Chapter 1 - Braiding Indigenous Science with Western Science

Gloria Snively and Wanosts'a7 Lorna Williams

One aim of teaching conventional school science is to enrich all students' lives by conveying how academic scientists understand nature. Some students enjoy understanding their world in a way similar to their science teachers. They share a scientific worldview and enjoy the challenge of the academic mindset as they learn the standards of a scientific discipline. Science-oriented students want to think, talk and believe the way academic scientists do. Some will eventually become doctors, science teachers, scientists or engineers.

However, not all students possess such a scientific mindset. Research shows that a majority of students prefer to understand nature through other worldviews (Aikenhead, 2006, 2007), such as primarily aesthetic, religious, or economic (Cobern, 2000), or orientations such as utilitarian, spiritual, aesthetic, recreational, or scientific, or a mix of orientations (Snively, 1989, 1990). These "science-shy" students tend to be much less enthusiastic about thinking, talking, and believing scientifically. Western Science, the science taught in most schools, is neither personally meaningful nor useful to their everyday lives. These students experience school science as a foreign culture and may even become alienated by their school science experiences (Aikenhead, 1996, 2001, 2007).

When growing up, a child encounters the culture of peers, the culture of school, the culture of the science classroom, and the overarching culture of the community and society in which the child lives. The concept of culture is a shared way of living which includes knowing, valuing, interacting with others, feelings, and conventional action (Phalen et al., 1991, p. 228). These characteristics of culture help explain the differences between the pupil's home culture and the culture of school science. It does not take long for a child of a traditional Aboriginal ancestry to recognize that the knowledge and wisdom of their culture is not welcome at school.

Until recently, almost all Canadian teachers were educated in Eurocentric systems that dismissed Aboriginal knowledge as science, and they taught a silent curriculum that attempts to assimilate Aboriginal students into a Western Science framework—forcing some children to abandon their traditional ways of knowing and reconstructing in its place a new scientific way of knowing. The majority of these science-shy students resisted learning by not participating. To their credit, an increasing number of science educators want to understand the cultural influence on school science achievement by students whose cultures and languages differ from the predominant Eurocentric culture and language of science. These students may be of Aboriginal ancestry living in traditional home communities, or have grown up in traditional communities and moved to urban centres. They may be first or second generation immigrants from countries in Asia, Africa, or South America. These students likely will not feel comfortable with the culture of Eurocentric science and learn to live in two worlds.

In contemplating a title for this book, the phrase "Knowing Home" is a reflection of the fact that traditional knowledge and wisdom is contextual. The stories and testimonies of Indigenous peoples are usually related to a home place. Indigenous peoples world-wide have an intimate relationship to their home place. In the words of Kimmerer (2013):

> To the settler mind, land was property, real estate, capital, or natural resources. But to our people, it was everything: identity, our connection to the ancestors, the home of non-human kinfolk, our pharmacy, our grocery store, our library, the source of everything that sustained us. Our lands were where our responsibility to the world was enacted, sacred ground. It belonged to itself; it was a gift, not a commodity, so it could never be bought or sold. (p. 17)

Knowing Home takes us on a timeless journey that is every bit as mythic as it is scientific. It attempts to capture the true reverence between Aboriginal people and the earth, the relationship that we need to survive. We acknowledge that plants and animals are our oldest teachers. *Knowing Home* is a significant step that unfolds the creative vision of Indigenous scientific knowledge and technology that is derived from an ecology of a home place.

In this book, "braiding Indigenous Science and Western Science" is a metaphor used to establish a particular relationship, an obligation of sorts to give, to receive, and to reciprocate. We braid cedar bark to make beautiful baskets, bracelets and blankets. When braiding hair, kindness and love can flow between the braids. Linked by braiding, there is a certain reciprocity amongst strands, all the strands hold together. Each strand remains a separate entity, a certain tension is required, but all strands come together to form the whole. When we braid Indigenous Science with Western Science we acknowledge that both ways of knowing are legitimate forms of knowledge. For Indigenous peoples, Indigenous Knowledge (Indigenous Science) is a gift. It cannot be simply bought and sold. Certain obligations are attached. The more something is shared, the greater becomes its value.

This book presents concepts and models that have been used for thousands of years to educate Aboriginal people. It shows us how we can braid Aboriginal ways of learning with Western Science to facilitate the science education of Aboriginal students, other Indigenous peoples around the world, as well as non-Aboriginal students. The braids are seen as a gift to all; to heal, to strengthen and to keep in motion.

Our intended audience for this book comprises science educators open to, or at least curious about cultural perspectives in their field. Our audience is not the professional scientist whose perspective on Indigenous Science is understandably much different from the perspective of science educators. Our audience is the reader who accepts Eurocentric knowledge but who simultaneously appreciates and understands Indigenous knowledge systems. Thus, in an attempt to take into account the multidimensional cultural world of the learner this book calls for co-existence, a kind of parallel relationship, between Western and Indigenous Science in the science classroom.

The Goals of Cross-cultural Science Education

We believe that the goal of science education is that students develop a richer understanding of science, the nature of science, and scientific inquiry. By nature of science, we do not mean a single prescription for what science is and how it should be conducted. Following Ogawa, a Japanese educator and researcher, we believe that it is important to distinguish between “understanding science” from “believing in science.” A belief in science, scientific attitudes, and scientific ways of thinking is deeply rooted in the western value system. As Ogawa (1997) explains, “My position is that whether one can believe in science and scientific worldview or not should be determined, not by the value within western modern science, but by the value within the daily life world of the people concerned” (p. 9).

Thus, drawing from examples in different cultures and stories of classroom practice, we seek to assist educators to feel more comfortable about teaching a pluralist form of science education. The following story describes how one elementary teacher of Aboriginal ancestry resolved the conflict between the worldview of her culture and that of incorporating Western Science topics in the science classroom.

Donna's Story

Donna is an elementary teacher of Kwakwaka'wakw ancestry who teaches at the T'łisalagi'lakw Band School in 'Yalis (Alert Bay, BC). She grew up in a very traditional family and has lived all her life in Alert Bay, which is on a small island. She was a University of Victoria graduate student and author of chapters 12 and 13. She wanted to focus on the sciences during undergraduate school with the intent to show that her Kwakwaka'wakw way of life was science, from making cedar bark clothing to preserving fish. She was excited to take her first biology course at Simon Fraser University, but failed the course because of her own lack of high school science, and that experience ended her interest in pursuing the sciences. It wasn't until she developed her own dzaxwan (oolichan fish) curriculum as part of the current research project that she realized she could teach science from both an Indigenous Science and Western Science framework, and that the two often overlap. In undergraduate school, Donna felt like an outsider who was expected to devalue or even abandon her identity and take a different identity similar to her science professors. Donna grew up understanding that animals, plants and other life forms were her teachers. Like many Indigenous people, she understood that everything is spiritually imbued. "What I've learned from my non-Kwakwaka'wakw world will help me, my family, and community; but I'll always believe our creation story." As Donna states, "the master's program showed me how to teach both Kwakwaka'wakw traditional knowledge and WS side by side" (personal communication, September 5, 2013).

When Donna entered the Graduate Program in Environmental and First Nations Education she felt inspired to revisit her plans to teach science to Aboriginal students, but first she needed to know more about it:

- What kind of knowledge did she know about from her ancestors?
- What kind of knowledge is Indigenous Knowledge? Is Indigenous Knowledge scientific?
- What kind of knowledge is Western Science?
- What does Indigenous Knowledge have in common with Western Science?
- How is it different? How can teachers implement the wisdom and knowledge of Indigenous Elders into the science classroom in a holistic and respectful way?

Teachers of Aboriginal ancestry must discover who they are as teachers of Aboriginal children and what they can bring to the classroom that would be relevant and honoring of the knowledge and wisdom learned from Elders. As teachers and educators, whether Aboriginal or non-Aboriginal, we can distinguish between understanding an idea and believing it, we contribute our own expertise with the understanding that we do not assume to have *the* one right answer of the way of knowing the natural world.

It becomes essential for teachers of Aboriginal children to understand that serving their people is a paramount purpose of Indigenous education. Its purpose is not individual advantage or status. Aboriginal children are taught from childhood to contribute to the greater good, to be useful, help one another, and pay attention to Mother Earth.

Similarly, teachers of all ethnic backgrounds must know who they are as teachers when teaching from a pluralist perspective. The following vignette, as told by Snively, describes an elementary science methods class she taught at the University of Victoria, and the compelling response of Harjeet, a student of East Indian ancestry.

Harjeet's Story

When teaching my elementary science methods class, I include several sessions devoted to Indigenous Science from a multi-science perspective. This discussion includes the Indigenous Science of the Americas, as well as Chinese, East Indian, African and South American peoples. I include a discussion of how over 2000 years ago, East Indian and North African peoples developed highly effective biodegradable pesticides from neem tree oil. The pesticide is so powerful that it kills swarms of locusts and other harmful insects, yet is biodegradable, and doesn't harm the environment. Neem oil works by blocking the real hormones from working properly—insects forget to eat, mate, or lay eggs, or eggs do not hatch. Neem oil is not known to be harmful to mammals, birds, reptiles, earthworms, or beneficial insects such as butterflies, honeybees or ladybugs, only chewing and sucking insects. Traditional Ayurvedic medicinal uses of neem has an extensive history of human use in India and surrounding areas for a great variety of therapeutic purposes; including the treatment of acne, fever, leprosy, malaria and tuberculosis, to name a few (Puri, 1999; Schmutterer, 1995). Discussion focuses on how families in India, if possible, have a neem tree nearby because it is considered a sacred drugstore. In fact, Western scientists and pharmaceutical companies have patented numerous pesticides and medicines from neem oil using ancient IS knowledge, and profited heavily.

After one such discussion, Harjeet, a student of second-generation East Indian ancestry and high achiever, asked to speak further. Harjeet recounted how as a little girl she loved science and wanted to go into the sciences at university, but her parents forbade her to take a science degree. She never understood why. With tears in her eyes, she continued, "Now I know that my parents didn't want me to go into the sciences because they were afraid I would lose my culture. Now I know that I can focus on science and not lose my culture."

I lost contact with Harjeet for several years. Then, 4 or 5 years ago, I received a phone call from an ecstatic Harjeet who was getting dressed to attend graduation ceremonies at Simon Fraser University. Her Masters of Arts degree would be in education, with a specialization in the sciences. She wanted me to know that our discussions of multi-sciences convinced her parents she could study science at university. They understood that in the future, when she teaches science, it will include the science of her people.

Teachers from Aboriginal ancestry who come from traditional backgrounds, and those Indigenous peoples from around the world, must discover who they are as teachers incorporating WS alongside IS in the classroom. As well, teachers from European ancestry must ponder how they feel as teachers for Indigenous students and what they can bring to the science classroom that would be relevant and inclusive without being tokenistic and that does not perpetuate assimilative practices.

Thus, we enter a co-learning journey that brings participants together who desire healthier communities and a healthy Mother Earth. Co-learning involves learning from each other, learning about our commonalities and our differences, and learning to weave back and forth between our cultures and beliefs and values as circumstances require. Within our co-learning journey, pluralism is increasingly acknowledged. We also recognize spirituality as central within Indigenous ways of knowing. In this regard, pluralism is increasingly acknowledged in the science classroom, but spirituality is seldom acknowledged. In this book, our understandings recognize spirituality as central within Indigenous ways of knowing. Many Aboriginal leaders are adamant that spirituality cannot be separated from the physical world within Aboriginal worldviews (Atleo, 2004; Bartlett & Marshall, 2012; Battiste, 2000, 2002, 2007; Battiste & Henderson, 2000; Ermine, 1995; Little Bear, 2000, 2009; McGregor, 2002; MacIvor, 1995; Michell, 2005; Sutherland & Henning, 2009). As Mi'kmaw Elder Albert Marshall explains, "We need to relearn how to talk with and listen to the trees" (Bartlett & Marshall, 2012, p. 7).

In this book, our goal is to provide a model of science education that McGregor (2002), called co-existence which promotes functioning of both systems side-by-side (WS and IS). This co-existence model strongly aligns with the model of "two-eyed seeing," in which an individual draws from two existing knowledge systems in ways dictated by the person's context. "The model of co-existence encourages equality, mutual respect, support, and cooperation" (Bartlett, 2012, p. 454). By walking in both worlds, or by "two-eyed seeing", Aboriginal students in both rural and urban communities gain cultural knowledge and experience essential for accessing power as citizens in a Eurocentric dominated world while maintaining their cultural roots in Aboriginal wisdom traditions. For non-Aboriginal students who often live in impoverished mono-cultural worlds, the practice of walking in both worlds, "two-eyed seeing", student can gain access to wisdom-in-action principles for a richer cultural life. Thus, future scientists and engineers will be better prepared to help ensure quality of life while making wise environmental decisions and sustainable progress on this planet.

It should be noted that we avoid using terms such as "integrating" knowledge systems because the term is often used to denote two merged systems. The latter would, and has, opened the door to forms of knowledge domination and assimilation. Integrative implies taking bits and pieces from Indigenous Knowledge and ways of knowing and appending them to Western knowledge and approaches.

Science educators are now being asked to rethink some fundamental issues on science education and establish a new rationale for developing scientific literacy, which fits to contemporary socio-cultural contexts. Teachers must work towards an understanding of the cultural ideas and beliefs of their students and assemble a tool kit of teaching methods that are responsive to, and honoring of, all our students' lived experiences. To enter into relationship with students whose life-world may be different from that of our own, and to begin to see and understand the world in new ways makes the teaching of science interesting and challenging. It is a worthwhile journey that enriches our lives and that we can enjoy pursuing.

Clarification of Terms

In this book, we use the term Aboriginal to refer to the collective First Nations, Métis, and Inuit as was stated in the 1982 Canadian Constitution. We generally worked with First Nations communities in British Columbia and we refer to them as First Nations or by their Nation's name. Beyond Canada, we use the generic identifier Indigenous as it is used by the United Nations.

Several terms referring to science are used in this book. First, we use the term *science* in a pluralist context, as described by Ogawa (1995, p. 588) as a "rational perceiving of reality," so that both Western and Indigenous Sciences can be categorized under this umbrella. We use WS to represent *Western Science* or Eurocentric Science or Modern Western Science. The science taught in most schools falls into this WS category. We use the term *Indigenous Science* (IS) to refer to the science of Indigenous cultures worldwide. Because the wisdom component of IS is rich in time-tested approaches that sustain both community and environment (Snively & Corsiglia, 2001), we take a pluralist definition of science because it fosters the teaching of science in culturally responsive ways. Following Warren, et al. (1993), the term Indigenous Knowledge (IK), is defined as "the local knowledge held by Indigenous peoples or local knowledge unique to a given culture or society." As a concept, Indigenous Knowledge systems correspond to the entire spectrum of philosophy, history, heritage, ethics, flora and fauna, educational processes, and much more. Thus, IK is a broad category that includes IS.

One additional concept, Traditional Ecological Knowledge (TEK) needs to be explained. Although the term TEK came into widespread use in the 1980's there is no universally accepted definition. The terms *traditional, ecological,* and *knowledge* are themselves ambiguous. As Berkes (1993) points out, societies change over time,

constantly adopting new practices and technologies, making it difficult to define a practice as traditional. The term "ecological knowledge" poses definition problems of its own. If ecology is defined narrowly as a branch of biology in the domain of Western Science, then strictly speaking there can be no TEK; most traditional peoples are not modern Western scientists. As well, TEK is not about ecological relationships exclusively, but about many fields of science in its general sense including agriculture, astronomy, medicine, geology, architecture, navigation, and so on. Even the term "knowledge" as a descriptor for this form of understanding is problematic. According to McGregor (2008), "Native people tend to describe TEK more as a 'way of life' than something which can be concisely described or written down" (p. 144). Concepts of TEK and WS are gradually changing as more Aboriginal people gain voice in the environmental movement and in science and science education discourse..

Thus, in this book, we use the terms IS and WS, and we use TEK more explicitly to refer to the land-related, place-based knowledge of long-resident, usually oral Indigenous peoples, and as noted, consider it a subset of the broader categories of IS and IK. Although the term TEK arose at a time when ecology was beginning to inform Western knowledge and practices, many working scientists continue to prefer to use the term TEK, rather than IS. According to McGregor (2002, p. 2) whether one calls it Aboriginal Science, TEK, or IK "it is something one does."

In Canada, government documents in most provinces use TEK interchangeably with IS/IK. Importantly, although the term TEK appears in some science education textbooks and reference books, Ministry of Education documents in most provinces refer to "Indigenous Knowledge," "Aboriginal Knowledge," or "Indigenous Science," not "TEK." In this book, we capitalize Aboriginal, Indigenous, Indigenous Science, Indigenous Knowledge, Traditional Ecological Knowledge, Elder, and Western Science.

Finally, we distinguish between the Indigenous Science of various ethnicities, for example, traditional Chinese science, traditional East Indian science, and traditional Japanese science. This distinction simply serves as a way to distinguish between highly heterogeneous groups whose way of knowing nature are both non-Eurocentric and place based. There are additional concepts that recognize subordinate sciences (Aikenhead & Ogawa, 2007), but these categories are not discussed here because they are deemed beyond the scope of this book. The focus of this book is on the Indigenous Knowledge and Indigenous Science of Canadian Aboriginal peoples, and in particular, glimpses the knowledge and science of the Aboriginal peoples of British Columbia. Such a clear convention is used throughout this manuscript.

About this Book

The science curricula and chapters in this book explore a vision of science education that pays attention to the unique ways of Indigenous teaching and learning. Together the chapters create an image of what a culturally energized science curriculum can look like. Although the book's authors may not all subscribe to the same interpretation of IS or of IS education, their work or the work of the Elders and resource persons they describe, demonstrate a similar form of understanding. It is imperative that feasible models be placed in the hands of educational practitioners throughout our society in an effort to encourage further investigation as well as hope.

The book is divided into four sections to enable readers to either read the book cover to cover or just delve into areas they are specifically interested in reading. The first section includes five chapters that taken together provide a theoretical, historical, pedagogical, and epistemological foundation for the book. Chapter 2, by Gloria Snively and Wanosts'a7 Lorna Williams, describes the under-representation of Aboriginal students in upper-level science courses and in science related careers, outlines barriers that need to be addressed, and suggests a number of reasons for placing Indigenous Science in school curricula. Chapter 3, by Williams and Snively, develops a theoretical framework for Indigenous Science education, explores the assumptions and beliefs that form the basis

of an Indigenous worldview, and presents six principles that represent the nature of science education from an Indigenous perspective. Chapter 4, by Snively and John Corsiglia, explores different versions of what science is, describes many examples from the Americas of Indigenous people's achievements in a broad range of science disciplines, and describes a rich and well-documented branch of Indigenous Science known to biologists and ecologists as Traditional Ecological Knowledge (TEK). Chapter 5, by Snively and Williams, explores how teachers can become culturally responsive science teachers, changes in curriculum and instruction that support effective science learning experiences for both Aboriginal and non-Aboriginal students, and changes in science education programs in university teacher education that can facilitate these objectives.

The second section of two chapters provides insights for exploring fundamental commonalities and differences between Eurocentric Western Science and Indigenous Science, and explores how Indigenous Science examples can enrich our understanding of nature. Chapter 6 by Snively and John Corsiglia explores the different versions of what science is, describing many examples from Meso-America of Indigenous people's achievements in a broad range of science disciplines, and describes a rich and well-documented branch of Indigenous Science known to biologists and ecologists as Traditional Ecological Knowledge (TEK). Chapter 7 by Snively and Corsiglia provides a window into the vast storehouse of innovations and technologies of the Indigenous peoples who live in Northwestern North America, thus providing numerous examples and cases for developing science lessons and curricula that more accurately reflects the richness and significance of Indigenous knowledge systems.

The third section of two chapters describes case studies and research that provide insights into topics such as students' perceptions of science, curricular implementation and evaluation strategies, and changes in students' thinking as a result of instruction. Chapter 8, by Snively, explores the ideas and beliefs of children of different cultural backgrounds, considers problems that can arise in teaching science to children whose view of reality may be different from that of Western Science, outlines concerns with how we as educators disadvantage Indigenous students who may hold a worldview that is different from the Western scientifically accepted worldviews, and explores teaching strategies for creating classrooms where neither knowledge system is rejected. Chapter 9, by Snively, investigated what effect an Indigenous Science workshop would have on middle school and high school students' perceptions of scientists, the work of scientists and who does science. Student drawings of scientists at work collected from both Aboriginal and non-Aboriginal students showed that after instruction, many stereotypical images of scientists were dispelled, and many Aboriginal students drew themselves as scientists engaged in science related activities.

The fourth section of six chapters provides a rich sampling of culturally appropriate curriculum projects that focus on local Indigenous Science, into the school science curriculum, providing teachers with support and resources. Chapter 10, by Emily Aitken, describes a seasonal wheel for the Kwak'wala speaking people and highlights the annual harvesting, cultural events and worldview of the Kwakwa̲ka̲'wakw. Developing a seasonal wheel is a way of allowing students, Elders, and resource persons to participate in a worthwhile community and cultural building event; and is a powerful way of getting in touch with the place where people live. Chapter 11, by Snively, begins by describing how for over 2,500 years the Ehattesaht and Quatsino people harvested dentalia shells from the deep seabed. Middle and high school students, of both Aboriginal and non-Aboriginal ancestry in Victoria, were challenged to invent a way of recovering dentalia from the deep seabed, and to draw sketches of their contraption, device, and/or method of collection. The chapter describes the students' experiences and their resulting perceptions of Indigenous Knowledge. Chapter 12, by Donna Cranmer, tells the story of the oolichan (a small oily fish) that since time immemorial has migrated into Kwakwa̲ka̲'wakw territory, bringing economic wealth to the people. The author explores the cultural significance of dzaxwa̲n, the knowledge that was required to render the t'ɬi'na oil, diminishing dzaxwa̲n runs, and concern for the future making of t'ɬi'na oil. Chapter 13, by Cranmer, describes the development, teaching and evaluation of a science curriculum on dzaxwa̲n and the rendering of oolichan oil. Lessons included both the TEK of the Kwakwa̲ka̲'wakw people, as well as W̄S concepts with the intention that the curriculum could be accepted alongside the B̄C̄ Science curriculum. Chapter 14, by Irene Isaac,

describes the development of a science and environmental education program using the story "Raven Steals the Light" as a catalyst for study. Lessons were pilot-tested with students in Grade 6/7 at the T'ɬisalagi'lakw Band School in Alert Bay. Observations and evaluative techniques all combined to show that after instruction, the students understood the TEK of the Kwakwaka'wakw people, a range of Western Science concepts, their interest level was high, they practiced maya'xala (respect for the people and the land), and they understood what it means to be Kwakwaka'wakw. Chapter 15, by Judy Thompson, was designed to provide the Gitga'at youth of Hartley Bay with the opportunity to learn about the plants and places that have been, and continue to be important to their people, and to re-establish the connections between the youth and their Elders in order to facilitate the transmissions of TEK. Major findings include implications for community-based curriculum development and solutions dealing with loss of knowledge and language.

The reader will note that several chapters in the book focus on the knowledge and experience of the Kwakwaka'wakw people. This focus on the Kwak'wala speaking people is a result of the principal researcher, Gloria Snively, having enjoyed a 38-years-long relationship with the Kwak'wala speaking people, having presented several marine education workshops in the community of Alert Bay, and having conducted her doctorate research in association with the Alert Bay Community School and the 'Namgis Band Council. This association eventually led to the establishment of Alert Bay as the site location for the Graduate Program in Environmental and First Nations Education, and several articles written by graduate students of Kwakwaka'wakw ancestry.

It is our hope that the science research and curriculum models in this book will plant seeds of thought and deep reflection regarding the under-representation of Aboriginal students in the sciences. We must develop the openness and courage to take a creative leap and find in ourselves a vision of science education for all our children. Most important, it is intended that the rich examples and cases of Indigenous Science described in the various chapters, combined with the curricular connections, websites and resources listed in the Appendices A, B, C, and D will enable pre-service teachers, teachers, districts and curriculum projects; and serve as starting points for developing a broad range of culturally sensitive learning experiences and curriculum projects. When IS and WS coexists respectfully in the science classroom, *all* students will have a greater understanding of the science knowledge, skills, philosophy, and opportunities they need to direct their creative energies to the benefit of our collective futures.

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