finding is consistent with previous studies by Aikenhead & Huntley (1999) suggesting that for students who "move from their everyday culture into the culture of school science, the move is called *cultural border crossing*..." They need a teacher who is a "cultural-broker" to move between the Indigenous cultural worldview and Western science cultural worldview to help students "deal with cultural conflicts that might arise" (p. 160). Other educators (Cajete, 2000; Kawagley, 1999; Haig-Brown, 1992) maintain there is an underlying need for this process to occur in a science classroom in order for Indigenous students to feel validated. Teachers indicated they do IS, but how much or how well they function as cultural brokers is unclear.

Pre-workshop Questionnaire Implications

Western education has failed to accommodate Indigenous students whose knowledge systems and worldviews are different from their Western counter-parts. In order to appreciate IS, teachers would benefit from education in IK and values (Aikenhead & Huntley, 1999; Barnhardt & Kawagley, 1998; Cajete, 1994; Ignas, 2004). Knowledge of the historical background of Indigenous people; the effects of colonization including issues of poverty, land, health, and intergenerational trauma from residential school abuse would help teachers build understanding of their interrelation to Indigenous student success. Otherwise, teachers' beliefs and cultural assumptions carry the potential to re-victimize the victims.

The Workshops

The first workshop was a nine-hour experiential field trip to visit the territories of two Witsuwit'en Hereditary Chiefs. The second workshop was a half-day informational session, which included an overview of Indigenous Knowledge (IK) and a local perspective on IK and Traditional Ecological Knowledge (TEK).

Workshop #1

The overall intent of this workshop was to present elements of IS demonstrated by the Witsuwit'en Chiefs' relationship to the land and to identify culturally appropriate and effective ways of teaching and learning science knowledge based on local TEK of land use that maintained sustainable economies and communities for generations. When out on the land the Elders shared their knowledge through stories pertaining to Witsuwit'en ways of knowing and being. These stories were grounded in the holistic knowledge of the Witsuwit'en people, their use of science-based knowledge, and their methods for survival in these territories. Stories from the Elders about sacred places, use of place names, and ecological consciousness helped participants to understand that the Witsuwit'en people have territories they have been care-taking for centuries, and that it is their close spiritual connection to the ecosystems of these territories that has allowed them to sustain themselves and their culture over time.

Some key concepts of IK as it applies to the Witsuwit'en covered the vastness of the territory, the seasonal cycling of the people through the hills, valleys, and waterways of these lands, and many time-honored traditions. Of particular note was the way in which each of the Chiefs referred to and described their territory. The territories we were on were defined by house boundaries and Witsuwit'en place names the Chiefs could physically point to and talk about. They identified the hills, land benches, mountains, rivers and streams, meadows, as well as, trails and migration routes that define their territory. "Chiefs who knew

the boundaries of their territories well had authority that was respected" (Morin, 2016, p. 60). The overriding understanding in defining territorial boundaries and land use is that it is controlled, and the harvesting and regeneration of resources are kept in balance. This is still evident today.

The Elders told stories of the former caribou migrations and ethical stories about the return of the salmon people. *The Boy Who Played with Fish Bones* (Morin, 2016) told by Gisdewe, taught the lesson that the return of the salmon depends on how they are treated. He explained how the Witsuwit'en believe it is important to treat fish and fish bones with respect. In this way the spirit of the fish is honored ensuring the fish will return again the following year. Wigidimsts'ol talked about traditions of spiritual guidance in naming ceremonies as they applied to him. He described the footprints of their prophet Bini still located on this territory. He shared how the peoples' keen observation skills allowed families from all over the territories to arrive at their summer camp, 75 miles overland from their winter territories, within a few days of each other. We learned how the Witsuwit'en peoples' knowledge of IS stems from their knowledge of plant and animal resources of the forests, plateaus, and valleys. The use of this knowledge for producing food and medicines extends to the tools they design and use for sustainable existence. The IS that persists today is evidenced in their values of protection and management of the natural resources. The Elders explained the technology of the fish traps and the fishing weir and their traditional use as a form of selective harvesting. These ancient technological methods allowed for the identification of different species of fish and for tracking them by their sex and size—returning the spawning females without harm (Morin, 2016, p. 78). Wigidimsts'ol emphasized that the Witsuwit'en peoples' relationship with the land is an ongoing and complex way of life that is continually evolving and changing as they seek a balance with the high demand for traditional resources. (See ***The Ways of Our Ancestors*** by Morin, 2016, for a treasure trove of significant information about the Witsuwit'en worldview, technology and IK).

The extensive logging and mining observed along this journey served as a comparison study for sustainability practices between corporate economies and Witsuwit'en traditional values. Passing by a long abandoned, silver mine (formerly Equity Silver Mine) teachers were moved to learn that the mine was still responsible for the ongoing acid rock drainage pollution of neighbouring streams and distant water systems. Wigidimsts'ol, told us he had to haul his own water to his isolated cabin because the stream running behind the cabin is polluted from the acid rock drainage. As we approached this Elder's cabin, we could see there was a high level of logging taking place. In the post-workshop questionnaire one of the participants commented:

> I can't emphasize enough how profound it was to be with the Elder when he 'discovered' the intense logging around his cabin and on his territory. At that moment, I became very aware that we are 'visitors' on land we think of as our own." (Participant G)

All the territories we were driving through had experienced high levels of logging operations, road building across territories, polluted streambeds and pesticide spraying that impacts the fishing, hunting, and gathering practices of the Witsuwit'en people. Wigidimsts'ol, commented earlier on how the logging and mining has disrupted their traditional trap line use and their berry picking opportunities. Participant L commented:

> I was amazed when I saw for my own eyes how the forest industry has affected the Aboriginal people. The Elder's concern was for the animals, "Where do they go when the trees are all down?" He told us the reason the logging company gave him for logging his territory was because of the pine beetle bug infestation. When asked about the clear-cut logging, Wigidimsts'ol explained: "The beetles flying ability is limited to short distances, can't fly too far on their own, all this cutting and hauling may be spreading them."

Canadian Forest Products Ltd. (Canfor), the largest producer of softwood lumber in Canada, has operated for decades throughout the Witsuwit'en territories. What stood out for Participant H on this trip was the "continued lack of communication and understanding between industry and First Nations." Another teacher participant commented in the post-workshop questionnaire, "It was very powerful. Their knowledge of their land, their connection to nature, and their past experiences helped me to understand the deep connection that science plays in their culture" (Participant L).

Workshop #2

The second workshop was a half-day informational session held in the Aboriginal Resource Centre that included dialogue circles and brainstorming. Different presenters spoke to the literature on IK, IS, and TEK.

Indigenous Ways of Knowing

Dr. Ross Hoffman, from the University of Northern British Columbia, shared *A Conceptual Framework of Indigenous Knowing* from his doctoral dissertation (2006). He presented on the components of Indigenous Knowledge and the characteristics of how this knowledge is transmitted. This presentation sparked questions such as, "Is Indigenous knowledge genetic?" and "What about those who have grown up in modern times, away from their traditions? Does this still apply?" The prolonged question period and discussion that followed made it apparent this was new information for most of the teacher participants. Post- workshop questionnaire responses indicated teacher appreciation for the Indigenous Knowledge presentation.

Local Traditional Ecological Knowledge (TEK)

Morin recounts the traditional knowledge and wisdom of the Witsuwit'en as practiced on their traditional territories:

> Our Ancestors, because of necessity, were keen ecologists. This knowledge was gathered from thousands of years of observation and experience. Understanding how animals and fish reproduced and migrated made our Ancestors better fishers, hunters, and caretakers. In-depth knowledge of animals and their habitats allowed our Ancestors to take what they needed without over-harvesting the creatures they relied upon.
>
> Scientists often refer to this as "Traditional Ecological Knowledge" (TEK). This knowledge, deeply rooted in respect, was expressed through stories and rituals. (2016, pp. 71-72)

Thanks to the work conducted by the House Chiefs and the Office of the Wet'suwet'en [Sic] Natural Resources department I was able to present a poster of a TEK matrix (2005) and a map of the Chiefs' territories depicting traditional land use, including food plants and animals found within each Chiefs' territory. This time-proven knowledge and in-depth information about the local resource areas provided by the Elders and Chiefs and documented through a modern Geographic Information System (GIS) demonstrated how traditional knowledge and contemporary technology can help protect Witsuwit'en interests and lands for treaty as well as protect against future intensive mining, fishing, and forestry practices (Gauthreau, Mitchell, & Naziel, 2007; Office of the Wet'suwet'en, 2011). I also shared archived photographs of local Witsuwit'en engineering technologies for building bridges, building fish traps, nets and weirs, drying racks, traditional longhouses, carved poles, and canoes to help teachers locate the different scientific principles inherent in Witsuwit'en technologies. A Witsuwit'en cultural teacher presented an authentic tumpline (a belt worn over the top of the forehead and attached to a large pack for carrying supplies) his grandmother had woven. This same teacher also discussed with us the difficulty he and his class experienced trying to construct a traditional conical fish trap. He expressed the mathematical and technological challenges. Mel Basil of Gitxsan and Witsuwit'en heritage explained the concept of controlled burns as a means of sustaining the forests and berries. Traditionally, Witsuwit'en women maintained most berry patches through the use of fire to control brush and increase nutrients in the soil. Hot, quick fires stimulated growth and increased the production of larger berries (Morin, 2016). Mel shared a story that demonstrated how the once abundant and well-tended huckleberry bushes may have contributed to the health of the woodpecker population, which kept the pine beetle population in check. He explained how his people traditionally prescribed burns of the forest to bring health and abundance to the berry patches. The people maintained the growth of the huckleberries; the propagating mature woodpeckers fed the

desired huckleberries to their young while they in turn feasted on the pine beetles. This cycle naturally produced more mature woodpeckers and fewer beetles until the settler community intervened in that cycle and made burning illegal. Eventually there were fewer huckleberries which led to fewer mature woodpeckers, who we were told, were the greatest natural predator to the pine beetle.

Dialogue Circles

Sharing participants' own experiences of WS education and then reflecting on their field experiences in dialogue circles helped deepen educators' understanding of the holistic nature of IS and ways of knowing. The inherent value of dialogue between different cultural groups is illuminated by this teacher's comment:

> The whole idea of the balance between the huckleberry bushes and the burning and the woodpeckers and the beetles, I mean that's fantastic! If we can all help our students gain a better sensitivity to balances like that you know we all gain. (Participant A)

Brainstorming ideas to integrate cross-cultural science initiatives included: partnering teachers with Elders and resource people from the Witsuwit'en community; developing grade specific experiential learning opportunities based on the curriculum requirements to increase local cultural and scientific understanding; school and district wide thematic planning that acknowledges IK, TEK and IS systems; incentives to encourage Indigenous Science Fairs; and ongoing mandatory workshops on culturally appropriate teaching methods and professional development in local IK and Indigenous history.

Teachers' Responses to the Workshops

Post-Questionnaire Findings and Implications

The analysis of teacher responses presented re-occurring thoughts and points of view that were grouped into themes and restructured into a narrative report. These themes continue from the pre-questionnaire.

Sample questions from the post–workshops questionnaire:

1. After the field trip and dialogue what stands out for you about your experience?
2. Have the workshops changed your thinking about Witsuwit'en knowledge and culture? If so, in what way?
3. Do you think you could include IK and IS in your science classes? Why or why not?
4. What do you think might be some barriers to teaching IS in the classroom?
5. What do you think some benefits might be of teaching IS in your class?

Theme 3 - The Power of Experience

Participants used terms like "profound," "aware," "wonderful," "surprised," "impressive," "interesting," and "powerful" to explain what stood out for them from this professional development experience. Overall the teachers believed they gained a deeper and broader knowledge of the Witsuwit'en people:

> This opportunity to go with these people and have them say this about the land and the catalogue that they have. I didn't know they had territory out there and I certainly didn't know how they interacted with that territory. After that day I got all that knowledge. You get it in a roundabout way, from listening and not from the traditional WASP ways. It's quite impressive. (Participant J)

Another participant explained:

> I appreciated having genuine experts share their knowledge about land management and relationships with the environment.... It seemed to me that the day spent on the Elders' territory took us into a time/philosophy machine where values of respect, responsibility, and relationships were the most important values. It made me realize the amount of technology and science that exists amongst the Aboriginal culture; a science that in my view surpasses often what we think as scientific. (Participant K)

The participants acquired knowledge on many levels about the Witsuwit'en people they didn't previously know:

> I was surprised by the kindness of the Elders and guest speakers towards us. They were so welcoming and open with us despite our lack of knowledge and the racism they must all experience at the hands of us whites and the history of the terrible relationship between whites and the Aboriginals in the past. (Participant I)

This new knowledge provided insights:

> I think that the complexity of the culture that was certainly here before us, stood out for me. Complexity in diet, in political structure, in rules, you know all those things surprised me, that it would be that complex! It certainly made me interested in looking into it in greater detail. (Participant A)

Teachers began to identify elements of IS:

> Astronomy and navigation/orienteering are considerations for me to explore. I'll try to use physical, biological, and technological examples in my science classes. (Participant G)

Most teachers indicated a greater awareness of another point of view, underlining the importance of inviting Witsuwit'en resource people into their classes in the future. Teachers recognized Indigenous technology as, "not just out there (Inuit, kayaks) but as localized." One participant wrote, "I hadn't thought in terms of Aboriginal science and knowledge in regards to conservation and sustainability in nature" (Participant I). Teachers agreed, "the experiences opened lines of communication." They expressed respect for the local Witsuwit'en culture and a more positive outlook toward Witsuwit'en peoples; "more hope"; a sense that a "better understanding of the history and culture of the people leads to greater tolerance;" and the ability to "see more possibilities." "Anybody who lives here should know about the people who have lived around here in the past and their former way of life" (Participant B). A teacher of 26 years wrote, "The dialogue made me very aware of how closely Aboriginal people are linked to the land. I've been rethinking my teaching in order to be more holistic" (Participant G). This same participant crystallized the reflective actions necessary to evoke teacher change, "I used the time to make connections between past beliefs and emerging understandings."

Theme 4 - Barriers to Teaching Indigenous Science

Participants cited lack of time and resources as well as curriculum restraints as barriers to teaching IS. While many wanted to address IS knowledge in their classrooms they were not sure about what is considered public vs. private knowledge. Many teachers felt uncomfortable and unknowledgeable in teaching IS. They identified a need for additional training and teacher friendly resource materials. Specifically, they asked for more role models (Indigenous teachers), more field experiences led by Elders, more resources and materials developed in concert with Indigenous educators as ways to connect with the knowledge holders. Elementary teachers asked the Indigenous educators for help in gathering local Indigenous resources to meet the learning outcomes in the BC Ministry of Education's Indigenous Science curriculum. It was understood that this meant meeting the IS learning outcomes in Ministry documents that were in the process of being revised and updated. Many teachers expressed a willingness to work alongside Indigenous educators to create materials defined by the local Witsuwit'en community as meaningful to Indigenous student knowledge.

Theme 5 - Benefits

Most teachers believed that including IK and IS in science curriculum would foster role models, pride, self-esteem, and respect amongst the Indigenous students and an appreciation for Indigenous skills and expertise amongst the non-Indigenous students. As a result of the workshops the majority of teachers agreed that IK, including IS, provides a holistic perspective for students to consider in their thinking. They felt that demonstrating additional ways to think about and do science would broaden students' views of science, allow for more applied science and increase student participation in the sciences.

Unpacking the Learning Experience

Challenges

Western models of science education have a great deal to learn from Indigenous scholars, Elders, and teachers. Two critical challenges that need to be addressed in education are spirituality in science and Indigenous language development. Indigenous language and spirituality are rooted in the land and are dependent on the relationship of the people with the land.

Spirituality

In the pre-workshop questionnaire Participant A referred to the perspective of spirit in IS as not being science, "Things that are more spiritually based necessarily wouldn't be science, but things of the practical world that people picked up are." Another teacher questioned how the link to spirituality fit into science? During our fieldtrip out on the land, Western science-based teachers were introduced to the idea that all knowledge is sacred. Various spiritual teachings demonstrated the physical, biological, and spiritual fusion of the environment with the Witsuwit'en knowledge systems:

> It was marvelous to hear about the markings at birth. One fellow was marked with a feather and the agility of a squirrel, so he would be strong and would be able to walk, climb, and hunt for his clan. (Participant J)

In the post-workshop questionnaire, Participant A explained that they should be better prepared for the spiritual aspects:

> You can't just talk about the person who predicted, Bini their prophet, because for the Western people it loses all relevance, their eyes glass over. You have to prepare others

> for that kind of experience. Those things are so extremely important because how do you get to know about people?

This example from the non-Indigenous teacher explains the need for change in science education. Many non-Indigenous people are challenged by the fact that spirituality is an important component of IS. It is a complex subject and needs to be respectfully addressed in science education. Respected Witsuwit'en Elder K'illset Violet Gellenbeck explains:

> I think that the Witsuwit'en Nation is no different than any other nation in that we look at everything around us as being spiritual. And, when we say that, we're talking about everything that grows on this earth and everything that walks and crawls on this earth: the water, the seasons, the food and the animals. (Morin, 2016, p. 78)

The late Dr. Oscar Kawagley and Yupiaq Elder was educated both traditionally by his grandmother and in Western education, cites the seriousness for educators ignoring this disparity:

> My own undergraduate science education was derived from textbooks, laboratory manuals, and learning through the scientific method. These teaching and learning processes do not, however, take advantage of the students' environment, or the environment's ecological processes. Nor do they prepare the student to recognize a creative force flowing in and around them at all times. The removal of the mystical force from scientific processes has rendered a society…that no longer honors and reveres nature, but often misuses, abuses, and disrespects it. (Kawagley, 1995, p. 89)

Teachers indicated the need to be "reminded of the importance" of spirit to knowledge and the importance of studying science from and with the land. For example, biology teacher Participant C stated, "I was reminded of the importance of taking students out to experience the learning on the land when studying fish, herbal medicines, and the forest." This knowledge seems critical for WS education to attract and retain Indigenous youth. Supporting an Indigenous perspective of reverence, which seeks respect for the plants and animals and demonstrates thanksgiving for the life forms that support and feed mankind may help all students to ultimately deal effectively with sustainability and resource issues.

Conclusion

The Elders, in their role as teachers, sparked an interest into how their spiritual connectedness to the land informs their past, present, and future. Their holistic lessons of "sustainable prosperity" introduced concepts of reverence and synergy in relation to all living things. This Witsuwit'en worldview of science

presented a cumulative and intergenerational model that not only embodied many principles of Western scientific methods (observing, questioning, predicting, theorizing, experimenting, and adapting); but also incorporated deep, powerful experiences and wise traditional practices derived from an intimacy with the earth. This shared knowledge provided educators with a holistic, bioregional model that incorporates the human being into the story of local ecology passed down through generations and suggests how to live in "good relation" to our natural environment. Engaging science teachers in a dialogue with Witsuwit'en knowledge holders contributed to teacher understanding and respect for their Witsuwit'en neighbours. Teacher responses summed it up very well, "It is important that people learn the history of how things came to be and just listen to each other," and "It is important to know the history of the First Peoples to build relationship and understanding amongst all people."

When I was canvassing the school district for teachers to take part in the workshops, I was led by my intuition. I didn't know exactly what would happen out on the land with the Elders, but my intuition told me I was looking for teachers who would come to experience, reflect, and interpret their own learning from their own point of reference. This then is precisely the essence of experiential learning. The teacher responses captured in this study came from their direct experiences on the field trip, the informational workshop, the traditional foods luncheon, and the dialogue circles. Their experiences came from consciously engaging in relationships, travelling the land, tasting the nourishment that comes from that land, dialoguing, questioning, and listening while all the time relating their experiences to their own epistemologies and in some cases making new meaning out of old perceptions. This type of learning is not one dimensional, it takes place on many levels in many moments of time, all in relation to what we already know and who we are, but conceived by our relationship to the land. And this is where non-Indigenous peoples may find Indigenous Knowledge a blessing. As Kimmerer (2013, 2017) explains, it is not enough to love the land we need to also learn to respect it and to heal it.

When teachers choose to go out on the land and experience the land through an Indigenous lens they are opening doors to a future in which teachers can become facilitators between the youth and the Elders, setting up the opportunities necessary to allow holistic learning to take place. Through consultations with respected, local, Elders teachers can provide the place and space necessary for knowledge holders to pass along the oral histories to youth as they have done for tens of thousands of years, connecting the next generation to their culture and Traditional Ecological Knowledge. As educators, we can make the conscious choice to recognize Indigenous Elders and Indigenous students as resources and assets to the education system and to science knowing, and provide a learning space for that knowledge to thrive.

References

Aikenhead, G., & Huntley, B. (1999). Teachers' views on Aboriginal students learning western and aboriginal science. *Canadian Journal of Native Education. 23*(2), 159-175.

Barnhardt, R., & Kawagley, O.A. (1998). Culture, chaos, and complexity: Catalysts for change in Indigenous education. ANKN. Retrieved from http://www.ankn.uaf.edu/Curriculum/Articles/BarnhardtKawagley/ccc.html

British Columbia Ministry of Education. (2005). *Science K-7 integrated resource package* [IRP], Draft, 1-328. Victoria, BC: Author.

British Columbia Ministry of Education. (2008). *Science 8-10 integrated resource package* [IRP], Victoria, BC: Author.

British Columbia Ministry of Education. (2015) *BC's new curriculum: Science.* Victoria, BC: Author. Retrieved from https://curriculum.gov.bc.ca/curriculum/science/introduction

Cajete, G. (1994). *Look to the mountain: An ecology of Indigenous education* (1st ed.). Durango, CO: Kivaki Press. Retrieved from http://files.eric.ed.gov/fulltext/ED375993.pdf

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

Cajete, G. (2000). Indigenous knowledge: The pueblo metaphor of indigenous education. In M. Battiste (Ed.), *Reclaiming indigenous voice and vision* (pp. 181-191). Vancouver, BC: UBC Press.

Delgamuukw v British Columbia, [1997] 3 S.C.R. 1010.

Gauthreau, N., Mitchell, C. & Naziel, W. (2007) *Witsuwit'en use study for the proposed Blue Pearl Inc's Davidson Project.* Moricetown, BC.

Gisday Wa & Delgam Uukw. (1989). *The spirit in the land: The opening statement of the Gitksan and Wet'suwet'en hereditary chiefs in the Supreme Court of British Columbia,* Gabriola BC: Reflections.

Haig-Brown, C. (1992). Choosing border work. *Canadian Journal of Native Education, 19*(1), 96-116.

Hoffman, R. (2006). *Rekindling the fire: The impact of Raymond Harris's work with the Plains Cree* (Doctoral dissertation). Trent University, Peterborough, ON. Retrieved from http://www.collectionscanada.gc.ca/obj/thesescanada/vol2/002/NR15721.PDF

Ignas, V. (2004). Opening doors to the future: Applying local knowledge in curriculum development. *Canadian Journal of Native Education, 28*(1/2), 49-60.

Kanu, Y. (2005). Teachers' perceptions of the integration of Aboriginal culture into the high school curriculum. *Alberta Journal of Educational Research, 51*(1), 50-68. Retrieved from http://ajer.journalhosting.ucalgary.ca/index.php/ajer/article/view/498

Kawagley, A.O. (1995). *A Yupiaq worldview: A pathway to ecology and spirit.* Prospect Heights, IL: Waveland Press.

Kawagley, A.O. (1999). Yupiaq education revisited Alaska native education: History and adaption in the new millenium. *Journal of American Indian Education 39*(1), 31-51. Retrieved from http://www.ankn.uaf.edu/Curriculum/Articles/OscarKawagley/yer.html

Kendy, N. (2007). *Gathering teachers' ideas and beliefs about science and creating space for Traditional Knowledge in the science classroom* (Master's thesis), University of Victoria, Victoria, BC. Retrieved from http://hdl.handle.net/1828/966

Kimmerer, R. W. (2013). *Braiding sweetgrass: Indigenous wisdom, scientific knowledge, and the teachings of plants.* Minneapolis, MN: Milkweed Editions.

Kimmerer, R. (2017). Indigenous science: Let our voices be heard. Retrieved from http://www.esf.edu/indigenous-science-letter/

Meyer, M. (2008). Indigenous and authentic: Hawaiian epistemology and the triangulation of meaning. In N. Denzin, Y. Lincoln, & L. Smith (Eds.). *Handbook of Critical and Indigenous Methodologies* (pp. 217-232). London, UK: Sage Publications.

Morin, M. H. (2016). *Niwhts'ide'ni Hibi'it'en – The ways of our ancestors. Witsuwit'en history & culture throughout the millennia*, (2nd ed.). Smithers & Moricetown, BC: School District #54 (Bulkley Valley) and Wisuwit'en Language and Culture Authority.

Murray, J.J. (2015). Re-visioning science education in Canada: A new polar identity and purpose. *Education Canada, 55*(4), 18-21. Retrieved from http://www.cea-ace.ca/education-canada/article/ re-visioning-science-education-canada

Office of the Wet'suwet'en. (2011). *Wet'suwet'en rights and title and Enbridge's Northern Gateway Pipelines Project* [Office of the Wet'suwet'en Natural Resources Department submission to the Northern Gateway Joint Review Panel]. Wet'suwet'en territory, BC: the author. Retrieved from www.wetsuweten.com/images/uploads/Wetsuweten_Written_Submission_revised.pdf

School District #54 (2013-2018). *'Alhk'ikh ' Hëdlih - Walking together: A framework for the enhancement of Aboriginal education in the Bulkley Valley.* Bulkley Valley, BC: Author. Retrieved from http://www2.gov.bc.ca/assets/gov/education/administration/kindergarten-to-grade-12/aboriginal-education/enhancement-agreements/framework/sd54.pdf

Snively, G., & Williams, Wanosts'7 L. (Eds.). (2016). *Knowing home: Braiding Indigenous science with western science, Book 1.* Victoria, BC: University of Victoria. Retrieved from https://pressbooks.bccampus.ca/knowinghome/

Williams, L. (2005). *Mapping a journey to change: Teachers and facilitator learning together* (Doctoral dissertation). University of Tennessee, Knoxville, TN. Retrieved from http://trace.tennessee.edu/utk_graddiss/2319/

Williams, L., & Tanaka, M. (2007). Schalay'nung Sxwey'ga Emerging cross-cultural pedagogy in the academy. *Educational Insights, 11*(3). Retrieved from http://einsights.ogpr.educ.ubc.ca/v11n03/articles/williams/williams.html

Yore, L.D., Pelton, F.P., Neill, B.W., Pelton, T.W., Anderson, J.O., & Milford, T.M. (2014). Closing the science, mathematics, and reading gaps from a Canadian perspective: Implications for STEM mainstream and pipeline literacy. In J.V. Clark (Ed.), *Closing the Achievement Gap from an International Perspective: Transforming STEM for Effective Education* (pp. 73-104). New York, NY: Springer. https://doi.org/10.1007/978-94-007-4357-1_5