

A Two-Way Street: Indigenous Knowledge and Science Take a Ride

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Abstract: Indigenous knowledge systems are integrated epistemological systems taught through Indigenous pedagogies that support an understanding of an interconnected world and our places within it. Stories from two studies examine Indigenous youth participants' perceptions of science on the land and at school alongside Indigenous Elder participants' understandings of Indigenous science foundations and applications. The paper uses a two-way street approach (Barnhardt & Kawagley, 2005) as a conceptual frame to bring the studies together. A two-way street approach suggests that by understanding Indigenous science expressed through Indigenous pedagogies, we can better understand relationships within the natural and living systems of which we are a part and deepen classroom science learning. We examine diverse participants' stories to complicate our understandings of Indigenous science knowledge and to draw findings relevant to the teaching of science in classrooms for a two-way street approach. The findings provide seven tenets of Indigenous science to aid science and community educators and students in learning about science. These include experiential, transformative, and cultural learning, interconnectedness and learning within relationships, and apprenticeships with Elders. Other tenets recognize sacred teaching and learning so the knowledge is respected and used appropriately, and a relational approach where students learn these concepts from Elders and other knowledge-keepers. These tenets teach how to blend Indigenous approaches with mainstream science as a two-way street approach for educators' teaching of science in classrooms to benefit learners. Conclusions follow.

Indigenous knowledge systems are integrated epistemological systems taught through Indigenous pedagogies that support an understanding of an interconnected world and our places within it. These systems integrate ideas that are commonly referred to as science knowledge (Barnhardt & Kawagley, 2005; Cajete, 2000; Michell, 2005) and may be interchangeable with other terms like ethno-science, Indigenous science, and *minobimaatiwiiwin* (McGregor, 2009).

This article integrates two studies. The first by Desmoulins documents stories from Indigenous youth who are immersed within Indigenous knowledge systems and the challenges they face within mainstream science classrooms. The second study by Iseke provides excerpts from Indigenous Elders' stories that examine Indigenous science knowledge and pedagogies. We examine diverse participants' stories to complicate our understandings of Indigenous science knowledge and to draw findings relevant to the teaching of science in classrooms for a two-way street approach.

Barnhardt and Kawagley (2005) explain a two-way street metaphor that requires western scientists and educators to begin to understand Indigenous epistemologies as knowledge systems rather than the more typical approach of requiring Indigenous students to learn Western science and to carry the burden of integrating it with their Indigenous science knowledge. They suggest:

Native people may need to understand western society, but not at the expense of what they already know and the way they have come to know it. Non-Native people, too, need to recognize the co-existence of multiple worldviews and knowledge systems, and find ways to understand and relate to the world in its multiple dimensions and varied perspectives (p. 9)

The two-way street metaphor suggests that by understanding Indigenous science expressed through Indigenous pedagogies, we can better understand relationships within the natural and living systems of which we are a part. This process can enrich students' understandings of knowledge learned within communities while they come to understand and appreciate science concepts at school.

We begin this paper by introducing the authors and their respective methodologies. We then integrate the findings from their studies as students' expressions of challenges are further complicated by the words of Elders. These challenges and complications are presented before relating the literature of Indigenous education, science, and pedagogies so that there is a more discovery approach to learning about the two studies as they are related to epistemological foundations of Indigenous thought. In the discussion section that follows we provide educators with seven tenets for a two-way street approach to teaching science that respects Indigenous science/knowledge.

Introducing the Authors:

Judy M. Iseke, is a Métis woman, researcher, educator, filmmaker, and scholar of Métis and N'hiawuk heritage along with European ancestry from St. Albert, Alberta, Canada. In her academic work she has been working with Métis Elders to explore Indigenous storytelling. Elders share their stories and expertise through collaborative dialogues. The Elders have given Iseke the responsibility to edit their words and ideas and to share these back with them, the community, and more broadly.

Leisa Desmoulins gained Indian Status and membership with the Ojibways of the Pic River First Nation through marriage. Since that time, she has worked as an ally with Indigenous Peoples in urban and reserve communities and through her scholarship. She is

an Assistant Professor in the Faculty of Education at Lakehead University. Her research explores and addresses issues that emerge from the urban Aboriginal community using use community-engaged scholarship. These include Indigenous approaches to language and literacy and transformative learning.

Desmoulins' Study of Student Perceptions of High School Science

Desmoulins' study is drawn from a larger community-engaged study, the Urban Aboriginal Task Force (UATF), which explored Aboriginal Peoples' relationships with the city of Thunder Bay, Ontario, Canada and its institutions. Desmoulins' study focused on youth and their experiences within public schooling. Selected from this larger data set are responses to science by six of the eight self-identified youth in grades 10-12 (aged 15-20 years) who self-selected for the larger study. All six students had come with their families from Oji-Cree and Ojibwa communities within Northwestern Ontario, Canada to Thunder Bay before their current year of high school. Over the four-month study Desmoulins' data collection methods for the larger study included: students' photography, interviews, talking circles, and letter writing. In the interest of space, data from formal and informal interviews with 3 students are presented here based on transcribed and coded themes from which analysis were returned to community for feedback. Student discussions of school included their perceptions and experiences within science classrooms in grades 10, 11, and 12.

Students Learning Science From Elders

Ella and Lorraine (all names are pseudonyms), two high school students, talked about their experiences at home, learning from their grandmothers. They talked about

their grandmothers as important teachers in their lives and they shared examples of the Indigenous knowledge that they learned from them. Ella explains the things she did with her grandmother in her home community

She taught me lots of things about our culture ... like physical, outside things, like setting traps and check up on the net. I don't know, I did a lot of things with her.

But now she can't do those things. This summer when I went home I really wanted to do all that but she couldn't. She's too old.

Like Ella, Lorraine's grandmother taught her and her siblings "things like how to do beadwork, how to skin a beaver, and how to make a teepee". She explains about her grandmother's emphasis on the teepee for shelter, saying, "It was kind of tricky but we could get in [to the teepee]. It was fun." Lorraine made connections to culture and knowledge through her grandmother's teachings equating culture to learning to live off the land and other traditional place-based activities. Ella and Lorraine grew up understanding science as interrelationships embedded within Indigenous knowledge.

Understanding Indigenous Knowledges and Science Systems

Indigenous knowledges are expressions of the everyday reality of occupying a place. These knowledge systems are based on long habitation, careful observation, and living in close relationship with a place (Dei, 2000; 2011; Hanson & Vanfleet, 2003).

Indigenous knowledge systems are complex and have an adaptive integrity of their own (Barnhardt & Kawagley, 2004). Integrated within Indigenous knowledge of science is the important roles that Elders and traditional practitioners serve as knowledge keepers about living in a place (Barnhardt, 2005; Barnhardt & Kawagley, 2005; Dergousoff, 2008; Iseke, 2011). Elders and knowledge keepers have long researched the

natural world and our relationships to it (Iseke-Barnes & Danard, 2006). Their stories express these relationships, teach the next generations about interrelationships (Iseke-Barnes, 2009; Castellano, 2000), and are embedded in Indigenous educational practices (Barnhardt & Kawagley, 2005; Kawagley, 1995; Cajete, 2000).

Indigenous Educational Practices

Indigenous educational practices use natural learning environments on the land and in culture camps (Barnhardt & Kawagley, 2005; Belczewski, 2009; Cajete, 2000). Thus, Indigenous science is relational, expressed through land-based education, which engages geographical, relational, and experiential domains of place (Barnhardt, 2008; Guilar & Swallow, 2008; Michell, Vizina, Augusta, & Sawyer, 2008). Michel et al. define place as “*the product of the relationship with and connection to the land*” (p. 29, italics original).

Stories carry understandings of the living systems in which we share our lives (Iseke & Brennus, 2011). To illustrate how stories provide understandings of science for listeners, Barnhardt and Kawagley (2005) share a story told by an Elder learning to hunt from his father many years earlier, before the use of guns. His father approached the caribou herd, which moved away from him in a line following the lead bulls. The hunter stopped, put down his bow and arrow and began flapping his arms, emulating a bird attempting to take flight. The caribou bulls saw him and turned towards him; spiraling around him so close he could easily use his bow and arrow to cull the choice animals from the herd. The hunter knew the inquisitiveness of caribou and exploited this knowledge to hunt them, showing the interconnectedness of Indigenous knowledges in the natural world (p. 8-9).

Elders and other traditional practitioners, like the grandmothers of these students, educate about the complex relationships involved in these living systems and help to create a clearer understanding of the traditional ecological knowledges (TEK) used in living in close relationships to a place. Indigenous peoples have begun a process of reasserting traditional knowledge and examining how it can be useful to the next generations and to a broader world. This continues a tradition of adaptive processes that has long served Indigenous communities in survival, learning, and knowing about living in a place (Arctic Environmental Protection Strategy, 1993; Cochran, 2004). The students in Desmoulins' study come from communities and families still immersed in Indigenous knowledge systems and learning from Elders and traditional teachers.

Iseke's work with Métis Elders—Overview of the Study

Iseke's research reported here is part of a larger research program working with Métis Elders as collaborators to examine stories, histories, and pedagogies shared by Métis Elders in storytelling sessions (Iseke-Barnes, 2009; Iseke, 2011; Iseke, 2013a; Iseke, 2013b; Iseke 2013c; Iseke & Moore, 2011; Iseke & Brennus, 2011; Iseke & Desmoulins, 2011; Iseke & Desmoulins, 2013). The purpose was to use a collaborative analysis with Elders to understand the stories and histories of Métis peoples and the role of storytelling in the sharing of Indigenous knowledges – past and present.

In this research program Iseke contacted the Elders based on their previous involvement with a research program involving Métis Elders. They consented to come to Thunder Bay, in Northern Ontario, to be with the other Elders and to be video and audio recorded sharing discussion of storytelling. Iseke and a local Elder welcomed the Elders onto the territory through a ceremony. Gifts of tobacco and cloth were given to signify

that each person would speak truth, as they understood it. It also signified the relationship and responsibility of the researcher to respect and honor the relationship with the Elders and the knowledge that they shared throughout the research process and in the process of representing their stories in papers and other dissemination activities.

Iseke used an Indigenous methodology, with participants as collaborators and ceremony as part of researching to explore storytelling. For methods, she provided a set of research questions to Elders to help them think about stories and discussions they wished to share. A talking circle format was used to encourage discussion and to ensure opportunities for full participation of each Elder. Elders were audio and video recorded in circle. All Elder discussions were transcribed and roughly sorted into topics. Follow up interviews were recorded in Elders' homes and then transcribed and sorted. A version of this article has been shared with the Elders to support ongoing discussion, dialog and feedback.

Introducing Tom McCallum

Tom McCallum, who was born and raised in Ile à la Crosse, Saskatchewan, is fluent in Cree and Michif – a unique language of Métis peoples consisting of an Indigenous language structure with French and/or English words used. Tom has a passion for the Cree language and promotes its use as he explains the way the language has shaped his way of seeing the world. Tom grew up on the land and has a close relationship with it and in working with medicines. Tom uses traditional teachings to work with Indigenous inmates, youth, men's healing circles, and in cross-cultural workshops. He has extensive experiences with the two-way street approach, sharing with Indigenous and non-Indigenous learners.

Understanding Cree Epistemology and Science

Tom explains a story from his upbringing to bring Indigenous worldviews into focus and to help listeners understand Indigenous perspectives on Indigenous science.

When I was a kid our method of travel was by canoe. ... My mom used to make a little bed for me ... on the bottom of the canoe. And that's where I would lay in the canoe. And she would be sitting in front, and my dad would be sitting in the back and he'd be paddling. We'd be going home. And I could hear that water. I could hear the paddles. ... I remember going through them bull rushes, and as the bull rushes went around the gunnels of that canoe, they had a song of their own. A sound that was so unique, it was just beautiful, because it was synchronized. The wood was synchronized with those bull rushes. Two lives coming together and making a song together. ... To me it was so soothing. The voice of the water, the voice of the wind, the voice of the bull rushes, the wood, the voice of the paddles and the voice of the water when the paddle is moving through the water. All of those were so soothing to me--that's indigenous language. It's much more than the spoken word.

In this story, Tom tells us about the interconnectedness of all of creation and our own relationships to the natural world, illustrating a foundational concept of Indigenous knowledge systems. By delving further into these stories and hearing more detailed stories situated on the land and in communities, listeners to the stories begin to understand a more complex relationship with environment, and one's place in relationship within it.

Students' Reflections on Experiences in the Biology Classroom

In Desmoulins' study, students talked about their positive and negative experiences within high school science classrooms, particularly as they related to dissections and respect for animal life. In a talking circle, participants talked about challenges when the science teacher required them to dissect rats in Biology class. To expand, when Isabel had just come from science class to meet with Desmoulins for an interview, she was agitated and upset as she talked about the dissection class:

Isabel: It's ... more about nature, I don't know. Today, playing around with the rat, I felt wrong doing it. Because it's disrespecting an animal. I didn't want to sit there and do it, cause that one of the things I care about. What this world has.

Leisa: What did you do about that? Did you put that aside and do the assignment or how did you resolve it?

Isabel: Yeah I just put it aside and we were asked to take turns to skin the rat but I didn't want to [skin it], but I watched. Yeah I just put it aside as part of my science. ...

Lorraine was also doing dissections as part of the Biology course. She dealt with the dissection class in a different way than Isabel had. Lorraine mentioned that she never skips school:

Lorraine: But I didn't want to go to my biology class. I don't know. 'cause I was like I was feeling kinda tired and I wanted to go home. I didn't have a lunch and I was feeling hungry too. So I went home for period four [biology] and then I came back for period 5. And I was dissecting rats too, and I don't like that.

Leisa: Is that why you wanted to miss it too, to miss dissections?

Lorraine: Yes that was in Biology. And I wanted to go ... back to school after...,
to do this project for cooking.

Indigenous regard for animal species is commonly disregarded in so-called “scientific experiments” that students are asked to perform on animals in classrooms in many high school science classrooms across Canada. Prior to European arrival on indigenous soil, wildlife communities were generally treated as sovereign nations with authority equal to, if not greater than, that of humanity (Deloria, 2006; Lawlor, 1991; Thomas, 2007). Animal lives were accorded dignity. Indigenous hunters performed rituals to mark the deaths of their prey and there is evidence of mutual regard from other species (Bradshaw, 2010).

Scholars contend that mainstream school curricula, teaching approaches, and assessment strategies often do not appreciate nor recognize Indigenous understandings of an interconnected world and the importance of place in society (Battiste, 2000; Kawagley, Norris-Tull & Norris-Tull, 1998). Barhardt and Kawagley (2005) note that mainstream science teachers typically present science as decontextualized facts or information that is applicable globally, and teach facts through textbooks and situated in a classroom setting. Cajete (1999) challenges educators to move their teaching away from one legitimated science to understandings of science as relational and drawing upon understandings that demonstrate how everything is connected to everything else. This aids students who come to science from other ways of knowing and cultural systems of scientific thought, specifically those “...which have evolved from unique perceptual orientations of natural reality” (p. 37).

Importantly, Indigenous expressions of TEK have become increasingly relevant

for science educators and within mainstream high school science curricula (Barnhardt, 2008; McGregor, 2000, 2004, 2005; Sniveley & Corsiglia, 2000). Barnhardt (2008) explains its relevance for “connecting what students learn in school with life out of school” and reducing the tensions “...at the root of many of the problems that Indigenous peoples have endured...” (p. 113-114). Elders and other community members hold this in-depth knowledge as long-term residents with knowledge of peoples’ interactions with the land (Barnhardt, 2005; Dergousoff, 2008; Leclair, 2002). Their extensive knowledge of and relationship with place provides a holistic view of a place-based education.

Understanding Cree Epistemology and Science

In Iseke’s study, Elder Tom McCallum explains his perspective informed by his being of the four-directions people – the Nehiawuk or Cree people- and the connectedness in stories.

We believe that everything has a spirit, everything has an energy from the Cree way of looking at the world, and looking at existence, creation. Everything is a vital part of everything that exists, as opposed to English. [In English] ... they have what they call a spirit duality – spirit and matter are two different entities – but not in the Cree way it isn't. It's one and the same thing.

Forbes (2001) explains that many Native Americans understand the universe as being alive – “having movement and an ability to act” and further as “a fantastic and beautiful creation engendering extremely powerful feelings of gratitude and indebtedness, obliging us to behave as if we are related to one another’ (p. 284). This notion of kinship relations is an extremely important concept in Indigenous knowledge systems and directly relates to understandings of the natural world and relationships within it. If one is

part of all of creation one does not disrespect any part of creation, from the rat to other humans. Experimentation is human centric and disrespectful.

Later Tom returns to the concept of duality that is evident in the English language and in mainstream science.

There's another faction over here called physics. I talked about that earlier.

Newtonian physics, where spirit and matter are two separate entities. They're not. They're connected. From our spirit world, spirituality we call it, it's one and the same thing. Well they're finding out now, scientists are finding out that may have some basis, may have some merit to what we've been talking about. And they have what they call a new biology, that's called quantum physics. Where they say well you can't find out matter in it's purest form because it isn't there. It's all energy. What we call spirit as Aboriginal people. That's what it is. That's what drives everything.

Forbes returns to a similar concept in discussing Indigenous epistemology in which he describes “creation as a living process, resulting in a living universe in which a kinship exists between all things” and thus we are in relation to all things around us and all parts of the universe (p. 283). Elder George McDermott illuminates the practice of these concepts through bush knowledge and how it can apply to mainstream schooling.

Introducing George McDermott

Another Elder in Iseke’s study is George “Lonewalker” McDermott who was Métis from Northern Alberta who lived in Lumby, British Columbia until his passing in 2009. He traveled throughout Canada and the United States to share his knowledge of traditional medicines. George learned about life on the land, picking medicines, and

healing practices from his grandparents and Elders in Métis and Cree communities in Northern Alberta. George shared his knowledge of plant medicines and healing as well as his knowledge of land in healing people holistically—through physical, mental, spiritual, and emotional aspects.

Teaching Indigenous Knowledge Systems of Science

George McDermott, a healer who was particularly experienced in life in the bush and who knew the medicinal plants through many years of experience, ponders how to teach the interconnectedness with living things.

There's a lot of other things that we have to look at to make it possible to do it in the school system. But to teach somebody, to take them into the bush and share with them, introduce them to the medicine tree. Here, Tom, here's the medicine tree. Hug it, taste it, smell it. But spend some time with it. And the next time you see that medicine tree some other place, you know it's the right one because you have tasted it, smelt it, and it was given to you spiritually.

George is expressing that to learn to understand the medicinal plants you cannot just be told about them or read about them in a book: one needs to come to know the plant through direct experience and spiritual connection. This is one aspect of Indigenous experiential learning.

Tom McCallum considers the process of Indigenous experiential learning.

When we talk about how we used to learn a long time ago, somebody skinning a moose. Then old people then say, "okay, this is how you have to stand, you have to have your arm like this, the knife has to protrude like this and you make quick little slices like that." You don't need that. You just watch, watch how they do it. And

you watch, and then ... they'll say, "do you want to try?" And of course, the young people will want to try. When they get in there they might cut a hole in the hide but that's okay. You keep going. That's experiential learning. But giving them that opportunity to learn, we have to give them that.

Tom's explanation provides an example of the importance of watching as a learning strategy for Indigenous young people, which is then followed by the opportunity to develop skills. Beyond the physical acts of killing a moose, learners are also taught the spiritual practices of respect and how to make offerings to take a life. Elders teach these spiritual and cultural aspects directly. Alma Desjarlais shows how Elders teach directly.

Introducing Elder Alma Desjarlais

Alma Desjarlais was born in Frog Lake, Alberta, a First Nations community in Northeastern Alberta. She was the daughter of Cree parents. Her grandmother and family were healers and helped her to become a healer herself. Alma speaks Cree and has become a pipe carrier¹, works with healing medicines (herbs) and is part of the healing lodge that she and her husband Albert have on their land. She also oversees a cultural camp for young people to help them learn Cree traditions and language. Alma, while of First Nations parents, married Albert who is Métis. She was stripped of her status as a treaty Indian through this marriage and who now identifies as Métis.

Alma Desjarlais is a well-known healer and educator in her community of East Prairie Settlement in Northern Alberta. Alma's words help us understand processes that partially inhibited the passing on of cultural traditions as well as ways she plays a role in

¹ Pipe Carriers are spiritual people in communities that use a sacred pipe to pray and ask for assistance and to seek a greater connection with the Creator. One needs to develop to a level of spiritual awareness before being gifted a pipe.

ongoing cultural regeneration through culture camps. Alma and Albert are committed to teaching within their own communities and beyond through their travels and sharing in research. Alma and Albert are Elders to a culture camp held on their land to help teach the traditions, language, and culture as well as understandings of the natural world and relationships to it.

We had it for two years now. The cross-cultural awareness camp. But we just call it East Prairie Culture Camp. In there we use our local people as presenters - the ones that know what they're doing. They didn't learn from the book. They lived that. So we have making dry meat and the kids absolutely do it themselves too. And smoked fish. We show them how to dry the berries. Also ... we have canned meat in there to show them, the canned fruits. This year the men also showed them how to clean beaver, skin beaver, and how to make the moose callers and call moose. They make birch bark baskets, and fish scale art. And then just talking to them. And the sweat. We don't force them to. They want to. They just go and watch there outside. A lot of them sweat. And it's not only kids that come and learn, the adults too that come. And they have a pipe ceremony every morning. ... A lot of them don't learn, even around here in our community, they don't learn that traditional way at home so they show ... them. They went picking berries and a bit of picking medicines.

Through these culture camps, children and adults learn about the relationship of living things in the environment, the skills to harvest and process the bounty of the land, and to respect and appreciate the relationships through acknowledgment in ceremony. Learning to name the parts of creation in the Cree language also brings people into the relationship

and helps to transform their thinking. Elders support this idea of teaching science through direct experience with the natural world, and including cultural and spiritual knowledges.

Teaching Indigenous Science through Direct Experience

Tom explains how being involved in culture camps changes people. He describes his experiences with taking children into the bush, saying:

When I take them to the bush, they'll hold hands, they'll hug each other. It completely changes their way of seeing each other. Their relationship changes immediately as soon as you take them to the bush. So I take them to the bush a lot. I take them for walks. And they're just so excited about exploring everything. And I let them explore, let them look for bugs, but I don't like them to take those bugs out of their environment. I let them play with them for a while but they gotta put them back and I explain to them why. So those are the kind of teachings that's important for children to learn. That's part of respect. Respecting those that have life too. They need to do that. They need to see them that way. That's a start.

Imitating adults and playing will encourage the child to learn what to do (Flannery, 1995). For example, Alma pointed out that as child she was busy playing while her grandmother picked medicines. She wasn't really paying attention "but in a way you are" she explained. As a result of this early teaching and her later apprenticeship she is a skilled healer in the use of medicines.

George McDermott, a well-known Cree who used herbs to heal many people explains the process of learning.

When I received my first herb ... the balsam bark, I was also told its got eleven or twelve brothers or sisters that aint healing. You got to have the right one the

exactly right one. So if she came with me into the bush, and I'm gonna give her a herb of mine that I learnt, I tell her the story of that herb. Orally. ... You do it right there, its a ceremonial thing. Its not here's the herb it will heal anything. That don't work. ... I stayed with my (Cree herb) for two days. I never went home for two nights. I hugged it. I smelt it. I tasted it. And now a whole bush of (Cree herb) I can walk right to where it is, exactly where it is. ... You don't just harvest it ... you pray because what's in front of you is going to save a life. It's very, very, very sacred to learn one of these - one of many that you need to blend for cancer or for diabetes. It's in a blend we're taught, it's in the blend of things that you put together. Some herbs don't like to work together. So you got to know exactly what you're doing!

Tom McCallum explains the challenges of moving from an abstracted view of science and global issues, saying

Can we teach that stuff in school? Sure we can. We can do that. We've taught people to think in a certain way. We have a mind set that we're not a part of everything. We're apart from. We control everything. We put ourselves up here and everything is below us for us to use and exploit and this is where it has gotten us today. When they say global warming, water's being poisoned. All that stuff.

He suggests that the way forward for educators is through a relational approach to science, where science is understood through its interconnections. He explains, "It's time to start thinking in a different way. That is what we need to teach our children. That is what we need to teach the youth of today".

Tom further explains stories for teaching "these are the stories that will help us

and assist us, as children to have that perspective. That doesn't mean we can't go to school. You go to school, that's a different way of learning. You blend the two together, make them work for you, and others, coming behind you.” Like the two-way street metaphor proposed by Barnhardt and Kawagley, there needs to be a connection between Indigenous science and the science taught in classrooms.

Barnhardt and Kawagley (2005) provide an example of teaching science as connectedness in choosing an eddy in which to locate a fishing net along a river. Using an Indigenous approach to explaining is important in “pointing out the currents, the movement of debris and sediment in the water, the likely path of the fish, the condition of the river bank, upstream conditions affecting water levels, the impact of passing boats, etc.” (p.12). Using the understandings of this specific example and explaining using circumstances students have encountered, the “western terms, such as flow, velocity, resistance, turbidity, sonar readings, tide tables, etc.” can then be understood within the Indigenous understandings so that “the modern explanation adds to the traditional understanding (and vice versa)” (p. 12). By starting with what students know and their experiences, students will be motivated by something useful and helpful in living in a community and which reflects their worldview.

Indigenous scholars have long held a holistic view of the natural world that can inform the science classroom (Barnhardt & Kawagley, 2005) through Indigenous models of science learning (Cajete, 1999; Sutherland & Dennick, 2002) and building upon Indigenous students’ existing knowledge and experience of Indigenous science (Nelson-Barber & Estrin, 1995).

Discussion

When we examine these two studies we can see the potential for bridging and connecting Indigenous epistemologies, knowledge systems, and learning settings including the more formalized educational settings of classrooms. To enhance Indigenous students' engagement with school, changes to curricula, pedagogy, and educational environments are needed, including engagement with Indigenous knowledge in science classrooms (Barnhardt & Kawagley, 2004, 2005; Dion, 2009; Michell, Vezina, Augustus, & Sawyer, 2008; Snively & Williams, 2006). What guidance do the Elders' stories provide?

Tom provides science educators with an understanding of several foundational concepts of Indigenous science including the interconnectedness of all of creation and the connection of humanity to the cosmos. Another foundational concept is an understanding that everything has a spirit. In scientific terms understanding that everything is composed of energy may well allow a bridge to this concept. To understand that spirit and matter are not two separate entities but one and the same if one considers this from the perspective of energy. Understanding creation as a living process and ever changing is another central idea that must be acknowledged.

Further, Indigenous science is related to understandings of ecology – the holistic/interdisciplinary study of the entire universe including geo-ecology, human ecology, ecology of oxygen, and ecology of water. These ways of connecting Indigenous ideas to understandings in mainstream science will aid Indigenous students in incorporating science within Indigenous epistemologies. Yet, educators also need to learn to use a two-way street approach, to deepen their own science understandings and

enhance their students' understanding and learning.

A two-way street approach asks mainstream educators “to recognize the co-existence of multiple worldviews and knowledge systems, and find ways to understand and relate to the world in its multiple dimensions and varied perspectives” (Barnhardt & Kawagley, 2005, p. 9). Through their stories, the Elders explored seven concepts that will aid mainstream educators in teaching broader conceptions of Indigenous knowledge systems as they relate to science. These concepts include: experiential learning, transformative learning through experience and all four aspects of being, cultural understanding as part of learning, interconnectedness as learning within community and within relationships, informal apprenticeships with Elders, recognizing sacred teaching and learning so the knowledge is respected and used appropriately, and a relational approach where students learn these concepts from Elders and other knowledge-keepers.

First they identify the importance of experiential learning as it relates to knowledge systems and culture. They explain experiential learning as learning by watching and doing and the spiritual connections that emerge through direct experience. George and Tom emphasize the importance of spirituality in the understandings of knowledge systems. Alma gives examples of watching as doing through the activities that the youth at the cultural camp that she runs with her husband, Albert, engage in—for example, smoking fish, canning fruit, cleaning and skinning beaver. These are the similar activities to those that the youth participants in Desmoulins' study shared in their stories of learning science from Elders.

Related to using experiential learning, the second concept is that all people transform their understandings through experiences and experiential learning.

Transformative learning provides deep understandings because it engages all aspects (emotional, physical, social, and mental) of learner's being. Elder George McDermott believes that transformative learning through experience allows learners to apply their learning in other contexts as well. Thus, it provides students experiences with Indigenous knowledge and science will aid them.

The third concept is to acknowledge the accumulated knowledge within cultural knowledge systems and the relationship of this accumulated knowledge to learning. Along with learning how to smoke and can foods, harvest plants, and snare and process animals, Alma and her husband Albert teach the youth traditions, language, and cultural knowledge within their cultural camps. In his stories, Tom gives the example of how he includes cultural teachings about respect within the context of his cultural camps.

The fourth concept is interconnectedness. Learning within Indigenous knowledge systems generally occurs in community and within relationships to all things. To learn within community contextualizes the knowledge within place and within the cultural teachings of that place. As Alma shares, language, traditions, and cultural teachings are integrated with the skills to be learned. Interconnectedness occurs when science is learned experientially and within natural learning environments. Acknowledging this interconnectedness will aid students in making connections to Indigenous knowledge and science.

Fifth, informal apprenticeships can help students have these experiences and develop skills and mastery of skills over time if the apprenticeship is suited to the level of the learner. The role of older adults in this learning cannot be underestimated. They can serve as mentors and teachers in apprenticeships, can be guides in experiential learning

and can aid in the learning process. In different ways, Tom, George, and Alma offer apprenticeships to youth to pass on their knowledge to future generations.

Sixth, some learning is of sacred knowledge – like the knowledge of how to use plants to heal and how to conduct ceremonies– and must be treated as such. George McDermott carries sacred plant knowledge. Alma carries sacred knowledge as pipe-carrier as well as plant knowledge. Both of them gained this knowledge through their parents and grandparents through a long apprenticeship. Those with relationships with the medicines must be the only ones to conduct sacred teaching and learning so the knowledge is respected and used appropriately. Misuse and misunderstandings could be dangerous.

Finally, the seventh concept is the relational approach. Iseke (2013) explains, “The Elders’ stories express these interrelationships and teach them to the next generation. They educate children, youth, and adults about the living systems of which we are a part” (p. 561), which will aid students in connecting to science through Indigenous knowledge. Using a relational approach will support students’ continued development as Indigenous persons and as knowledgeable in science. It aids students in seeing that their experiences in home communities contribute to their understandings of school science.

Desmoulins’ participants show their need for a two-way street approach to science in the classroom. The Elders’ stories show an Indigenous approach, grounded in their localized, Indigenous knowledge that applies science learning through seven tenets. Barnhardt and Kawagley (2005) highlight the importance of these Elder’s stories. They write,

By documenting the integrity of locally situated cultural knowledge and skills and critiquing the learning processes by which such knowledge is transmitted, acquired, and utilized, Alaska Native and other Indigenous people engage in a form of self-determination that will not only benefit themselves but will also open opportunities to better understand learning in all its manifestations, thereby informing educational practices for the benefit of all (p. 20).

Conclusions

From the participants stories from Desmoulins' and Iseke's studies we show that the benefits of learning from Elders' stories will aid students and provide a guide for mainstream educators who are open to a two-way street approach to teaching science.

To move forward with a two-way street approach, educators must address the development of a sense of self in students, respect individual, collective and cultural knowledge, and must "cultivate a sense of community and social responsibility" (Dei, 2008). Exploring examples from general science with Indigenous science examples enables a comparison that facilitates understanding that both sciences are the result of creative thought processes. Perceiving, analyzing, and synthesizing the findings from creative study aids students in making meaning of learning processes, scientific understandings, and culturally meaningful epistemological principles.

Challenges for educators to address in considering next steps in science classrooms are: What does it mean to study Indigenous knowledges? What does it mean to respect Indigenous science for student learning, for curriculum content, for teaching practices, and for assessment approaches about knowledges? How can educators use the pedagogic and epistemological principles to inform mainstream science education from a

two-way street approach?

References

- Arctic Environmental Protection Strategy (1993). A Research Program on Indigenous Knowledge, Anchorage, AK: Inuit Circumpolar Conference.
- Barnhardt, R. (2005). Indigenous Knowledge Systems and Alaska Native Ways of Knowing. *Anthropology and Education Quarterly*, 36(1), p. 8-23.
- Barnhardt, R. (2008). Creating a Place for Indigenous Knowledge in Education: The Alaska Native Knowledge Network. In G. Smith & D. Gruenewald, (Eds.), *Place-Based Education in the Global Age: Local Diversity* (pp. 113-134). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Barnhardt, R. & Kawagley, A.O. (2004). Culture, chaos, and complexity: Catalysts for change in Indigenous education. *Cultural Survival Quarterly*, 27(4), 59-64.
Accessed 10-08-10 @ <http://www.culturalsurvival.org/publications/cultural-survival-quarterly/united-states/culture-chaos-complexity-catalysts-change-ind>
- Barnhardt, R. and Kawagley, A.O. (2005). Indigenous Knowledge Systems and Alaska Native Ways of Knowing. *Anthropology and Education Quarterly*, 36(1), 8-23.
- Battiste, M. (2000). *Reclaiming Indigenous Voice and Vision*. Vancouver: UBC Press.
- Belczewski, A. (2009). Decolonizing science education and the science teacher: A white teacher's perspective. *Canadian Journal of Science, Mathematics, and Technology Education*, 9(3), 191-202. DOI 10.1080/14926150903118326.
- Bradshaw, G. (2010). You see me, but do you hear me? The science and sensibility of trans-species dialogue. *Feminism & Psychology*, 20(3), 407-419.
- Cajete, G. (1999). *Igniting the spark: An indigenous science education model*. Skyland, NC: Kivaki Press.

- Cajete, G. (2000). *Native science: natural laws of interdependence*. Santa Fe, NM: Clear Light Publishers.
- Castellano, M. B. (2000). Updating Indigenous Traditions of Knowledge. In G. J. S. Dei, B. L. Hall, and D. G. Rosenberg (Eds.), *Indigenous Knowledges in Global Contexts: Multiple Readings of Our World* (pg. 21-36). Toronto: University of Toronto.
- Cochran, P. (2004). *What is Traditional Knowledge? Traditional Knowledge Systems in the North*. Anchorage: Alaska Native Science Commission.
(http://www.nativescience.org/html/traditional_knowledge.html)
- Dei, G.J.S. (2000) African development: the relevance and implications of 'Indigenusness'. In G.J. Sefa Dei, B.L. Hall & D. Goldin Rosenberg (Eds.), *Indigenous Knowledges in Global Contexts: Multiple Readings of Our World*, (pp. 70–86). Toronto, OISE/UT, University of Toronto Press.
- Dei, G. J. S. (2011). *Indigenous philosophies and critical education: A reader*. New York: Peter Lang.
- Deloria, V. Jr. (2006). *The World We Used to Live in: Remembering the Powers of the Medicine Men*. Golden, CO: Fulcrum Press.
- Dergousoff, D. (2008). Ethnobotany, Institutional Ethnography, and the Knowledge of Ruling Relations. *Canadian Journal of Native Education*. 31(1) 162-180.
- Dion, S. (2009). *Braiding histories: learning from Aboriginal peoples' experiences and perspectives*. Vancouver, BC: UBC Press.
- Forbes, J. (2001). Indigenous Americans: Spirituality and ecos. *Daedalus*, 130(4), 283-300.

- Guilar, J. & Swallow, T. (2008). Alenenec: Learning from place, spirit, and traditional language. *The Canadian Journal of Native Studies*, 28(2), 273-293.
- Hansen, S. A. & VanFleet, J. W. (2003). *Traditional Knowledge and Intellectual Property*. Washington, D.C.: American Association for the Advancement of Science.
- Iseke, J. (2011). Indigenous Digital Storytelling in Video: Witnessing With Alma Desjarlais. *Equity and Excellence in Education*, 44(3), 311-329.
- Iseke, J. (2013a). Indigenous Storytelling as Research. *International Review of Qualitative Research*, 6(4), 559-577. Special Edition on Indigenous Qualitative Inquiries.
- Iseke, J. (2013b). [Negotiating Métis culture in Michif: Disrupting Indigenous language shift](#). *Decolonization, Indigeneity, Education, & Society*, 2(2), 92-116.
- Iseke, J. (2013c). Spirituality as Decolonizing: Elders Albert Desjarlais, George McDermott, and Tom McCallum Share Understandings of Life in Healing Practices. *Decolonization, Indigeneity, Education, & Society*, 2(1), 35-54.
- Iseke, J. & Brennus, B. (2011). Learning Life Lessons from Indigenous Storytelling with Tom McCallum (pp. 245-261). In G. Dei (ed.), *Indigenous Philosophies and Critical Education*. New York: Peter Lang.
- Iseke, J. & Desmoulins, L. (2013). Critical Events: Métis Servicewomen's WWII Stories with Dorothy Chartrand *Canadian Journal of Native Studies*, 33(2), 29-54.
- Iseke, J. & Desmoulins, L. (2011). Spiritual Beginnings of Indigenous Women's Activism: The Life and Work of the Honourable Thelma Chalifoux, White Standing Buffalo. *Canadian Woman Studies*, 29 (1/2), 24-34.

- Iseke, J. & Moore, S. (2011). Community-Based Indigenous Digital Filmmaking with Elders and Youth. *American Indian Culture and Research Journal*, 35(4), 10-37.
- Iseke-Barnes, J. (2000). Ethnomathematics and Language in Decolonizing Mathematics. *Race, Gender and Class: An Interdisciplinary and Multicultural Journal*, 7(3), pp 1-17.
- Iseke-Barnes, J. (2009). Grandmothers of the Metis Nation: A Living History with Dorothy Chartrand. *Native Studies Review*, 18(2), 69-104.
- Iseke, J. & Brennus, B. (2011). Learning Life Lessons from Indigenous Storytelling with Tom McCallum (pp. 245-261). In G. Dei (ed.), *Indigenous Philosophies and Critical Education*. New York: Peter Lang.
- Iseke-Barnes, J. & Danard, D. (2006). Indigenous Knowledges and Worldview: Representations and the Internet. In L. Dyson, M. Hendriks, & S. Grant (Eds.), *Information Technology and Indigenous People* (pp. 27-37). Hershey, PA, USA: Idea Publishers.
- Kawagley, A. O. (1995). *A Yupiaq worldview: A pathway to ecology and spirit*. Prospect Heights, IL: Waveland Press.
- Kawagley, A.O., Norris-Tull, D., & Norris-Tull, R.A. (1998). The indigenous worldview of the Yupiaq culture: Its scientific nature and relevance to the practice and teaching of science. *Journal of Research in Science Teaching*, 35(2), 133-144.
- Leclair, C. (2002). ['Memory Alive': Race, Religion, and Métis Identities](#). *Essays on Canadian Writing*, 75, 159-177.
- Lawlor, R. (1991). *Voices of the First Day: Awakening in the Aboriginal Dreamtime*. Rochester, VT: Inner Traditions International.

- McGregor, D. (2009). Linking Traditional Knowledge and Environmental Practice in Ontario. *Journal of Canadian Studies*, 43(3), 69-100.
- Michell, H. (2005). Nehithawak of Reindeer Lake, Canada: Worldview, Epistemology and Relationships with the Natural World. *The Australian Journal of Indigenous Education*, 34, 33-43.
- Michell, H., Vizina, Y., Augustus, C., and Sawyer, J. (2008). *Learning Indigenous science from place: Research study examining Indigenous-based science perspectives in Saskatchewan First Nations and Métis community contexts*. Aboriginal Educational Research Centre Accessed 05 June 2010 @ aerc.usask.ca/projects/indigenous_science.html
- Nelson-Barr, S. & Trumbull Estrin, E. (1995 Summer). Bringing Native American perspectives to mathematics and science teaching. *Theory into practice*, 34(3) 174-185.
- Snively, G. & Corsiglia, J. (2000). Discovering Indigenous science: Implications for science education. In W. Cobern (Ed.), *Culture and Comparative Studies* (pp. 6-34). Toronto, ON: John Wiley & Sons, Inc.
- Snively, G. & Williams, L. (2006). The Aboriginal knowledge and science education project. *Canadian Journal of Native Education*, 29(2), 229- 244.
- Sutherland, D., & Dennick, R. (2002). Exploring culture, language and the perception of the nature of science. *International Journal of Science Education*, 24(1), 1-25.
- Thomas, E.M. (2007). *The Old Way: A Story of the First People*. London: McMillan