Knowing Home: Braiding Indigenous Science with Western Science, Book 1

Knowing Home: Braiding Indigenous Science with Western Science

Book One

EDITED BY

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We gratefully acknowledge and honour the territory and the lands on which the project originated: the Lekwungen (Songhees), SXIMEŁEŁ (Esquimalt), and W̱SÁNEĆ (Saanich)

Foreword

It is a thrill for me to see this book and to know that it will be a readily available reference for learners and educators alike. At a time when Canadians are finally embarking on a journey of Truth and Reconciliation with Aboriginal Peoples, this insightful edited volume is both timely and critically important. Together, the co-editors and authors, almost all of them Aboriginal, present multiple useful paths towards identifying and recognizing two huge shortfalls in the Canadian educational system to date. One is the abysmal failure of many schools to provide quality education for Aboriginal children and youth, particularly in the areas of science, technology and health. This situation is reflected today in the marked underrepresentation of Aboriginal students participating in university level programs in these areas, and, further, in the dearth of professional scientists from Aboriginal communities across the country. The second gap, equally lamentable, is that students of mainstream western science and technology have been deprived of learning about the immense body of Indigenous scientific knowledge, perspectives and applications acquired and built over generations of dwelling in particular places. *Knowing Home...* will be a wonderful resource that will bring all Canadians to a higher level of understanding in these two areas.

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Preface

The “Aboriginal Knowledge and Science Education Research Project” was a collaborative venture between the Aboriginal Education Enhancements Branch of the British Columbia Ministry of Education (Canada) and the University of Victoria (Canada), and was created to address issues associated with the under-representation of Aboriginal peoples in the sciences. The project had a three-fold purpose: (1) to broadly describe why Aboriginal students are under-represented in high school science biology, chemistry, and physics classrooms, (2) to find ways to improve significantly their involvement and achievement in both elementary and high school science leading to post-secondary, and (3) encourage Aboriginal people to consider science and health related occupations.

According to Cajete (1999), “Native science evolved in relation to places and is therefore instilled with a ‘sense of place’. Therefore, the first frame of reference for Native science curriculum is reflective of their place” (p. 47). Thus, a key component of the research project was to document the Aboriginal science knowledge of specific home communities and to construct an epistemological framework and pedagogical orientation for developing school science programs pertaining to the learning and use of scientific knowledge in the local Indigenous community.

It is anticipated that the project will contribute to the realization of increased participation of Aboriginal peoples in the sciences by generating: (a) understanding of the underlying reasons for the lack of participation in upper level sciences courses, (b) knowledge about the lack of participation of Aboriginal people in science and health related careers, (c) knowledge of the Indigenous Science of British Columbia Aboriginal peoples, (d) knowledge about how children of Aboriginal ancestry have a worldview other than the Western scientific worldview, (e) significant research opportunities for Aboriginal graduate students, (f) research partnerships amongst Aboriginal and non-Aboriginal teachers and scholars, (g) directions for leadership and career opportunities in science for Aboriginal graduate students, and (h) more effective science education curricula and programs by and with Aboriginal scholars and Aboriginal communities to be developed, implemented and evaluated.

With the aging population of the Elders in the community, Indigenous Science (IS) knowledge is vulnerable and the urgency to research and document this knowledge is vital to Indigenous peoples and to the global society. We take the view that unless IS is acknowledged as science, Western Science (WS) will continue to completely dominate the science curriculum, and IS will continue to be excluded or given tokenistic inclusion at best. Thus, we take the view that IS and WS can co-exist side by side in the science classroom.

Building a Community of Researchers

By working with Indigenous graduate students, rather than with practiced researchers, this project was unique in that it was designed to provide opportunities for Indigenous peoples to participate in a research project. Although this was an important key element of the research project, it had challenges of working with a cadre of inexperienced graduate students, many of whom were at the beginning stages of taking graduate level research courses.

In an attempt to address the stated purpose of this research, the research team developed an implementation strategy consisting of the following elements: (a) build culturally appropriate research skills amongst graduate students; (b) collect and analyze what Indigenous knowledge based curriculum materials and programs already exist; (c) design a graduate level program of courses to teach basic research techniques and concepts associated with the project; and (d) locate and encourage networks with and amongst researchers and research centres focusing on Indigenous knowledge and science education projects. Seven Indigenous graduate students and two non-Indigenous graduate students volunteered to research specific components of the project deemed relevant to their personal career goals and the needs and goals of their home communities.

During the summer of 2004, an off-campus Graduate Program in Environmental and First Nations Education was offered to both Aboriginal and non-Aboriginal students in 'Yalis (Alert Bay), British Columbia, home of the Kwakwaka'wakw people. The Kwakwaka'wakw, against enormous pressures, have remained close to the essence of their traditional and still viable life-ways. Like other Indigenous peoples who retain their traditional identity, they are in a position to share many of their beliefs and values. They teach through a wide range of means and expressions, and their relationship to the larger society. A key tenet was that environment and culture could not be considered separately, there could be no course on Kwagu'ł culture that was not also about the Kwagu'ł environment. Common experiences included direct experiences with Elders and scientists, and conducting archival and research associated with historical events related to colonization and decolonization.

The aim of this graduate program was to bring together Aboriginal and non-Aboriginal persons to work together in learning about the forest and ocean environments, respecting the cultures of Aboriginal people, and educating future citizens to make wise decisions regarding long-term sustainable communities and environments. The design of the program and courses followed Indigenous ways of learning; learning by being on the land; learning together by forging a sense of community within the program; learning from the expertise of First Nations communities and the university community. Because the majority of graduate students were full-time teachers, the program was developed to take place in three summer sessions (Snively, 2006; Snively & Williams, 2006). (See Appendix D for a more elaborated description of the research project and graduate program).

Walking Forward

Since Indigenous peoples have developed time-proven approaches to sustaining both community and environment, Elders and young people are concerned that this rich legacy of Indigenous Science with its wealth of environmental knowledge and the wisdom of previous generations could disappear if it is not respected, studied and understood by today's children and youth. A perspective where relationships between home place and all other beings that inhabit the earth is vitally important to all residents—both inheritors of ancient Indigenous Knowledge and wisdom, and newcomers who can experience the engagement, joy and promise of science instilled with a sense of place. This book takes a step forward toward preserving and actively using the knowledge, stories, and lessons for today and future generations, and with it a worldview that informs everyday attitudes toward the earth.

Over the past two decades many jurisdictions worldwide have placed Indigenous Knowledge in their science curricula, for example: New Zealand, Australia, and in the United States, Alaska, Hawai'i, New Mexico and Washington. In the spirit of reconciliation, a number of ministries of education and departments of education in Canada have increasingly recognized Indigenous Knowledge as fundamental content in school science.

Indigenous Science encourages a welcoming and interested attitude toward the local, the timeless, and the emotional. All science educators must strive to design new curriculum that represents a balanced perspective, exposing students to multiple ways of understanding science. Indigenous perspectives have the potential to give insight and guidance to the kind of environmental ethics and deep understanding that we must gain as we attempt to solve the increasingly complex problems of the 21st century.

***Knowing Home*: Books 1 and 2**

Knowing Home: Braiding Indigenous Science with Western Science is far more than a set of research papers or curriculum studies. The project outputs include both, but they are incorporated into a theoretical structure that can provide the methodological basis for future efforts that attempt to develop culturally responsive Indigenous Science curricula in home places. It is not just one or two angels to organize, but multiple interwoven approaches and cases that give this project its exceptional importance. Thus, the project outputs have been organized into two books.

Book 1 provides an overview of why traditional knowledge and wisdom should be included in the science curriculum, a window into the science and technologies of the Indigenous peoples who live in Northwestern North America, Indigenous worldview, culturally responsive teaching strategies and curriculum models, and evaluative techniques. It is intended that the rich examples and cases, combined with the resources listed in the appendices, will enable teachers and students to explore Indigenous Science examples in the classroom; and in addition, support the development of culturally appropriate curriculum projects.

Book 2 provides supportive research, case studies and commentary that extends and enriches the chapters presented in Book 1. The chapters provide rich descriptions related to Indigenous cultural beliefs and values; an Aboriginal concept of time; transforming teacher thinking about Indigenous Science; the use of digital video as a learning tool for secondary Aboriginal students; the perceptions and experiences of post secondary Aboriginal students during science instruction; a W̱SÁNEĆ concept of "knowledge of most worth," and a study of successful Aboriginal students in secondary science.

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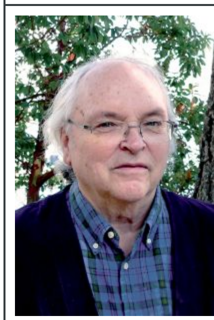
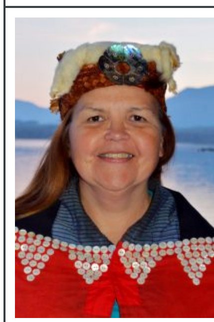
Our acknowledgements would not be complete without paying tribute to the late Yup'ik science educator and scholar, Dr. Angayuqaq Oscar Kawagley, who taught one of the graduate courses in 'Yalis. Kawagley asserts that strong bridges are built by examining the collective ways people in Eurocentric and Indigenous cultures experience and make sense of their natural worlds. Words cannot capture his inspired teachings and gentle spirit, but the wisdom of his stories will be with us always as we strive to find new approaches to science education that invite all students to participate by articulating a cultural approach to science.

Last, we are grateful to Laura Corsiglia for providing us with several of her spontaneous ink drawings that appear in this book. Growing up in the Gitlaxt'aamiks Nisga'a community of the Nisga'a First Nation was formative to Laura's work and worldview. She attended Nisga'a Elementary Secondary School before completing a graduate degree in art from the *École des Beaux-Arts* in Paris. She has written and illustrated several titles, including a definitive manual on seabird rescue and rehabilitation.

This research was funded in part through grants from the Aboriginal Enhancements Branch of the British Columbia Ministry of Education, the Social Sciences and Humanities Council of Canada, and small grants from the Faculty of Education and the Department of Linguistics at the University of Victoria. The publication of this book was funded by an Open Education Resources grant from BCcampus.

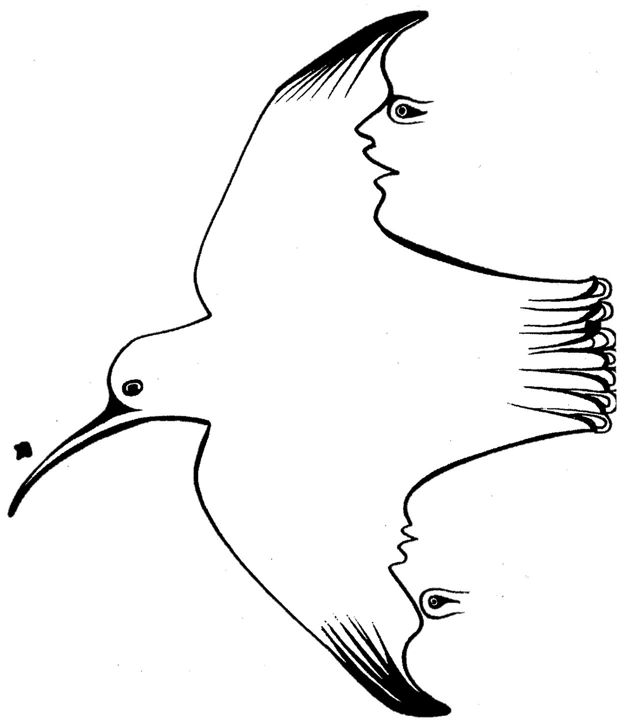
Contributing Authors

	**Dr. Gloria Snively** is Professor Emeritus at the University of Victoria where she taught science methods, environmental/marine education, and culture courses. She was Director of the Graduate Program in Environmental Education. For 12 years, she was involved with the Asia Pacific Network whose purpose is to strengthen links between the research community and school-based environmental education in the Asia-Pacific region. Her work with Indigenous education spans 4 decades and has always been inspired by Indigenous leaders. She enjoyed giving natural history talks and walks to students, teachers, park interpreters, First Nations and community groups for 50 years; she prefers to explore forest, ponds and seashores first-hand.
	**Dr. Wanosts'a7 Lorna Williams OBC** *walking in peace* is Lil'wat of the St'at'yem'c First Nation. Her life has been devoted to promoting and restoring Indigenous culture and language. She worked as an Indigenous educator and language specialist for more than 50 years in diverse settings, including Indigenous communities, public schools, and adult education settings. Dr. Williams recently retired from the University of Victoria as Canada Research Chair in Indigenous Knowledge and Learning (co-appointment with Faculty of Education and Department of Linguistics) and an associate professor, where she developed and delivered an innovative series of courses on learning and teaching in an Indigenous world.
	**Gwixsisa̲las Emily Aitken** *how to place your feet* is of the Ławit'sis Nation, one of the Kwakwa̲ka̲'wakw nations. She is a certified Kwak'wala language teacher and has been teaching Kwak'wala for 12 years at a community driven language class. She has made a life-long commitment to revitalizing the Kwak'wala language.
	**Wii Smax John Corsiglia** *Big Bear* helped develop K-12 and post-secondary language and culture programs for the Nisga'a Schools and university system, and worked with the Nisga'a Tribal Council on research related to land use and ownership. He also worked with the Ahousaht and Haida First Nations, and taught First Nations education, history and culture courses at the University of Victoria.
	**'Nalaga Donna Cranmer** *the dawning of a new day* from the 'Na̲mgis First Nation received her BEd from SFU and her MA from UVic. Donna feels it is important for our children to learn 'Na̲mgis Traditional Ecological Knowledge with the creation of a 'Na̲mgis social, science and language arts curriculum. For sixteen years she was a Grade 1, 2, 3 and Kwakwala language and culture teacher at T'łisalagilakw School in 'Yalis, and is principal of Wagalus Elementary School in Fort Rupert.

	**‘Welila’ogwa Irene Isaac** *strong woman* is Kwakwaka‘wakw, a member of the ‘Namgis First Nation (BEd 2000, UBC & MA 2010, UVic). Irene worked with the Vancouver School Board, Parks Board, BCIT and the ‘Namgis First Nation to incorporate local and traditional knowledge into the current BC curriculum. For 16 years Irene was an intermediate teacher at the T’łisalagilakw School in ‘Yalis, and is district principal, Aboriginal Programs for Vancouver Island North.
	**Dr. Edōsdi Judith C. Thompson** *someone who raises up pets and children* from the Tahltan Nation. Edōsdi BSc (Kinesiology), MSc (Environmental Studies), PhD (Environmental Studies/Education/Linguistics). She is the Tahltan Language and Culture Lead for her nation and was a college professor at Northwest Community College in Prince Rupert, BC. She is currently Assistant Professor at the University of Northern British Columbia.

PART I

THEORETICAL, HISTORICAL AND EPISTEMOLOGICAL FOUNDATIONS



"Untitled." Drawing by Laura Corsiglia. Reprinted with permission from (2001) Our Thang, p. 89. Victoria, BC: Ekstasis Editions. CC BY-NC

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 Indigenous 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 have 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 Kwakwa̱ka̱'wakw ancestry who teaches at the T'łisa̱lagi'lakw Band School in 'Ya̱lis (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 Kwakwa̱ka̱'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 dzaxwa̱n (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-Kwakwa̱ka̱'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 Kwakwa̱ka̱'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 Kwakwa̱ka̱'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 Kwakwa̱ka̱'wakw territory, bringing economic wealth to the people. The author explores the cultural significance of dzaxwa̱n, the knowledge that was required to render the t'ł'ina oil, diminishing dzaxwa̱n runs, and concern for the future making of t'ł'ina oil. Chapter 13, by Cranmer, describes the development, teaching and evaluation of a science curriculum on dzaxwa̱n and the rendering of oolichan oil. Lessons included both the TEK of the Kwakwaka'wakw people, as well as WS concepts with the intention that the curriculum could be accepted alongside the BC 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'łisa̱lagi'lakw Band School in Alert Bay. Observations and evaluative techniques all combined to show that after instruction, the students understood the TEK of the Kwakwa̱ka̱'wakw people, a range of Western Science concepts, their interest level was high, they practiced maya'xa̱la (respect for the people and the land), and they understood what it means to be Kwakwa̱ka̱'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 Kwakwa̱ka̱‘wakw people. This focus on the Kwak’wala speaking people is a result of the principal researcher, Gloria Snively, having enjoyed a 38-year 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 Kwakwa̱ka̱‘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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Chapter 2 - Why Transforming the Science Curriculum is Necessary for Aboriginal Students

Gloria Snively and Wanosts'a7 Lorna Williams

For Aboriginal communities in Canada, the need for science education to be both transformed and transforming is more urgent today than ever before. The legacy of a colonialist educational system and the under-representation of Indigenous Science in the curriculum is a key factor in limiting Aboriginal people's futures. The need for Aboriginal peoples in science, technology, and health-related careers is urgent (Canadian Council on Learning (CCL), 2007a, 2007b). This is particularly true of the schooling and educational circumstances of most Indigenous peoples who live in colonized nations around the Pacific circle, the US, Canada, Australia, New Zealand, South America, and elsewhere in India and African countries.

In trying to understand what has gone wrong, various researchers have focused on problems associated with the Aboriginal learners themselves; others have focused on socio-economic problems; some on language and cultural differences; some on definitions of science and the so-called "science wars," still others have focused on school structures and governance. The transformation of science education for Aboriginal learners is not merely a set of strategies related to changing learners' behaviour, changing the curriculum or pedagogy, changing definitions of science, or changing governance. Transformation will also need to occur in the wider context of both the Aboriginal and non-Aboriginal communities.

From an educational point of view, our work as teachers and instructors must also be called into account. We need to question what we do educationally through academic teaching and research, through teaching Aboriginal children in the science classroom, and through interacting with parents, Elders, and communities.

Great care and skill are required from all stake-holders to help heal the divide and overcome concerns that students and communities have about how science is taught. We can begin by asking the following key questions:

- What is the current state of science education for Aboriginal students?
- How did we arrive at the current state?
- What is at stake?
- What factors inhibit the progress of Aboriginal students in science?
- What counts as science? Do Indigenous peoples have science?
- Should Indigenous Knowledge be included in the science curriculum?
- What is the role of education in the transformation of society?
- What counts as transformation? How will we know when transformation has been achieved?
- What is the mandate for transformation of the science curriculum?
- What interests are at stake, and whose interests are being served?
- What should the future of science education in Canada look like?

The above questions set the context for bringing together a range of issues touched upon in this chapter. The chapter concludes with a new vision for science education in Canada, with sustainability and Indigenous worldviews at its core.

The State of Science Education for Aboriginal Students

Canada has been celebrated for its contributions to human rights, the rule of law, a multi-cultural country of equality of opportunity, and a high socio-economic quality of life. It is clear that Canada is a multi-ethnic and multi-cultural society. Half a century ago, most immigrants came from Europe, now most newcomers come from Asia. While most newcomers have fared well and prospered, there is little evidence that Aboriginal peoples have participated in the economic, political, and educational spheres.

Canada is ranked in the top 10 countries on the UN Human Development Index, but Canadian Aboriginal communities ranked 79th, reflecting structural inequalities in access to education, housing and clean water (Bennett, Blackstock & De La Ronde, 2005, p. 7). Education for First Nations, Inuit and Métis is chronically underfunded. Aboriginal children receive 60 to 80 per cent of the funding that non-Aboriginal children receive. According to the 2006 Canadian Census, 60 per cent of First Nations and 75 per cent of Inuit students do not complete high school, compared with 15% of non-Aboriginals. While off-reserve status First Nations and Métis fare better, there is a growing education gap. The Aboriginal population with a university degree has increased slightly since 2001 (from 6 to 8%); however, they still lag far behind the non-Aboriginal population (23%) (2006 Census Aboriginal Demographics) and the gap continued to widen between 2001 and 2006.

Since 2001, the Canadian Aboriginal population increased by 25%, compared with 6% for other Canadians. The unemployment rate for Aboriginal people aged 25-64 remained almost three times the rate for non-Aboriginals, and exceeded the national rate in every region. It is projected that between 2001 and 2026, more than 600,000 Aboriginal youth will come of age to enter the labour market. The 15-29 age group, in particular, is projected to grow by 37% compared with 6% for the general Canadian population (Hull, 2008).

Yet, in recent years alarms have been raised about a possible crisis in the Canadian labour force—a shortage of labour caused by low birth rates and the aging Canadian population. Studies predict that this declining growth of the labour force will have a negative impact on the economy. Clearly, Aboriginal youth represent a potential wealth of future labour resources. Hull (2008) suggests that "the rapid growth rate of the Aboriginal labour force presents an opportunity to offset these demographic pressures to some extent and could benefit both Aboriginal people and the Canadian economy" (p. 40).

Science Education for Aboriginal Students

There is abundant evidence that Aboriginal students are under-represented in high school science classes Canada wide. According to Aikenhead and Michie (2011), "the under-representation of Indigenous students in high school science courses is a major challenge for science education in industrial countries" (p. 8). As well, Indigenous people in Canada are under-represented in science and engineering occupations (Battiste, 2002; CCL, 2007b; Canadian Education Association, 2016).

Performance of BC Aboriginal Students in the Sciences

The proportion of BC public school students self-identifying as Aboriginal is about 11% of the total student population (BC MoE, n.d.). The total BC public population (K-12) in the 2010/11 school year was 515, 206 with 63, 899 identifying as Aboriginal—9, 908 students were classified as on-reserve and 53, 991 as off-reserve.

A source of information for secondary school achievement in science courses are the required formal provincial examinations (BC MoE, 2011a) and optimal (BC MoE, 2011b) for Grades 10 and 12 courses in the BC graduation program. MoE provides examination scores and blended marks composed of examination and course marks. Yore, et al., (2014) defined Indigenous as First Nations, Inuit and Meti. The research group used both sets of data to explore Indigenous and non-Indigenous students' achievements. Comparisons of 2010-2011 enrollment and required examination data demonstrated that Indigenous students were substantially under-represented, with low participation rates in science and mathematics courses.

Specifically, Aboriginal students were substantially under-represented with low participation rates in university preparation courses (English 10, Mathematics 10, Science 10, Social Studies 11, English 12), and were over-represented in alternative and specialized First Nations courses (Math 10, Apprentice & Workplace, First Nations Studies, and Community 12). The success C-pass or better rates across the various examinations revealed a consistent pattern, where the percentage of Aboriginal students achieving a pass or better rating is lower than the percentage of non-Aboriginal students achieving the same rating. Aboriginal students fared well in the alternative courses indicting a higher level of achievement in these culturally-responsive courses.

An indicator of preparation that better predicts success requires a higher level of achievement on the required courses. When the cut-off was raised to indicate percentage of students earning a good rating (C+ or better) on these examinations, the gaps increased slightly for the alternative courses, but nearly doubled for the standard courses (Table 2.1). These data were considered likely better indicators of the performance gap between Indigenous and non-Indigenous students and predictors for acceptance into post-secondary sciences.

The newly revised science curriculum for British Columbia (2015), as described by the BC Ministry of Education web site, makes references to Aboriginal knowledge and worldviews, promotes a place-based approach to learning, and encourages teachers to incorporate Traditional Ecological Knowledge (TEK) examples into their science curriculum. However, the representation of Indigenous Science tends to be piecemeal and often as isolated examples and not as a coherent whole. While it is significant that teachers are given the mandate to incorporate TEK in the science curriculum, teachers are provided very little help to include examples of Indigenous Science into their curriculum. As well, teachers are not provided information about Aboriginal worldviews and teaching strategies that facilitate responsible cross-cultural science education. Thus, many Canadian provincial and territorial documents have not explicitly considered culture, dominance and power as variables in students' understandings (McKinley, 2007), and have overlooked the effects of colonialism in science education (Belezewski, 2009).

Table 2.1 Percentage of Indigenous and Non-Indigenous Students Earning Good (C+ or better). Yore, L.D. et. al. (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: Springer. Data Source: *Provincial required examinations—2010/11; Provincial public and independent schools combined.* Victoria, BC, Canada: British Columbia Ministry of Education.			
Course	**Indigenous**	**Non-Indigenous**	**Gap**
English 10	42.5%	64.2%	21.7%
Mathematics 10			
Foundations & Pre-calculus	33.8%	59.6%	25.8%
Apprentice & Workplace	12.1%	16.9%	4.8%
Science 10	29.5%	57.6%	28.1%
Social Studies 11	36.2%	57.8%	21.6%
BC First Nations Studies 12 *	35.7%	46.0%	10.4%
English 12	43.2%	61.1%	17.9%
Communications 12*	48.2%	51.4%	3.2%
* Denotes alternative course to normal required course.			

If a more rigorous cut-off criterion of the students' earning good grades (C+ or better) in these elective courses is used, the gap favoring non-Indigenous students increases to approximately 10-22% (Table 2.2). The authors consider these data were likely better predictors of the performance gap between Indigenous and non-Indigenous students, and therefore, better predictors for acceptance into post-secondary studies in the field of science.

For both Indigenous and non-Indigenous students, the least popular elective courses were modern foreign languages, mathematics applications, geology, geography, chemistry, and physics. The most popular elective courses were biology, principles of mathematics, and history.

Mathematics, often referred to as the "gatekeeper of science," is linked with success in the sciences as numeracy skills can impact success in science courses, particularly physics and chemistry. The WNCP research project reported that many Indigenous students struggle with mathematics (McAskill et al., 2004). An examination of the 6-year completion data for 2006-2011 showed a continuing increase in graduation rates for Indigenous students from 48% to 54% (2010/11) while participation rates in all the subjects remained relatively stable. Although the upward trend is positive, it is still concerning that this rate continues to significantly lag behind the 83% completion rate of non-Indigenous students. Mendelson, 2006) stated, "Failure to complete high school explains 87.7% of the variation in post-secondary education completion rates among provinces and territories. This is an extremely strong correlation and is further evidence that success in post secondary programs starts with success in the K-12 programs" (p. 31).

Table 2.2 Percentage of Indigenous and Non-Indigenous Students Earning Good (C+ or better). Yore, L.D. et. al. (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: Springer. Data Source: *Provincial required examinations—2010/11; Provincial public and independent schools combined.* Victoria, BC, Canada: British Columbia Ministry of Education.			
Course	**Indigenous**	**Non-Indigenous**	**Gap**
Biology 12	51.4%	68.6%	17.1%
Chemistry 12	61.9%	76.9%	15.0%
Geology 12	51.9%	68.0%	16.2%
Geography 12	65.1%	77.9%	12.8%
Physics 12	68.4%	78.6%	10.2%
Principles of Mathematics 12	55.3%	72.4%	17.1%
Applications of Mathematics 12	42.6%	44.9%	2.3%
English Literature 12	72.4%	85.3%	12.9%
History 12	74.2%	74.2%	22.2%
French 12	76.9%	90.2%	13.2%
French Immersion 12	60.2%	77.7%	17.4%
Spanish 12	75.7%	87.2%	11.6%

Clearly, these participation and success rates for Indigenous students in the sciences supports the need to develop more relevant, supportive, and culturally responsive science and mathematics curricula and programs at all levels: elementary, secondary and post secondary.

Contextual Barriers Blocking Indigenous Participation in School Science

The presentation and interpretation of statistical information in research is rarely accompanied by contextual information to help demonstrate the multitude of barriers that Aboriginal learners face as high school and university students. For example, as reported in the 2007 Report on Learning in Canada, current approaches to measuring First Nations, Inuit and Métis learning in Canada do not reflect Aboriginal people's approaches to monitoring and assessing holistic, lifelong learning. Current approaches to measuring Aboriginal learning in Canada often:

- are oriented toward measuring learning deficits,
- do not account for social, economic and political factors,
- do not monitor progress across the full spectrum of lifelong learning,
- do not reflect the holistic nature of First Nations, Inuit and Métis learning, and
- do not reflect the importance of experiential learning. (p. 8)

For example, the most commonly reported indicator that measures success of Aboriginal learning is the high school completion rate, and the most commonly reported indicator of success in school science is the completion rates in senior high school sciences.

Furthermore, current research tends to not recognize that the economic, health and social challenges that inhibit Aboriginal people's opportunities for life-long learning continue to exceed those experienced by non-Aboriginal

Canadians (CCL, 2007a). “Poor economic and living conditions also contribute to comparatively poor health” (p. 9). Thus, persistence and intention to complete post-secondary education is not necessarily about lack of ability, it is about the many challenges found by these students in their lives, their family’s lives, and the life of the community (Kanu, 2006).

In addition, many Inuit and First Nations students living on reserves have historically reported that their primary reason for dropping out of high school was the requirement to leave their community and travel long distances to attend the nearest high school or university. This meant that they had to leave behind parents and community support. Thus, the *Annual Report on the State of Inuit Culture and Society* (2010-2011), recommends an education in which Indigenous children attend school in their home communities or regions, have significant opportunities to learn in their own languages, and that parents and community have the right to control their educational institutions in a manner appropriate to their cultural methods of teaching and learning.

Canadian Residential Schools

An early federal government policy for First Nations was to use education as a tool to disconnect children from the older generation. The federal government took advantage of schools built by missionaries, funded them and built more schools across the country to send children as young as 5 or 6 of age to spend 10 months a year away from their families and communities. The children in the first several generations were fluent speakers of their mother tongue. In the residential schools, they had no opportunity to speak their mother tongue and had little opportunity to speak one of the colonizing languages. Children were punished physically and psychologically if they spoke in their mother tongue. Over the years, away from their families and communities, the children’s usage of English or French increased and their mother tongue usage dwindled in use. Thus, upon their return home communication with their families was negatively affected. Children were away from the active lives of their families on the land during the time they were in school. While on the land children worked alongside the family and community members and during these times they learned by observing and copying the experts who modeled how to live on the land. They heard the pertinent stories and songs that went with each activity. As a result of the residential school they did not benefit from the teachings of their families and communities. The human ability to adapt to new situations is dependent on the cultural teachings of the older generations.

The trend to break the hold of the older generation and to disrupt the natural communication patterns through schooling continued in the federal day schools built on some reserves and continued even after the children were admitted to public schools in the 1960’s. To protect them, many parents began to withhold cultural knowledge, stopped taking them out on the land, and stopped speaking their mother tongue to their children. Parents thought this would help the children be successful in the schools.

Factors Inhibiting the Progress of Indigenous Students

Clearly, a great many factors inhibit the progress of Aboriginal students in education. In an attempt to provide a succinct overview, we outline factors inhibiting the progress of Aboriginal students in Canadian schools generally:

- English is not spoken in some Aboriginal homes, or, if it is spoken, it is as a second language. Communication problems are both verbal and nonverbal (Aikenhead & Michell, 2011; CCL 2007a; Michell, Vizina, Augustus & Sawyer, 2008; Snively & Williams, 2008).
- There is continued insensitivity to Indigenous cultures and communities that often results in absence from school, parent apathy, and community alienation (CCL 2007a; Edwards, 2004; Michell, Vizina, Augustus & Sawyer, 2008).
- School frameworks, personnel and curricula are frequently characterized by attributes such as rigid time-tables, self-expression, aggressiveness, hierarchical, and working for personal advantage; which run counter to the values many Indigenous cultures place on cooperation, group and community well-being, and, when appropriate, silence (CCL, 2007a).
- Rigid timetables combined with lack of funding that allows for field trips and extended outings to explore and learn about cultural territories, landmarks, place-names, teachings on the land with Elders and language nests (Edwards, 2004; Snively, 1995).
- Lack of appropriate procedures for assessing understanding and competence of cultural knowledge (CCL, 2007a).
- Teachers and resource persons from Aboriginal or Métis backgrounds, who can serve as positive role models, are not widely available (Aikenhead & Michell, 2011; Michell, Vizina, Augustus & Sawyer, 2008).
- The racist attitudes of many non-Aboriginal staff and students (CCL, 2007a; Edwards, 2004; Kanu, 2005).
- Distance from university, leaving the home culture to attend university, and communication from a distance (Mullens, 2001).
- Poverty, poor economic and living conditions, and poor health (CCL, 2007a, 2007b).

In developing a cultural perspective to science education, we outline additional factors inhibiting the progress of Aboriginal students in the science classroom:

- The modern view of science is often completely foreign and at odds with Native spirituality or a holistic understanding of the world (Battiste, 2000; Cajete, 1999, 2002; Snively & Corsiglia, 2001).
- The image of the scientist as the controller, manipulator, and exploiter of the environment conflicts with the cultural values of many children (Cajete, 1999, 2000; Snively, 1995; Snively & Corsiglia, 2001).
- The reluctance or refusal of western science teachers and administrators to bring Native spirituality into the science classroom, and in so doing, reject all Native science as outside the world of science education (Cajete, 1999; Michell, Vizina, Augustus & Sawyer, 2008; Mullens, 2001).
- Lack of knowledge and research into Aboriginal students' prior knowledge (ideas, beliefs and understandings of science related concepts and processes), and how to take their ideas into account in the science classroom (Aikenhead & Jegede, 1999; Fleer, 1999; Kawagley, 1995; Snively, 1995).
- Mainstream teachers have a limited professional science knowledge for teaching science, and an even less adequate knowledge base for helping students move back-and-forth between their Indigenous culture and Western Science (Aikenhead & Michelle, 2011; Belczewski, 2009; Berger & Epp 2005; Lewthwaite & McMillan 2007; Lewthwaite, McMillan, Renand, Hainnu, & MacDonald, 2010).

- Lack of culturally appropriate science textbooks and resource materials (Aikenhead & Michelle, 2010; Battiste, 2000; Kanu, 2005, 2006; Lewthwaite, McMillan, Renand, Hainnu, & MacDonald, 2010; Michie, 2002).
- Lack of appropriate assessment procedures that take into account the cultural science related knowledge of Aboriginal communities, and that holds non-Aboriginal students responsible for knowledge of Indigenous Science (CCL, 2007a).
- Lack of clear and consistent guidelines from Ministries of Education and Territorial jurisdictions. Conflicting guidelines between elementary and secondary recommended and prescribed learning outcomes for science (Lewthwaite, McMillan, Renand, Hainnu, & MacDonald, 2010; Littlebear, 2009).
- Lack of unified leadership at the university level across Canada in the training of pre-service teachers with regard to culture and science methods courses (Snively, 1995).
- Lack of adequate funding; e.g., for developing culturally responsive science curriculum materials, funding for fieldtrips, providing focused and sufficient professional development for teachers, funding for Elders and knowledge keepers to visit classes and teach on-site in the local territory (Snively, 1995).
- Lack of research from an Aboriginal perspective, lack of appropriate methodologies for investigating the cultural knowledge of Aboriginal children (Battiste & Henderson, 2000; McGregor, 2004).

The marginalization of Aboriginal students in school science has long been a concern for Aboriginal leaders, science teachers, professors, ministries and departments of education, the Canadian government, the Science Council of Canada (1991), and science education organizations such as the Canadian Aboriginal Science and Technology Society (CASTS). Although thoughtful innovations in some jurisdictions have successfully encouraged teachers to incorporate examples of Indigenous Science in the science curriculum, and some science-minded Aboriginal students have been attracted into science courses and careers, these initiatives fall seriously short of resolving the general problem of under-representation. The findings indicate that an Indigenous cultural view of science education is not presently widespread in Canadian schools, particularly at the secondary level, and for many jurisdictions they describe a system of education in which students are expected to accept a western modern view of science as superior, and to accept presented information without question. Such techniques not only go against what is presently known about effective teaching, but also discourage students from seeking to understand the science that is taught in schools.

Indigenous Science: A Brief Overview

Cobern and Loving (2001) have defined what they call the "standard account" of science and exclude Indigenous Science from the science classroom primarily because they claim it does not have an experimental base, is not theory driven, and can't be used to predict future events. On the other hand, authors such as Cajete (1999, 2000; Snively & Corsiglia, 2001; Snively & Williams, 2008) have called for the inclusion of Indigenous Science, primarily because of its numerous scientific and technological innovations and its wisdom practices that focus on balancing human needs with environmental requirements.

Indigenous Science is fully integrated into the whole of life and being, which means that it cannot be separated into discrete disciplinary departments. As Cajete (1999) explains:

> The processes of Indigenous Science parallel and at times intersect with those of Western Science. Observation is emphasized. Indigenous people carefully observed aspects of Nature such as plants, animals, weather, celestial events, natural structures and ecologies of natural communities. They experimented with applications of their knowledge in the context of the environment or situation which was appropriate. There was no deliberate effort to decontext experimentation by moving beyond observations. In an Indigenous context predication was not associated with the ability to control but primarily with gaining understanding of a natural process; for this reason science meant establishing relationships which led to establishing and maintaining harmony. Indigenous science intuits the desired results and then enters into specific relationships to accomplish its aims. It stressed direct subjective experience and close relationship to Nature. (pp. 84-85)

Generally, Indigenous societies stress order and harmony, but they also acknowledge diversity, chance and the unexpected. It is a disciplined process of coming to understanding and knowing.

The fact is numerous traditional people's scientific and technological contributions have been incorporated in modern applied sciences such as biology, environmental science, geology, medicine, astronomy, architecture, pharmacology, agronomy, agriculture, animal husbandry, fish and wildlife management, nautical design and navigation, engineering, and plant breeding. Suggestions that Indigenous peoples cannot practice "science" reflect narrow and restrictive definitions, old justifications, and insufficient factual data. (See chapters 6 and 7 for more in-depth descriptions of Indigenous Science, with its innovations in science and technology and time-tested sustainability practices).

Many scholars of Indigenous Science, (Aikenhead & Ogawa, 1999; Aikenhead & Michell, 2011; Cajete, 1999; Michie, 2002; Snively & Corsiglia, 2001) argue that the Western way of thinking that has divided knowledge into various disciplines is a relatively recent phenomenon, and must reconstruct itself from its various disciplines in order to match the more holistic Indigenous approach to knowledge. As such, science education needs to celebrate the positives about Indigenous cultures, and this includes science as part of culture.

There are those who would argue that there is no such thing as Indigenous Science, that "science" is an invention of the modern Western society, and that Indigenous people have a body of cultural folklore and thought which cannot be considered a rational and ordered system of theory and investigation comparable to Western Science. Whether there exists an Indigenous Science in western accounts is largely an argument of semantic definition. Use of western definitions and orientations to measure the validity of non-western ways of knowing and being in the world has been applied successfully historically to deny the reality and validity of Indigenous Science. The fact is, Indigenous Science exists, has made invaluable contributions to the body of knowledge we call science, and has been validated by numerous western scientists, as well as courts and international governments. Any attempts to define "science" falls short, as definitions of science are fluid and always change as cultures change.

So Why Does the Low Participation of Aboriginal Students in Science Matter?

So, why does it matter that Indigenous students are not taking science, and why does it matter that non-Aboriginal students are not exposed to Indigenous Science examples? The value of including Indigenous Science in the science classroom is addressed in the following five ways:

- a way of righting inequalities in educational opportunities for Aboriginal youth, specifically in the areas of health and science careers,
- a way of ensuring Indigenous sovereignty, cultural survival and the rights of Indigenous learners,
- a way of teaching all students about the nature of science, and that Indigenous Science is one of many sciences,
- a way of teaching all students about respect-relating to nature, home place and long-term sustainability, and
- a way of enabling Aboriginal students to be successful in school science.

Although this chapter focuses on the need for transforming the science curriculum for Aboriginal students, there is also a focus on "science for all" as a guiding principle for achieving scientific literacy through science education. "This breaks away from the science/science education nexus which has seen the products of science education as proto-scientists rather than as people living in a scientifically literate, multicultural society" (Michie, 2002, p. 36).

Preparation of Aboriginal Students for Science Related Careers

So, why does it matter that Aboriginal students are not taking science? For a start, there is currently a critical shortage of Indigenous people in science and engineering related fields (CCL, 2007a, 2007b). In fact, the number of Indigenous people in both educational and occupational fields featuring science, engineering, technology, mathematics, resource developers and managers, and health and medicine is abysmally low and is of significant concern (Aikenhead, 2006; Aikenhead & Michell, 2011; Mullens, 2001).

In a time of land-claim settlements and moves to self-government all over Canada, Aboriginal people with scientific and technological education are needed to manage resources, build and maintain infrastructure, and deliver health care and other scientific services to their own people. This will specifically help Indigenous communities to initiate economic development projects and take greater control of land use, resources, education, and enhance Indigenous sovereignty (Aikenhead & Michell, 2011).

Reasserting authority in areas of economic development and health care requires community expertise in science and technology. But for many Aboriginal students seeking to return to their home communities and work in health and science related careers, a serious disconnect is often experienced between the values and worldview of the Western Science learned at university, and the values and worldview of their home communities. Many graduates must unlearn, re-shape or in some way reconcile their new science to their Aboriginal world. As well, past experience has shown that filling positions in science and technology in Aboriginal communities with Aboriginal people is highly desirable because non-Aboriginal people typically remain in their positions for less than two years. In contrast, Aboriginal professionals remain in their positions much longer and bring stability and pride to their communities (CCL, 2007a, 2007b).

The educational success of Aboriginal students increases Aboriginal people's incomes and is seen as a major contributor to economic progress for a country (Sharpe & Arsenault, 2009). Choosing careers in science, technology, and health will benefit Aboriginal students directly through employment, but equally important, they can make a tremendous contribution to Canada from the unique understandings based on the values implicit in Indigenous Science and ways of knowing nature (CCL, 2007a, 2007b).

Indigenous Sovereignty and the Rights of the Indigenous Learner

Some people might ask, “What does science have to do with ‘sovereignty’ and ‘social justice’?” For a start, a worldwide renaissance now supports the sovereignty and cultural survival of Indigenous peoples (McKinley, 2007; Niezen, 2003). This movement toward sovereignty is about acknowledging, healing and rebuilding Indigenous nations oppressed by colonization. In 2007, the UN Convention of the Rights of Indigenous people was signed by 182 member nations, Canada signed in 2009.

The Convention states:

Article 13:

1. Indigenous peoples have the right to revitalize, use, develop and transmit to future generations their histories, languages, oral traditions, philosophies, writing systems and literatures, and to designate and retain their own names for communities, places and persons. (p. 5)
2. States shall take effective measures to ensure that this right is protected and also to ensure that indigenous peoples can understand and be understood in political, legal and administrative proceedings, where necessary through the provision of interpretation or by other appropriate means. (p. 5)

Article 15:
Indigenous peoples have the right to the dignity and diversity of their cultures, traditions, histories and aspirations which shall be appropriately reflected in education and public information. (p. 6)

Article 24:
maintains the right of Indigenous peoples to access and to use their traditional medicines. (p. 7)

Article 31:
makes clear the support of the inclusion and development of Indigenous knowledge systems, including their sciences, in education:

Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts. They also have the right to maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions. (p. 9)

Prior to the imposition of schooling, Indigenous people had their own systems of passing on knowledge, values, language and culture onto the next generation. The school system has assumed the responsibility to educate the next generation. Those attending school have the right to have their knowledge, languages and cultures reflected in what they learn and how they learn. Indigenous peoples in Canada have always maintained that they want their children to have knowledge of both worlds, their own Indigenous world as well as the Euro-western world.

According to some scholars, integrating IS into the science curriculum ensures access by all students to science education, and as such is a social justice issue (Aikenhead & Michell, 2012: Michie, 2000, 2002; Michie & Linkson, 2000). The issue of equity and social justice is complex because, as we have seen, many factors influence the phenomenon of under-representation: e.g., generations of colonial oppression, the residential schools, the absence of Indigenous Science in curriculum, the presence of racism and adverse living conditions. Nevertheless, as Métis science educator Madeleine MacIvor (1995) explains: "We [can] transform the science curriculum from one which is essentially assimilationist to one which honours, respects, and nurtures our traditional beliefs and lifeways, and which presents science and technology in a more authentic way" (p. 90). As Aikenhead and Michell (2011) point out, science educators have no direct influence over these factors, but they do have influence over how Indigenous students experience marginalization in science education.

Indigenous Science Knowledge to Save the Planet

Why should IS be integrated into the science curriculum? The answer goes beyond social justice and economic issues. It is a survival issue for the planet. The survival of Indigenous cultures provides a wealth of information for all peoples dealing with the accumulated effects of non-sustainable human *progress* that have violated our planet's life-giving biological support systems. In short, wisdom is present in Indigenous scientific knowledge where it is for the most part absent in Western scientific knowledge. The co-existence of IS alongside WS in the science curriculum serves as a new catalyst for learning where *all* students will gain substantially in their understanding of scientific knowledge, technology, society and the environment.

The knowledge and wisdom of ancient and contemporary Indigenous peoples, especially their knowledge of specific home-places, represents a significant but historically neglected environmental knowledge and wisdom. As problems associated with resource depletion, burgeoning human populations, and ecological disasters worsen, increasing numbers of scientists, academics and environmental managers are turning to traditional knowledge for reliable, time-proven information regarding ecological processes and sustainability practices. Traditional knowledge and wisdom can provide important information and innovative strategies for implementing successful conservation and resource management programs (Corsiglia & Snively, 1997; Snively & Corsiglia, 2001).

In her observations of the Athapaskan and Tlingit languages in the Yukon and Northwest Territories, anthropologist Julie Cruikshank (1981) notes:

> Observations are made over a lifetime. Hunting peoples carefully study animal and plant life cycles, topography, seasonal changes and mineral resources. Elders speaking about landscape, climate and ecological changes are usually basing their observations on a lifetime of experience. In contrast, because much scientific research in the North is university based, it is organized around short summer field seasons. The long-term observations included in oral accounts provide important perspectives on the questions scientists are studying. (p. 18)

Thus, traditional knowledge can provide time-tested, in-depth information about a local area that may improve the effectiveness of sustainability and resource management strategies (Berkes, 1993; Knudtson & Suzuki, 1992; Menzies, 2006; Weatherford, 1991; Williams & Baines, 1993).

Unlike Western Science, which can reduce nature to its value-free mechanical properties, traditional knowledge usually begins with respect for the spiritual essence that infuses creation—all life forms must be respected as essentially conscious, intrinsically valuable and interdependent. In practical terms, traditional wisdom extends the caring relationship associated with family life to communities and even to the environment. We are all relations: it is wrong to exploit or waste other life forms, or to take more than one's share (Corsiglia & Snively, 1997).

Clearly, the planet's environmental crises cannot be solved solely with conventional WS and technology, but must call on knowledge systems that naturally embrace stewardship practices at their very core. Multiple ways of understanding the environment encourages hybridization and creativity, and enables all of us to view environmental problems from a variety of perspectives and to take sustainable action (Corsiglia & Snively, 1997; Davis, 2009; Sillitoe, 2007). It becomes increasingly important for educators to introduce students to the perspectives of both IS and WS in the science classroom because IS is used by scientists to solve important biological and ecological problems, and because problems of sustainability are pervasive and of very high interest to students and others.

Indigenous Science for non-Aboriginal Students

In addition to making science education more sensitive and appropriate to the needs of Aboriginal children, it is imperative that Indigenous people's considerable contributions to science be elucidated for non-Aboriginal students. The introduction of Indigenous examples adds interest and excitement to the science classroom. All students need to identify and debate the strengths and limitations of different approaches in order to explore how others experience the world, and to broaden their understanding of the nature of science. A critical approach to teaching science can be used to help confront and eliminate racism, ignorance, stereotyping, prejudice, and feelings of alienation. All students need to be encouraged to examine their own taken-for-granted assumptions and to distinguish between those that reflect perfectly natural and appropriate cultural preferences and those that are rooted in misinformation or an unwillingness to allow for the existence of alternative perspectives (Snively, 1995).

In classrooms with a wide ethno-cultural mix, it should be fairly easy for sensitive teachers to gather data and use resource persons of different cultural groups to explore different attitudes and beliefs about the environment. Discussion of differences in the ways in which societies view plants and animals, how they develop resources, and the reasons why they do so, establishes a base for discussion of environment, appropriate technology, and sustainable societies. As well, science education must emphasize the relationships between science and technology and the culture, values, and decision-making processes of the society within which we operate. As "outsiders" trying to make sense of a society continually being shaped and reshaped by science and technology, students need more from science instruction than an ever-increasing quantity of facts and concepts. Science education can help all students understand what science is—what its powers are, what its limitations are, and more importantly, what it can become.

Enabling Aboriginal Students to be Successful in School Science

One of the best reasons for IS to co-exist alongside WS in the science curriculum is that it has been shown to enable Aboriginal students to participate and succeed in the science classroom. Research has evaluated the impact of implementing an enhanced science curriculum in a culturally responsive way (Aikenhead, 2006; Aikenhead & Michell, 2011). For example, in Alaska, the Native Knowledge Network produced a set of science curriculum materials for Yup'ik students whose standardized test scores uniformly improved over four years to match the US national average (Barnhardt, et. al., 2000). The focus should be on helping children of all cultures to understand western science concepts as well as Indigenous Science concepts and values, to explore differences and similarities between their own beliefs and western science concepts, to explore combining the two approaches to knowledge, and to be successful in school (Snively, 1995).

Re-envisioning Science Education in Canada

A recent Delphi study conducted by the Canadian Education Association (2016), over a five-month period in early 2014 among a panel of over 100 Canadian science education specialists, university professors in the sciences and education, industry scientists, engineers and award-winning K-12 science teachers, and the science media, addressed questions related to identifying the priority areas of science education for Canadian youth.

The process was initiated by lengthy, free-form written responses to four "seed" questions:

- significant global trends,
- foundations and goals of the science curriculum,
- opportunities and barriers to a new national vision, and
- what might distinguish Canada as having a unique role internationally?

Once the panel's opinions were analyzed, a questionnaire was developed which asked the panel to rank in order of importance the dominant themes across the four questions, and to provide a justification for their respective positions. Between questionnaires, each member was provided with summaries of the group responses prior to the next round of deliberations. The process stopped when it appeared as though the positions of the panel had solidified, but not always with consensus achieved.

If there was a common thread making its way through the deliberations of the national panel, it was that sustainability of the planet's systems and humankind's relationship with and influence upon those systems rises to the top of the list of priorities for science education in this country. No less important, the panel encouraged decreased emphasis on science education for student assessments and economic competitiveness; and encouraged a priority on making strong connections among the pure sciences, sustainability issues, socio-scientific issues, and the relevance of the curriculum for students.

One member of the expert panel described the sense of urgency to change the orientation of science education in Canada this way:

> Why should we continue to deliver science education in our schools if we fail to recognize the fundamental importance of sustaining the very systems of this planet which humanity critically depends? Allow me to be absolutely clear on this point—the human species is on a trajectory that could have globally catastrophic outcomes; science education has a role in altering that trajectory and so presents an explicit reason to change our approach to education in the sciences, and soon. (p. 2)

Another member of the panel described more specific concerns about sustainability science:

> It should not be surprising that the science of sustainability is of the essence to be integrated through the disciplines. On what alternate grounds would the future of science education rest? Concerns about sustainability, health, energy, food security and water are examples of significant issues that face today's societies and must involve both curriculum policymakers and the requirement of action. The issues are massively interconnected. (p. 4)

If we were to list the qualities that should characterize science education in Canada into the future, and do so on a priority basis, the national consensus from this panel would be summarized in Figure 2.1.

INCREASED EMPHASIS	DECREASED EMPHASIS
Science education for the sustainability of earth systems	National and international student assessments (e.g. PISA, TIMMS, PCAP)
Literacy in socio-scientific issues	Science education for global economic competitiveness
Relevance of science for students of First Nations, Métis & Inuit (FNMI) cultures	Science, technology, engineering and mathematics (STEM)
Contributions to human health and well-being	Exclusive control of curriculum by provincial Ministries of Education

Figure 2.1 ▲ Delphi Panel consensus on Canadian science priorities. Reprinted from J. J. Murray, (2015). Re-visioning science education in Canada: A new polar identity and purpose. Education Canada, 55(4). CC BY NC-ND.

One new element was the explicit demand to focus attention on our founding people's aspirations, and to advance this aspect of a circumpolar approach to science. One panel member described it eloquently as follows:

> The involvement of Indigenous peoples in science education is paramount. Indigenous philosophies, ways of seeing the planet, and defensible and de-colonizing pedagogical practices need to be central to the development of science education among our communities. This is essential if we are to foster greater Aboriginal student engagement in the sciences…. learners who often have to engage in 'border crossing' in order to 'feel' what science is to them. In Canada, there is a critical underrepresentation of Aboriginal peoples going into science-related programs at the post-secondary level. This has an impact on their ability to participate fully, knowingly having a Canadian voice, and be representative in the world's scientific communities on an equitable footing. (p. 5)

We can now envision a new model for science education with sustainability at its core, inclusive of Indigenous view, thereby strengthening Canada's role as a circumpolar nation while simultaneously working to de-colonize curriculum (Figure 2.2):

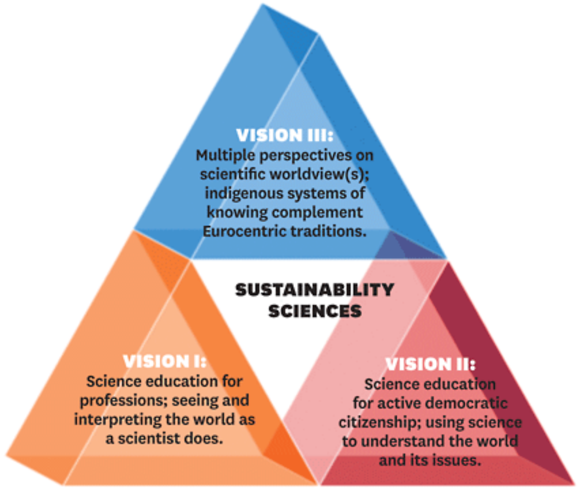

Figure 2.2 ▲ *Three dimensions of science education with the sustainability sciences as the foundation. Reprinted from J. J. Murray, (2015). Re-visioning science education in Canada: A new polar identity and purpose. Education Canada 55(4).* CC BY NC-ND

Sustainability sciences provides for a balanced approach to how society alters the physical environment and how the state of the environment shapes society. "There is perhaps no clearer and more provocative vision for a truly Canadian science education, than one that could develop the knowledge, skills and attitudes necessary to attaining a more habitable planet for all" (p. 6).

Conclusion

We are in an historic moment characterized by remarkable educational policy debate and change. Eurocentric scientists are increasingly recognizing Indigenous Science as an important and legitimate source of understanding the physical world. When teachers learn how the purposes of scientific activity have varied in different cultures and historical times, and how different cultures have developed science to meet their needs; they then can work towards developing innovative and sensitive resource materials and teaching strategies that encourage students to broaden their understanding of the nature of science and of the relationship between science and culture. Without the multicultural dimension, what we call "science education" is insufficient for our contemporary and future needs. Ministries of Education, the school system, and teacher education programs have the responsibility to deal respectfully with the knowledge and wisdom of Indigenous peoples. This may be difficult, but these responsibilities cannot be ignored.

DISCUSSION POINTS

- What is the current state of science education for Indigenous peoples? How did we arrive at the current state?
- What is at stake for Aboriginal learners?
- What factors inhibit the progress of Aboriginal students in science?
- What counts as science? Do Indigenous peoples have science?
- Should Indigenous Science be included in the science curriculum?
- What is the role of education in the transformation of society?
- What is the mandate for transformation of the science curriculum? What counts as transformation? How do we know we have it?
- What should be a new vision of science education for Canadian youth?

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

Wanosts'a7 Lorna Williams and Gloria Snively

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

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

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

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

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

Coming to know the use of fire, agriculture, the ancient fish wheel, key migration routes of the many types of salmon and developing sustainable harvesting technologies and practices were among the first elements of science. For example, as the salmon travelled their migration route, each salmon species was dried for preservation in a different way because of the varying fat content and with the different wind conditions. Humans live in relationship with nature and with plants, animals, forests, mountains and oceans. Humans need to pay attention to key "ecological" relationships and responsibilities to the natural world, including an understanding of the order and cycles of nature and having a sense of how things began and how things are in the natural order:

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

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

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

Indigenous Worldview

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

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

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

Principles of Indigenous Science Education

Outlined below are six principles or themes that we believe characterize the cultural forms of Indigenous discourse and, thus, represent the nature of science from an Indigenous worldview. We believe that these principles would be applicable in any Indigenous Science program or curriculum. Because IS is holistic and not easily subject to fragmentation, all of the principles discussed here are interrelated and can be considered in delivering all curriculum. In the words of Nuu-chah-nulth Elders "*hishuk ish tsawalk*" (everything is one) (Turner, 1997, p. 276). The first four principles are outlined in Snively and Williams, (2006, p. 122-123).

Place-based Knowledge

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

Multiple Perspectives

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

A Living Conscious Universe

In the Indigenous world, everything of Mother Earth possesses a spirit. This spirit is conscious and has awareness—the wind, water, stars, frogs, rocks, smoke, people, cedar trees, salmon, and killer whales possess a spirit. Everything in the universe lives and has its own place (Cajete, 1999, 2000; Deloria, Jr., 1995; Kawagley, 1999; Little Bear, 2009). In the Andean life-world, the relationship between nature and humans is familial and full of feeling: "Everything in the world is alive, everything is a person, everything speaks. Nature has a voice. Nature expresses itself through signs" (Ishizawa & Rengifo, 2009, p. 68). If you are going to gain knowledge over something you have to look after it; to make yourself ready to have that knowledge, you must form a respectful and positive relationship with self and everything around you. This expression of the relationship between humans and nature is shared with Indigenous peoples on every continent. Humans cannot place themselves before or above other life forms.

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

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

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

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

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

Focus on Balance and Harmony

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

Cycles and Circles

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

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

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

Interactive and Reciprocal Relationships

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

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

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

> One such caution instructs novice salmon fishers to consume all edible parts and return all unused wastes to the river Nass. Nisga'a people explain that the fish need the smell of the salmon remains in order to have a proper scent trail to find their way home from the open ocean. If we do not return the salmon remains to the river, the fish will feel insulted and will not come back …. Later, when a cannery was allowed to operate on the Nass, the Nisga'a required the cannery operators to return the wastage to the sandbars in order to create a natural "scent trail"…. This practice, along with the Nisga'a persistent petitioning of governments to address problems associated with White economic activities in the valley—is quite likely to have contributed to the survival, to date, of all the Nass River fishes that return from the sea to spawn. (p. 24)

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

Components of an Indigenous Science Education Model

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

Elders are Keepers of Knowledge

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

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

Learning is a Community Activity

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

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

> Thus, while growing up, learning is mediated by parents, grandparents, and community Elders. When preparing to go to the mountaintop, the young person is mentored and prepared by knowledgeable and caring Elders. While on the mountain, he might have thought he was alone, but he was never alone, his Elders and ancestors

> were there with him. Amongst the Lil'wat, as practiced when Wanosts'a7 Lorna Williams was a child, during puberty young women spent their days making implements like berry picking baskets as well as dolls, and beading and buckskin work. As they were completed, these articles were hung on bushes or rope lines drawn along walking trails. Anyone walking along the trail could take these articles. The purpose of this practice was to train young women to have strong, nimble, sure hands, have patience and persistence, approach tasks with a kind and loving heart, practice what they had observed their Elders doing, develop their own way of doing things and practice giving and gratitude. As well, narratives and stories told over and over to children are a highly important mode of communicating traditional knowledge and wisdom practices. And any one individual does not own what you learn; it is for and from the community seven generations back and forward (D. Donald, personal communication to Lorna Williams, February 6, 2013).

Learning is Holistic

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

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

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

Learning is Relational

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

> Here, power and place are dominant concepts—power being the living energy that inhabits and/or encompasses the universe, and place being the relationship of things to each other … the universe is alive, but it also contains within it the very important suggestions that the universe is personal and, therefore, must be approached in a personal manner …. The personal nature of the universe demands that each and every entity in it seek and sustain personal relationships. Here, the Indian theory of relativity is much more comprehensive than the corresponding theory articulated by Einstein and his fellow scientists. The broader Indian idea of

> relationship, in a universe very personal and particular, suggests that all relationships have a moral content. For that reason, Indian knowledge of the universe was never separated from other sacred knowledge about ultimate spiritual realities. The spiritual aspect of knowledge about the world taught the people that relationships must not be left incomplete. There are many stories about how the world came to be, and the common theses running through them are the completion of relationships and the determination of how this world should function. (as cited in Colorado, 1988, p. 52)

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

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

Hence, Indigenous education attempts to develop qualities and values in students such as modesty, generosity, resourcefulness, integrity, wisdom, courage, compassion for others, and living harmoniously with the environment. A classroom setting can be established that encourages working on class assignments for the benefit of others more than only benefitting the self. These values can be confounded by the current demands of the curriculum to compete for grades at the expense of other members of the class.

Learning is Carried in Language

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

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

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

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

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

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

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

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

Learning is Rooted in Home Place

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

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

Learning is Experiential

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

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

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

Learning is Ecological

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

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

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

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

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

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

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

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

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

Summary and Future Directions

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

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

The main purpose of this article is to show that there exists a framework, a place and a way for IS education. We have not attempted to show specifically what should be taught, how changes might come about, or how learning might be assessed, only that changes are necessary and to point a general direction. As with any change, it will take time before significant changes in the participation of Indigenous students in science takes place, but change is on the way.

In our journey to adapt and modify provincial curriculum to include an Indigenous perspective, teachers can "come to know" the knowledge, wisdom, metaphors and practices of Indigenous peoples. Teachers can see themselves as representing different worldviews and cultural constructions from within their worlds. We must be open to seeing the limits of our own boundaries of knowing. "Coming to know" in the Indigenous world is about utilizing the wisdom and knowledge gained by ancestors. It is approaching each task with an open and kind mind, heart, and spirit. We have no doubt that the work we will do as teachers to create learning experiences in science that allow for success of Indigenous students without expecting a form of cultural assimilation would be work that many teachers find of personal value. In the final analysis, grounding our teaching on the needs of a particular population is of significant benefit to all. Certainly, most teachers who do participate in such work find it both inspirational and liberating. (For a discussion of regional Aboriginal worldviews and new curriculum models that have recently emerged across British Columbia, see *Aboriginal Worldviews and Perspectives in the Classroom* (2015), British Columbia Ministry of Education.)

SUGGESTIONS FOR TEACHING

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

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

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Chapter 4 - Creating Change: Instructional Strategies, Teacher Education, Teaching Science in Rural Aboriginal and Urban Multicultural Schools

Gloria Snively and Wanosts'a7 Lorna Williams

If schools are going to respond to the needs of Aboriginal students, then it is imperative that science teachers develop instructional strategies that take advantage of the different cultural perspectives that can exist in today's classroom. Education that legitimizes the cultural norms of only one culture within a pluralistic society robs students from other cultural backgrounds of their self-esteem and the potential of pursuing science related careers. Consequently, science teachers who are willing to take a multi-science approach are providing numerous opportunities for their students to learn that many cultures have contributed to science. Because no single culture has a monopoly on the generation of science knowledge, a single cultural approach to teaching science alienates some groups of students. Therefore, it becomes important for teachers to recognize the potential of students from different cultures to contribute to science because of their different ways of understanding and experiencing the world.

Teacher Perceptions

Canadian and American education institutions of learning have historically been dominated by western approaches, therefore the vast majority of teachers lack much of the necessary knowledge to provide effective culturally responsive education to Aboriginal youth. The most obvious, but also most lacking among teachers is an awareness and understanding of Indigenous cultures, histories, worldviews, language barriers, and current social, economic and political issues (Agbo, 2004; Aikenhead & Michell, 2011; Belezewski, 2009; Berger & Epp, 2005; Kanu, 2005, 2006; Snively & Williams, 2008). This is consistent with Aikenhead and Otsiji's (2000) exploration of the role of teacher-as-culture broker as complex. This complexity is a result of most curriculum developers and teachers being members of a colonizing culture and coming from rapidly changing modern urban societies with limited knowledge of Aboriginal traditions, knowledge systems, values, and culturally appropriate pedagogies (Hainnu, et al., 2007).

Particularly distressing, is that racist attitudes of dominant-culture groups pose a challenge to the integration of Indigenous Knowledge into the curriculum. Kanu's (2000) study of high school teachers' perception of integration showed that teachers themselves overwhelmingly identified racist, stereotypical images of Aboriginal peoples held by some non-Aboriginal teachers and students as a most difficult challenge. Teachers held such ideas as Aboriginal people are "living in the past," "are always getting something for free," and "we have nothing to learn from Aboriginal people" (Kanu, 2005, p. 60-62). All teachers cited these negative stereotypical images of Aboriginal people as the main reason why Aboriginal students tended to deny their Aboriginal ancestry and identity. In addition, Anne, one of the Aboriginal teachers in the study, spoke about what she called "the tyranny of time" and how "clock time controls everything in Western culture to the extent that people do not listen to their bodies or their emotional or spiritual needs" (Kanu, p. 62).

Clearly, there are a number of barriers to enabling Indigenous Science to co-exist in the science curriculum. Pre-service and practicing teachers have identified concerns about practicalities as well as concerns about attitudes and knowledge, as follows:

- My class periods are too short and there's no time.
- I don't know enough.
- This is a new way of teaching for me.
- I don't have relevant materials and resources for teaching about traditional science.
- My colleagues, parents, and/or principal aren't supportive.
- I don't have a connection to an Aboriginal community.
- I'd like to teach about Indigenous Science, but I'm non-Native and I'm afraid to make mistakes. I don't want to get into trouble.
- Should teachers include IS in the school science curriculum when it includes spiritual teachings?

It is worth noting that this list includes perceived concerns over which teachers actually have control in their own classrooms. For example, teachers may feel that their lack of background in traditional knowledge is a significant barrier, they can however, control what they learn and teach. They have the option to enter the learning process with the students. While many remarked that the lack of more detailed science curricula was a significant barrier, others said the lack of curricula gave them a great deal of liberty in what they explored with their students (Hainnu, et al., 2007). Through opening oneself to the experiences of becoming knowledgeable about a different culture, teachers can begin to understand the different views of the world, and have increased respect for all students. Probably we need to respect the possibility that other traditions of understanding nature derive from complex human experience and generally recapitulate and incorporate illuminating an even more important insight.

A Nurturing Science Classroom for Aboriginal Students

When teaching in an Aboriginal community or in urban centres with classes of mixed ancestry, we must be aware that not all Aboriginal peoples are the same. This complexity has implications for how to create linkages between public schools and Aboriginal parents and communities. We must recognize that through a process of time and oppression, the residential schools forced assimilation and removals from traditional lands, resources, and wealth. Aboriginal communities have endured cataclysmic change and have taken a broad range of approaches to maintaining language, culture, traditions, and identity. There is also considerable diversity between communities and Nations. The Aboriginal children who come to our schools come from a wide-variety of backgrounds—coastal and interior, north and south, rural and urban, Christian, traditional Métis, Inuit and First Nations, and all possible blendings growing out of their unique histories and cultures. On the one hand, there are the few traditional groups who have, against enormous adversity, remained remarkably very close to the essence of their ancient and still viable life-ways; and on the other hand, there are those groups who have been completely assimilated within the larger Canadian society. Yet today, virtually all Aboriginal groups who retain any degree of self-identify are re-evaluating, acknowledging and celebrating their own traditional culture, and identifying themselves as First Nations, Métis, or Inuit. While most communities are struggling to reclaim past knowledge and identities, we must realize that Aboriginal people are not living in the past. As Bailey (2000) points out, “Aboriginal people are not returning to a past era, but are, rather, reaffirming their knowing by using the old with the new, using both traditional and western modes of physical and mental healing” (p. 228).

A problematic way in which teachers sometimes access Aboriginal histories, worldview and knowledge is through Aboriginal students who may have little experience with discussing the cross-cultural realities which they may have experienced; which can have both positive and negative ramifications (Groome, 1995; Butler, 2000). Many Aboriginal students are marginalized in the classroom and are rarely called upon. Thus, it can be quite shocking for some students to be placed in the position of pseudo-expert by teachers simply by their Aboriginality. For some students, being singled out for attention on this basis is unwelcome or shaming (Malcolm, 1998). Other students complain that they are seen as representative of all Aboriginal people, which calls upon them to contribute cultural knowledge, which they may not possess, and places them into positions to defend all views and action (Anderson et al., 1998; Butler, 2000). Thus, whilst some students may be able to provide information on the science knowledge of their culture, for others, the type of information sought such as language, medicinal, ecological knowledge or bush skills, is unknown. This is particularly true for those living in urban environments who have not experienced living on the land.

Careful observation and imitative play are tools of learning which are universal and not bound by culture. Pepper and Henry (1986) describe child-rearing practices in Native families:

> Much of the informal learning that takes place in Indian families is non-verbal in nature. The children learn the customs and skills of their society by sharing directly in the activities of others. In such situations, verbal instructions is neither offered nor required because the child’s close proximity to observable action makes instruction giving quite redundant. (p. 57)

Philips (1983) states, that the interaction systems in different cultures allocated use of the verbal and visual systems differently. What is of interest to science educators is that child-rearing practices emphasizing observation and experiential learning are consistent with good science practice. The discovery learning phase of inquiry science allows children unstructured time to explore a variety of hands-on activities without teacher guidance. Such connections have potential for integrating traditional teaching and learning styles into the science classroom.

We have been aware for quite some time of the importance of moving beyond making totem poles out of cereal boxes, making big houses out of Popsicle sticks, and igloos out of sugar cubes. We are aware that it is often inappropriate to make eye contact or expect hands to go up quickly. However, it takes work and experience to understand why so often one’s direct questions go unanswered or why students arrive late or are struggling so hard with an assignment. When students are absent from school, teachers should understand that Aboriginal students may be dealing with a death in the family, they may be grieving and they have family and community obligations that are deeply felt. For these reasons, schools require flexible and modular course planning.

When students have a sense of belonging in school they are engaged learners and participate in class and school activities. They do their homework, are prepared for their lessons, and participate in extra-curricular activities. Indigenous learners are no different from other learners. A major factor is learning in a nurturing classroom environment that is open and creates multiple opportunities for their voices to be heard and respected. A nurturing environment that fosters a sense of belonging involves teachers who are willing to learn about Indigenous culture, find the scarce resources to support their teaching and who are not afraid to include this knowledge in their classes (Willms, 2003; Steeves et al., 2010).

Instructional Approaches

Indigenous societies have rich and time-honoured ways of teaching their children and passing knowledge and wisdom from one generation to the next. These approaches include Elder guidance, apprenticeship, talking circles, storytelling, drawing, dancing, songs, ceremony, supervised practices, dreaming, and imagination (Cajete, 1994, 1999; MacIvor, 1995). As outlined by Aikenhead and Michell (2011, p. 137), these traditional methods typically follow a pattern:

- As much as possible, demonstrate what is to be learned while the students watch and listen. Allow time for the students to practice what they have learned.
- Involve a child in small tasks if possible.
- Allow time for a child to reflect on and practice what is to be learned.
- Provide an opportunity for a child to show what they have learned, but only when they feel ready.

This pattern harmonizes with the learning strengths of many Aboriginal students. Teachers should attempt to learn more about this pattern by watching and talking to Elders and knowledge keepers about how people in the community teach their children. The pattern is important to keep in mind in teaching contexts; however, it can have somewhat different implications for teaching in proximity to a small Aboriginal community and teaching in urban schools.

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When out on the land, Aboriginal students are taught to observe in multi-sensory ways and to cultivate their memory to recall important environmental information. This multi-sensory approach provides more input channels for information to be stored and recalled, and is consistent with good science and environmental education teaching methods. In the classroom, make available a variety of visual and sensory experiences (photos, tools, equipment, rocks, shells, pinecones). Provide students with hands-on inquiry based activities such as: playing and learning with snow and ice, heat and temperature, water, sand, soap, shadows, simple machines, magnets, electricity, and so on. Plan learning experiences inside and outside the classroom. Implement field trips whenever possible. This could include short trips to a nearby pond, field, forest, seashore or sacred site. Allow sufficient time for students to enjoy the beauty and peacefulness of the natural world; and to experience the interconnections of all life.

Hands-on community-based projects increase student engagement if the project involves culturally related environmental issues (Bowers, 2001; Orr, 2004; Sutherland & Henning, 2009). On southern Vancouver Island, BC, Wright (2010), engaged high school students of both Aboriginal and non-Aboriginal ancestry in the conservation and restoration of a sacred but abandoned SNITȻEŁ "SNITCEL" (Place of the Blue Grouse). Native eelgrass (*Zosteria marina*), an environmentally important plant once abundant in local nearshore marine environments, was seriously diminished by development and pollution. Students helped to monitor a newly restored eelgrass meadow. A sister project conducted by Eijck & Roth (2013), engaged Brad, an adult member of the Tsawout First Nations community, in a hands-on internship program that involved restoration of native terrestrial plants on the backshore of the eelgrass restoration site. Brad brought to the project a perspective of native plants used for tools, medicine and food by local First Nations communities that proved helpful for the practice of nature conservation, such as invasive plant removal and replanting of native species. In addition, Brad learned scientific protocols for monitoring levels of toxic pollutants in samples of nearshore marine sediments and invertebrates, and presented these findings to the academic community and to the public. A primary aim of both programs was to provide participants with experiences that could lead to feelings of empowerment and consideration of science related careers.

Young persons in Aboriginal communities, as well as many attending urban schools, have many rich experiences for the teacher to draw on. Many begin helping their parents and grandparents as soon as they are physically capable. By the age of 5 or 6, they may be gardening, picking berries, gathering clams and mussels, fishing from a line on a beach, setting crab traps, and cooking, smoking, drying and canning foods. Many will know a lot about Indigenous spiritual stories, medicinal herbs, and will have participated in ceremonial traditional songs and dances. Many will have experience drawing traditional figures, weaving baskets, making jewelry, designing and sewing button blankets, and carving animal figures and masks. By the age of 10 or 12, some will have had their own motor boat and know a lot about navigation, carpentry, and mechanics. Many will have experiences with fish hatcheries, commercial fishing, sonar and computers, processing fish, and running a family business. Teachers could develop science lessons around what students experience and talk about in the Aboriginal community (Snively, 1995).

Additionally, the following considerations may be helpful:

- No one textbook can comprise a viable science program for culturally different students. Textbooks should be reviewed for the purpose of removing offensive and racially stereotyped content. A variety of materials and resources should be used.
- Oral traditions must be respected and viewed by teachers as a distinctive intellectual tradition, not simply as myths and legends. The oral narratives and heritage of the Indigenous community should become part of the school science experience.
- Teachers should adapt written and spoken languages to avoid disadvantage to those with language difficulties, where possible provide bilingual science instruction. We should pay attention to the language of science education, and provide more opportunities for students to use language to explore and develop understandings––using analogies, models, metaphors, songs, role-plays, and stories.
- The history of colonization and how language has been used to legitimate economic and cultural imperialism should be acknowledged.
- We should acknowledge that issues of history, morality, justice, equality, freedom, and even spirituality are inseparable from the proper discussion of science and technology.
- Classes can gather and discuss data to show that there are many interpretations of the same phenomena, for example, different cultural notions of the concepts of heat and temperature, snow, classification (Phylum), and life cycles.
- Instruction should provide a high percentage of unstructured play activities, and “discovery” and “hands-on inquiry” learning that provides for the intake of sensory experiences and experiential learning.
- Throughout the unit, instruction should move from the concrete to ideas that are more abstract.
- Use science experiences to promote numeracy skill development as well as observation, predicting, collecting and analyzing data.
- Teachers should provide repeated opportunity and the time necessary for students to complete tasks.
- References can be made to current events and to present-day, home and community, real-life situations, and issues applicable to all children.
- Teachers should design curriculum materials and lessons that use exemplars from a variety of cultures and countries, so providing a “multicultural view” of science and technology.
- Teaching strategies should emphasize solving science and technology problems, environmental

problems, resource issues, and sustainable societies' problems. Instruction should identify local approaches for achieving sustainability. This will increase the meaningfulness of school and be consistent with traditional beliefs in working for the good of the whole group and community rather than of the individuals.

- Teachers can locate traditional stories and/or write stories around a science topic or resource issues related to a particular home place and engage students in opportunities to identify and articulate their own ideas and beliefs with others in small group situations.
- Promote scientific attitudes of curiosity and problem solving, thoughtful consideration of questions and challenges.

Approaches to Assessment

The way assessment is designed and carried out can be a challenge for Indigenous learners. Assessments in schools are designed to be competitive and stratifying in the way students strive for marks, usually timed and require a single "right" response. Barnhardt and Kawagley (2005) found the Eurocentric approach to testing to be very limited. "Such an approach does not address whether that person is actually capable of putting that knowledge into practice" whereas traditional knowledge is "tested in a real world context" (p. 11).

Written examinations are a major component of conventional school science culture during the middle and high school years, and represent a form of assessment foreign to students who have not been explicitly taught how to approach an exam. Consider that when science achievement exams are required, offer to students practice exams over several weeks, exams organized into smaller parts, as well as open-book exams; and give students ample time to finish.

As much as possible teachers should make every effort to use a variety of practical assessment techniques. Rubrics or checklists are helpful because they spell out what is expected. Self-evaluative questions and student journals can also be very helpful. Continuous feedback is critical to learning and for students to understand what is required and to feel supported and encouraged.

Knowledge and skills are not assessed in isolation from their purpose and application. In addition to assessing the students' understanding of key concepts, assess students on the science processes; their ability to observe, describe observations, predict outcomes, collect information, and evaluate outcomes of a project. For example, assess the students' ability to observe the details of a plant or animal, predict when specific animals will migrate through an area or estimate and map populations of organisms in a given area.

Give students opportunities for independent studies in which they identify a science-related topic or issue that is important and motivational such as: interviewing an Elder and/or scientist, making a film, conducting a questionnaire or poll. Research how their ancestors and community members observe how plants and animals thrive on the land so that they would not be over harvested.

In the Indigenous worldview, the purpose of learning must be to be helpful to the self, family, community, the ancestors and descendants, and the environment. Service learning engages students in projects such as removing invasive plant species from a forest, re-introducing indigenous plants or animals, cleaning up a salmon stream, or picking berries and making jam for an Elder. Assessment should take into account the goals of the project, knowledge of science associated with the project, the plan and timeline, organization of necessary materials and equipment, use of mathematics when appropriate, presentation of the project to class and possibly beyond, and indicators of success—how will we know if the project was successful. For group work, consider assessing the contributions of each student to the group project. The Alberta document *Learning Strategies for Aboriginal Students* (2005) provides insights for helping students design independent studies and conduct successful service learning projects.

The following list is derived from a judge's rubric for a First Nations and Métis traditional science fair. It illustrates community-based notions of assessment that inspire effective teaching practices, in contrast to conventional notions of assessment that can inhibit effective teaching and learning. For example, did a student

- indicate a sense that a journey was taken to become wiser?
- demonstrate harmony with nature and other values of the local Indigenous community?
- benefit the community in some way?
- embrace physical, mental, emotional, and spiritual aspects in their in-depth understanding?
- indicate that relationships were formed or strengthened, that responsibilities were taken on, and that protocols were properly followed? (FSIN, 2009)

As well, indicators of success might include

- increased knowledge of flora and fauna of an area.
- increased knowledge of the geology of an area.
- increased knowledge of the medicinal uses of plants, and the properties of plants that aid in healing.
- increased knowledge of the history and cultural significance of an area.
- ability to access the impact of specific technologies on the environment.
- ability to predict impacts on future generations.

Collect as much assessment evidence as feasible over a reporting period. At the end of the grading period, make an assessment based on knowledge of science along with a range of assessment techniques. Assessment strategies should be holistic, frequently anecdotal, and part of the on-going learning process. As much as possible, assessment should be positive. Several chapters in this book describe traditional forms of assessment: chapters 13, 14, and 15.

Teaching in an Aboriginal Community

When teaching in an Aboriginal community every attempt must be made to extend the world of learning beyond the school walls and bring the world of the Aboriginal child into the classroom (Battiste, 2000a, 2000b; Cajete, 1994, 1999; Edwards, 2004; Snively, 1995; Aikenhead & Michell, 2011). These attempts draw on concrete and real situations as a basis for science learning and allow movement away from learning out of context. In this regard, it is important for the teacher to find out what is going on in the Aboriginal community, to seek help from Indigenous scholars, teachers, teacher aides, and to encourage students to seek counsel from their Elders.

Beyond reaching out to the community yourself, students can be involved as student researchers and become involved in gathering and documenting local knowledge. This can be as basic as having students work with tape recorders, cell phones, or iPods to gather information from such sources as their families, Elders, or cultural groups. Plan medicinal herb walks, bark gathering or berry picking walks with an Elder or knowledge keeper to connect students with the land. With the help of Elders and other resource persons, plan a holistic Indigenous Science camp at an ancestral or culturally significant location. Such community-based projects will help alleviate alienation that is common to those who cannot participate fully in the typical science classroom.

When teaching in an Aboriginal community, your task as a teacher will be more successful if you adhere to the following guidelines:

- Invite Elders, parents, and local resource persons. Come to a mutual agreement of the purpose of the activity if taking a trip.
- Ask permission to use certain stories, songs, dances, etc. If there is any uncertainty, refrain from using the materials until you have the permission to incorporate them into your teaching.
- It is critical that teachers acknowledge his or her limited understanding of Aboriginal songs, stories, ceremonies, etc., and articulate this to the students. This avoids unintended misinformation of Aboriginal teachings. Orally reference the materials and the family/band/tribe/nation from which it came. This follows proper protocol and if not practiced is analogous to plagiarism.
- Ask permission to take photographs, videos or notes at ceremonies in or out of the big house/long house. Most songs, dances, and ceremonies are owned by families and recording this information if often prohibited.
- Find out and follow local protocols when asking Elders to come into the classroom.
- Acknowledge the traditional territories upon which the school, ceremony or fieldtrip activity is taking place. This respecting and acknowledging of Indigenous history and territory follows proper protocol.

Family support is often the deciding factor in student success or failure, as is with any child. By building on existing Indigenous curriculum materials and inviting parents and Elders to the classroom, the teacher is communicating an attitude of respect and shared teachings. In Indigenous cultures, grandparents (especially culturally knowledgeable grandparents) are held in high esteem as they contribute to the community by passing on knowledge, skills and wisdom.

Bring Elders and knowledgeable grandparents into the classroom to share personal knowledge when studying subjects like nutrition, plants, ecology, medicine, harvesting techniques, sustainable resource traditions, use of modern fishing techniques, the residential schools, and local cultural history. Aboriginal students must be given every opportunity to feel a sense of belonging and understanding in the two-worldviews that dominate their lives. As well, all students can benefit from the knowledge and wisdom of Elders and cultural knowledge holders.

When Teaching in Large Urban Schools

While many of the teaching strategies described are appropriate for small or average sized schools, there are additional ways to make a large multicultural urban school more culturally sensitive. Some of the negative aspects of size can be the impersonal and bureaucratic conditions that go along with large-scale factory-like institutions. These large schools can be broken down into several smaller learning communities, or schools within schools (Barnhardt, 2006). Students and teachers can form clusters that can function as a cohesive unit with a support system based on personalized relationships. Classes can be organized in a block format, where longer periods of time are made available for extended field trips and intensive projects without interfering with other classes.

The potential problem of cultural differences can be made into an asset in an urban school where the student population is a rich cultural mix. Many students of Aboriginal ancestry attend urban schools, and these students may or may not have close ties to a strong traditional place-based culture. The interests, knowledge, and strengths of each student can be recognized and rewarded through cultural demonstrations, group projects, language comparisons, and the inclusion of cultural songs, dances and customs. Over time, students in large urban schools can learn to celebrate cultural differences, and identify cultural difference as a strength rather than a threat.

In the higher grades, whether teaching in rural or urban communities, it is important to convey a sense of occupational purpose for their science learning. Provide opportunities for students to research and if possible, interview by e-mail, phone or in person, Indigenous scientists, biologists, engineers, technicians, architects, health specialists, fisheries and forestry professionals, environmental managers and technicians. Have students create posters, reports, and biographical collages of Indigenous scientists and their science-related work.

Connecting With Aboriginal Communities

There are many layers of shared understandings in any community, and especially in a small cultural community. For an outsider to begin to understand those deeper layers takes a considerable openness of mind and a great deal of effort and reflection. While the nearest library can be a helpful introduction to a new community, Barnhardt (2006) contends, "The fewer prior conceptions and the less cultural baggage that you carry into the situation, the more likely that you will be able to avoid jumping into superficial conclusions leaving you free to learn what it takes to make a constructive entry into the local flow of life" (2006, p. 2). The most important consideration is keeping an open mind and a good heart, reserving judgment and accepting people on their own terms. Remember the old saying, "first impressions count."

In 1972, when the students of a community-based teacher education program in Mount Currie, BC, interviewed prospective instructors for the Lil'watul, they were looking for specific qualities. Wanosts'a7 Lorna Williams, who was involved with the decision-making process, outlines the qualities they were looking for:

- An openness toward people who are different from them, a willingness to learn, and understand, a sense that our ways would be respected and not be unsettling. We looked for instances where they might have lived in or travelled to places where they were a minority and had to learn to live with cultural or linguistic differences. How did they respond to the experience? What did they take away from the experience? What were their views about Indigenous people? It wasn't necessary for them to have extensive or intense knowledge about us; we could teach them about ourselves if they were open. Sometimes if a person came who had studied about First Nations, they thought they knew everything and stopped listening.

- We were interested in their thinking about colonization and imperialism. If they hadn't been aware of it, how willing were they to learn? At the time this was something we were learning, and exploring how colonization affected our lives and learning. We knew that as teachers we needed to break the pattern of the devaluation of our way of life.
- We were interested in their level of passion for the subject that they were coming to teach. We wanted to see the light in their eyes and bodies when they talked about the course they were going to offer. We wanted to feel the excitement in our bodies and to see the possibilities for our learning. When we asked for changes to the content or their approach we could see how flexible they were and how they too could see new possibilities for the course. We looked at what we were learning in each course, not just for ourselves but how it would impact our students and community. We were building a school for our community's future and we needed the tools and knowledge to bring two worldviews together.
- How able were they to communicate their ideas to us and to help us be understood so that there was mutual understanding? For many of us our English was limited, so how well could the candidate explain their ideas to us without making us feel stupid. It wasn't our intellectual limitation that kept us from understanding, it was our limited English and our limited experience with the Western world. Whether communicating legal, scientific or educational concepts it was the jargon that limited understanding. It is patience, knowledge, kindness, and willingness to find alternative ways to explain the concepts in the content readings that made the learning and teaching effective.

As opportunities arise, get involved, attend or find out about community events as early as possible. When appropriate, visit local Elders and other cultural bearers, and try to become familiar with aspects of the language. Showing enough interest in the local language to pick up even a few words or phrases will go a long way toward building your credibility in the community. Always assume the role of both teacher and learner.

Thoughts about Spirituality in the Science Classroom

From an Aboriginal perspective, understandings of spirituality are fundamentally interconnected with understanding of Indigenous Science (Cajete, 1999; Little Bear, 2000, 2009). Gregory Cajete (2000) suggests that divisions do not exist between science and spirituality, and states: "every act, element, plant, animal, and natural process is considered to have a moving spirit with which humans continually communicate" (p. 69). Teachers need to understand that religion and spirituality are different. There is no Traditional Ecological Knowledge (TEK or TEKW Traditional Ecological Knowledge and Wisdom) in the bible; and there are no TEK or TEKW spiritual missionaries.

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, pay attention to Mother Earth, and pray. This view of education is in marked contrast to the "me-first" attitude that is often found in most public schools and universities (Cajete, 1994, 1999; Kawagley, 1990, 1995; Kawagley & Norris-Tull, 1998).

To participate in school science, many Indigenous students are expected to set aside their Indigenous ways of knowing nature. Knowledge in Eurocentric science expresses an *intellectual tradition* of thinking, while Indigenous knowledge expresses a *wisdom tradition* of thinking, living and being. Broadly speaking, an intellectual tradition emphasizes individual cognition, while a wisdom tradition emphasis group-oriented ways of being as practiced by living in harmony with Mother Earth for the purpose of survival. Thus, practical wisdom tends to resonate with wisdom-in-action (Aikenhead & Elliott, 2010; Aikenhead & Michell, 2011).

A reverence for life and an affinity of the interconnections of all beings are integral components of Aboriginal worldview (Canada Council on Learning, 2007a, 2009). Essentially, spirituality is about day-to-day living–how we relate to one another and with the planet. Spirituality is also about how we learn. The Canada Council on Learning (2007a) document *Redefining How Success is Measured in First Nations, Inuit, and Metis Learning* includes the following:

> For the Metis people, learning is understood as a process of discovering the skills, knowledge and wisdom needed to live in harmony with Creator and creation, a way of being that is expressed as the 'Sacred Act of Living a Good Life' (p. 20).

Many Aboriginal peoples share the concept of a learning spirit. Vizina (2008) states, as quoted in the updated Canada Council on Learning (2009) document, *The State of Aboriginal Learning in Canada: A Holistic Approach to Measuring Success*:

> Acknowledgement of the spirit world and acceptance of spiritual gifts, such as dreams and visions, are a natural part of traditional life for Aboriginal people. Spiritual experiences are integral to each person's learning journey and are honored through ceremony and relationships with the community's spiritual leaders (p. 29).

Thus, to make knowing possible, the individual turns inward to connect with the energy inside oneself and in all of creation. Spiritual experiences are equated with knowledge creation and is manifested through ceremony, vision quests and dreams.

There is concern amongst some teachers and school administrators about altering scientific course curricula to make it more meaningful for Aboriginal students, and that the inclusion of Aboriginal examples, and in particular the spiritual dimension, will dilute or diminish the quality and standards of science education. By teachers introducing IS, they are not introducing religion (as understood by mainstream Canadian society) into the classroom. Herman Michell, a Woodlands Cree and Director of the Northern Teacher Education Program, Northern Professional Access College in Saskatchewan, notes that it is important that all Aboriginal students complete all the standard course requirements. Michell states, (as cited in Mullens, 2001), "When they [the Aboriginal students] get a degree here, it's the same degree as the guy sitting next to them. If you get a different degree for Native students, it could very well carry a stigma" (p. 10). And, as Jette, founder of the Native Access to Engineering Program at Concordia University points out, "the seeds must be planted early. Unless students obtain the basics of mathematics and science in elementary school it is almost impossible to pursue it [science] at the post-secondary level" (Mullens, 2001, p. 10). It becomes critical to understand that while the Aboriginal people of Canada have long advocated learning that affirms their own ways of knowing, they also desire an education that can equip them with the knowledge and skills they need to participate in society. They simply do not want to be assimilated and lose their culture in the process.

Teacher Education Programs

In preparing our science methods for the challenging task of teaching elementary and secondary science in schools (based on Western institutional, cultural and science standards), we know that many university and science education professors continue to contribute to the cultural genocide of Aboriginal people, through their singular way of viewing the world. To counter this possibility, Bailey (2000) builds an argument for examining our institutions based on the following concerns:

- how we frame and name our own racism–to come to feel comfortable talking about our own biases and prejudicial thoughts, actions, and attitudes, as a necessary first step to action;
- how we disadvantage Aboriginal students in our universities, for whom success may require some form of personal amputation; and,
- how we, as teacher educators, can begin to model through our own culturally sensitive action, and through teaching, ways of becoming culturally sensitive classroom teachers. (p. 229)

In an attempt to examine our own institution, the Faculty of Education, University of Victoria, declared in its University Strategic Plan a strong will to address the under-representation of teachers with an Aboriginal ancestry in our schools, as well as an urgent need for pedagogical strategies that help Aboriginal children complete their school education (Faculty of Education, 2002). In our teacher education faculty, most of our classes on campus have some Aboriginal students.

It is possible that there are Aboriginal students in every school in the province, rural or urban, and teachers need to know how to teach this population that the school system has consistently failed. To that end, the University of Victoria created a course on Indigenous Education mandatory for all teacher education students. The course covers five areas: Indigenous knowledge and learning; information on Inuit, Métis, and First Nations peoples; their languages, cultures, and land base; the effects of colonization in education and decolonizing efforts; and the history and current policies and practices in schools that affect decision-making and pedagogical practice.

In addition, the undergraduate environmental education courses and Graduate Program in Environmental Education include many examples of IS, and in particular TEK. The aim of the graduate program is to draw people from diverse backgrounds together in learning about the forest and ocean environments, respecting the cultures of Indigenous people, and educating future citizens to make wise decisions regarding long-term sustainable communities and environments. Many respected Chiefs and Elders are regarded as professors and invited to speak to the students. Because the work of Elders is always grounded in their own spirituality, it has a different dimension to it––Elders speak from the heart and without a sense of competition. By bringing Elders, storytellers, scientists and other resource persons into the classroom and engaging them in field experiences, we invite all participants (both Aboriginal and non-Aboriginal graduate students) to work together in attempting to resolve environmental problems using both Western Science and Indigenous Science knowledge and experience. From the participants' experiences, the program provided a unique interdisciplinary starting point for developing research and curriculum efforts (Snively, 2006).

The idea of spirituality informing our work in universities is increasingly a topic of scholarly work (Bailey, 2000; Kanu, 2005; Little Bear, 2009; Snively, 2006). Often, the notion of spirituality remains unclear, with the terms "religion" and "spirituality" becoming fused. Whether we refer to Creator or God, the sense of a higher power has a significant impact on how people see their world and their actions within it. Unfortunately, in our Eurocentric culture many of us have lost the sense of spirituality, of oneness with the universe.

Starting Points and Information Sources

The questions raised by pre-service and in-service teachers provide a starting point for creating a more relevant science education for all children. Here are some possible considerations for teachers:

- Arrange for special speakers of various cultures;
- Develop lesson plans and teaching units around science themes of interest to children of specific home places and cultural origins;
- Develop lesson plans that address multi-sciences, traditional science, culture, and the changing nature of science;
- Develop questioning strategies that encourage active listening and the identification of personal beliefs about science concepts and the relationship between culture and science traditions;
- Observe children in multicultural classrooms;
- Interview teachers of multicultural students;
- Co-plan an Indigenous Science learning centre, science fair or Indigenous Science Camp.

Topics for Integrating Indigenous Science into the Classroom

The following are possible topics for integrating Indigenous Science activities, textbooks, and resource materials:

- medicines and medical procedures
- edible plants
- edible seaweeds and marine animals, harvesting and preparation
- knowledge of food preparation
- animal behaviour, life cycles, habitats, distribution, animal migration
- tides, ocean currents
- lake and river dynamics
- forest relationships
- knowledge of tanning hides, making moccasins, mittens, and parkas
- knowledge of wood products: cedar bark clothing, baskets, ropes, and twine
- knowledge of tools and machines, wedge, lever, maul, incline plane, fulcrum, and wheel
- traditional fish harvesting, Nisga'a fish wheel, weir, halibut hook, gillnet, halibut hook
- knowledge of weather and seasonal changes
- classification of plants and animals, classification of environments
- ecological knowledge, environmental change over time, climate change
- erosion and relocation
- sustainability practices

- enhancement practices, salmon and trout enhancement, clam bed enhancement, estuarine root gardens
- snow and ice, igloo, snow shoes, snow goggles, sled, toboggan
- wilderness survival, shelters, making fire
- use of controlled burning to enrich soil, enhance wild food crops, control insects, control forest understorey
- metallurgy
- astronomy, knowledge of constellations, movement of sun and moon
- navigation across oceans following constellations
- agriculture, knowledge of soil types, propagation of corn, pumpkins, potatoes
- geology, knowledge of soil types, knowledge of rocks (sandstone, flint, obsidian, jade, copper)
- nautical design, dugout canoe, birch bark canoe, whaling canoe, sturgeon canoe
- architecture (heat and temperature control), cedar log big house, teepee, igloo

For a more complete description of curriculum connections, see Appendix A.

Information Sources

Sometimes, collecting information on Indigenous Science is fairly easy such as when information is readily available in a book or film, or when an Elder can be used as a resource person. It can be more complicated when the information concerns specific local knowledge, is culturally sensitive or when the knowledge has been lost or distorted.

Gathering local Indigenous Science examples takes time, creativity, and effort. Primary teachers will need to identify materials and resource persons, but at the intermediate and secondary levels, teachers can also engage students in collecting information. The following are possible sources:

- informal interviews, talking circles, participant observations
- resource people from the local community
- students as researchers
- biographies of Elders
- field trips, camping trips
- books, legends, taped songs and stories
- maps, photographs, sketches, time lines
- internet, YouTube, Facebook, blogs, social media
- films, documentaries, National Film Board of Canada
- historical archives, archeological and anthropological archives
- tribal and band offices, (land claims research)

- school district Aboriginal education office, ministries of education (Aboriginal Programs)
- Traditional Ecological Knowledge (TEK) researchers (biologists, geologists, climatologists, ethnobotanists, etc.), TEK journal articles
- universities (Faculties of Education, Indigenous Governance, Linguistics)
- Appendices A, B, C, and D of *Knowing Home*.

Accessibility to the digital world varies in every community, and changes are made rapidly. It becomes worthwhile to find out what is available in the school community.

Responsibilities of Government

The responsibility of ministries of education and territorial governments is to include a meaningful degree of Indigenous Science explicitly in the science curriculum through collaboration with Indigenous Elders and knowledge holders. Ministry documents should include information on Indigenous Science, resources, and teaching strategies that facilitate responsible cross-cultural science education. It is the responsibility of school boards and government to create and fund workshops and alert teachers to opportunities to become engaged. Without administrators' interest and leadership, and without adequate funding, teachers feel unsupported.

Conclusion

One of the encouraging notes in these times is that in spite of all manner of historic and contemporary violence and oppression, both the Indigenous Knowledge stories and the people still thrive in many parts of Canada and throughout the world. It is given to us who work at universities and in the school system to create programs and spaces for the stories of Aboriginal practitioners to be told to both Aboriginal and non-Aboriginal students.

The rightful inclusion of Indigenous Science in school science will not be accomplished overnight. In spite of formidable forces, there are isolated pockets within the educational establishment across Canada where much progress has been made. While many educational institutions include in their educational philosophies idealistic statements about Indigenous Science, what is prescribed in ministry documents is all too often not reflected in science classrooms. Clearly, the resolution lies in people who are motivated to explore ways of respectfully accessing and building connections with Indigenous learners, their families, and communities. What is important is the need to recognize the value, indeed the usefulness of Indigenous ideas about the world in which we live, and how we should live in it. There are good reasons to stop arguing about the authenticity of Indigenous Science and recognize the importance of the knowledge and wisdom that it contains and reflects. While education is a major part of the problem, it can also be a major part of the solution.

DISCUSSION POINTS

In a small group of 3 to 5 persons, discuss the following:

- Tell a story that you observed or were engaged in that is an example of culturally sensitive science related teaching. Or culturally insensitive science teaching.
- Respond to the statement: "I'd like to include Indigenous Science in my school classroom, but I'm non-Native and I'm afraid to make mistakes. I don't want to get into trouble."

Things to do:

- Visit the Aboriginal Resource Centre in a School District to review their curriculum resources. If possible, find out what programs exist in the district that relate to Indigenous Science.
- Visit a classroom or event that engages students in topics related to Indigenous Science.

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Chapter 5 - Representations of Indigenous Science in Textbooks, Curriculum Resources, and Government Documents

Gloria Snively

Imagine what it would be like to never see anyone or anything familiar in science textbooks or science activities––to never see your ancestral heritage and never learn about the richness of Indigenous Science (IS) in the classroom. Imagine what it would be like to never see a famous environmentalist, astronomer, engineer or chemist of Indigenous ancestry. For hundreds and thousands of years, Indigenous mothers the world over, where willow trees grow, gave their children willow bark tea when they had fevers. We now know that willow bark is a mild analgesic that contains acetylsalicylic acid, the same ingredient in aspirin. However, encyclopedias and science textbooks credit Charles Gerhardt of Germany with the "discovery" of aspirin (acetylsalicylic acid) in 1853. As Roberta Barba et al., (1992) ask, "Who really discovered aspirin?" (p. 26).

Books and materials in Canadian schools do not accurately depict the history, cultural diversity, worldviews, and philosophies of Indigenous peoples. As Marie Battiste (2000) states:

> Although some provinces have made great strides in correcting the blatant racism found in texts, the truth is still obscured in favour of a more rational and polished early existence in Canada. Beautiful images of Aboriginal peoples in Native regalia cannot be allowed to subvert the historical truth that publishers wish not to discuss. Published texts obscure the Aboriginal history, cultures, and languages while perpetuating the myth of an empty land in the New World that was ripe for discovery by European explorers. Kits and thematic units prepared by public education in some areas of Canada depict a prehistoric life of Aboriginal peoples, complete with teepees, skins, animal bones, rock tools, and arrowheads. Aboriginal peoples are depicted as primitives, gone after the arrival of the early settlers of working their working their way toward assimilation in urban areas (p. 200).

In many elementary schools in Canada, you are likely to find that teachers are working hard to incorporate elements of IS in the classroom. That is because science educators have recognized the need to ensure science textbooks and curriculum resources used in classrooms deliver more accuracy in acknowledging the contributions of Indigenous Knowledge to the body of knowledge we call science. Although much has changed, a great deal more needs to be done to accurately and adequately present the culture, worldview, and science of Indigenous peoples in books and instructional materials. The best way to ensure greater accuracy is to involve knowledgeable Indigenous people (Elders, knowledge holders, and Indigenous scientists and teachers) in some stage of the production of those books. Without Elder direction, IS can be misrepresented and loses its context, location and its spiritual base (Battiste, 2002; Battiste & Henderson, 2000; Little Bear, 2009; Michell, 2005; Simpson, 2004).

Publishers target textbooks to province-wide or statewide mandated curricula. These teaching materials are generated for mass markets spanning regions and continents. Consequently, minority cultural representations of authentic place-based science are almost completely absent in bulk printing. For many Indigenous students, conventional science courses are seen as lifeless and mechanical, comprised of memorizing unconnected facts and formulas, taking tests and answering questions from the back of the book. The process has very little to do with their lives. Alienation from science, as it is conventionally taught, is widespread among Indigenous students, and to a considerable degree, amongst non-Indigenous students as well. This affects student performance as indicated by low test scores and limited participation in upper level high school science courses.

Curriculum that is culturally strong embeds a view consistent with a given culture and is relevant only to that culture because of its site-specific nature (Davison & Miller, 1998). Aboriginal students rarely, if ever, receive science instruction in their own language. Mason and Barba (1992) assert that bilingual students cannot create appropriate schema of concepts, models, and drawings that are presented in English. The use of culturally appropriate place-based content makes the curriculum relevant to the students' interests and provides a structure for the curriculum that systematically builds on the students' culturally embedded background knowledge.

BC Ministry of Education Science Curriculum

The newly revised science curriculum for British Columbia (2015) makes references to Aboriginal knowledge and worldviews, and encourages teachers to take a place-based approach to teaching and learning:

> The curriculum takes a place-based approach. Science will develop place-based knowledge about the areas in which they live, learning about and building on Aboriginal knowledge and other traditional knowledge areas.

The importance of home-place is a predominant theme in Aboriginal education, as the Aboriginal people interacted with the places in which they lived over millennia. The land is the basis of Aboriginal knowledge. A place-based approach encourages teachers and educators to incorporate local examples of traditional knowledge and wisdom, and to encourage collaboration with Elders and knowledge holders. In addition, the document acknowledges Traditional Ecological Knowledge (TEK) and includes a few examples of TEK in its prescribed learning outcomes, encouraging this type of side-by-side relationship.

There are some references to traditional foods, traditional plants and traditional stories. However, at present, there is little connection between the Ministry's "First Principles of Learning" statement and the required "big ideas" (knowledge statements) students are expected to learn. Teachers are given very little help to incorporate examples of Indigenous Science knowledge and processes into their teaching. For example, in relation to the Grade 5 unit on astronomy, teachers are encouraged to incorporate "local Aboriginal teachings and stories about the Sun and Moon," but are not provided any examples of local stories or how such stories might be used to teach science concepts. Curriculum for grades at the elementary, middle and secondary level include no mention of Aboriginal examples. Numerous potentially rich opportunities are missed, for example, the Grade 5 unit entitled "Simple Machines" includes no mention of Indigenous "simple machines," tools or technologies. The writers could have included the Nisga'a fish wheel; splitting cedar planks using wedges, crossbars and mauls; or raising massive house beams using a fulcrum, levers, inclined plane and manpower.

Overall, the representation of Indigenous Science trends to be piecemeal, often as isolated examples and not as a coherent whole. Consequently, the teacher has to work hard to find materials to supplement lessons. Success on most topics continues to rely on teacher creativity, resourcefulness and endurance.

While it is significant that teachers are given the mandate to incorporate TEK into the science program, TEK has often been presented as traditional or primitive, or in the past. Although much has changed over the past decade, a great deal more needs to be done to accurately and adequately present the culture, worldview and science of Indigenous peoples in ministry guides and curriculum resources. It is the responsibility of ministries of education and territorial governments to include a meaningful degree of Indigenous Science explicitly in the science curriculum K-12. Ministry documents and web sites should include ample information on Indigenous Science, information about Aboriginal worldviews, and teaching strategies that facilitate responsible cross-cultural science education. Without the necessary support and infrastructure such as adequate funding for curriculum development, resources and workshops, classroom teachers feel ill-equipped to carry out such a mandate.

The BC Ministry of Education web site states, "Eventually, once developed, rich examples of teaching and learning will be included in the web-site to show examples of relevant teaching units and place-based learning." Hopefully, with guidance from Elders and knowledge holders, these "rich examples of place-based learning" will incorporate numerous examples and cases of Indigenous Science, thus easing the transition from middle school, to secondary school and university for Aboriginal students. Academic success in science and mathematics is a critical first step in opening the doors to science careers. In order to open the doors of access to science careers for Aboriginal students, the difficulties at the school and district level must first be understood, addressed and continually attended to by the ministries of education and territorial governments. This must be a continual and active process of enabling all our children and future generations to understand more clearly the vitality and fundamental importance of Indigenous Science.

Science Textbooks and Publishers

There is a small but growing number of Canadian book publishers working to meet the demand for science textbooks with an Aboriginal voice. One of the publishers is McGraw-Hill Ryerson that published *BC Science Probe 6*, (Mason, et. al., 2005) and *BC Science Probe* 7 (Mason, et. al., 2004). The acknowledgements page credits many contributing Elders and knowledge holders who provided examples of TEK. Importantly, the Grade 7 textbook provides an overview of TEK, as follows:

> The spiritual connections among all living things, combined with the centuries of Aboriginals' experience and observation of their environments, means that vast bodies of knowledge about their environment have been gathered. Traditional Ecological Knowledge, as it is called today, is important to a full understanding of environments, species, and ecosystems. TEK is based on the following ideas:
>
> - Creator made all things one.
> - All things are alive, related, and interconnected.
> - All things are sacred and should be respected.
> - Balance and harmony are essential among all life forms. (p. xxi)

The section explains that TEK has contributed a great deal to the sciences in the Americas, and lists cotton, corn, chocolate, beans, squash, more than 3,000 species of potatoes, rubber, and many medicines that have found their way into the medicines we use today.

Both texts include photographs depicting examples of Aboriginal technologies: a dugout cedar canoe, a woman tanning a moose hide to make moccasins, a woman removing a strip of bark from a cedar tree to make cedar baskets, a birch bark canoe, a birch-bark basket, snowshoes, a woman using a drawknife to scrape a hide, an obsidian arrow head.

Textbook publishers need to be careful in the way that IS and technology is portrayed alongside WS and technology. In the Grade 6 text, the section on "Canadian Technologies" includes impressive photographs of robots used to design and test robots, Dexter (the robot), with arms that reach in different ways in action on the International Space Station and an astronaut attached to the Canadarm as he is moves towards the Hubble space telescope. The section on deep-sea exploration features a micro-submersible called Deepworker and a recent version of a revolutionary diving suit for deep-ocean exploration (the Newtsuit), both designed by Vancouver engineer Phil Nuytten. Information that is not included is that Nuytten is a world-renowned scientist of Aboriginal ancestry. A Métis raised in Vancouver, he apprenticed with Kwakiutl carvers from the age of 12, is a skilled carver, and has taken an active role in preserving the First Nations cultures along the northwest coast of BC. Most likely, this information was unknown to the writers, but the inclusion of a highly successful scientist and engineer of Aboriginal ancestry would have served as an important role model for young Indigenous students considering science related careers.

An important innovation in both texts is the "Ask an Elder" section that includes interviews with Elders and knowledge holders. For example, in the Grade 6 text, Barbara Wilson, a Haida Elder, is interviewed regarding her work as an expert in the conservation of nature and cultural resources on Gwaii Haanas. Wilson explains that if a scientist might be going into the National Park Reserve to do research on the land, "then a Haida goes along too. We both learn something. The Haida learn what we need to from the scientific world, and we also teach the scientists from the Haida perspective. It shows we can look after the land together" (p. 89). The inclusion of such Elder interviews is crucial because it helps to bring Indigenous Knowledge into a modern context.

Chapter 3 of the Grade 6 textbook devotes 29 pages to "classifying living things," of which over 28 pages explain the Linnaean system of classification which divides types of organisms into a series of increasingly specific categories, or levels of organization: *Kingdom*, *phyla*, *classes*, *orders*, *families*, *genera* (singular *genus*), and *species* (singular, also *species*). The section "Other classification Systems," which consists of less than half a page, explains how "different peoples of Canada have classification systems that are more detailed than scientific classification." For example, "the Nuu-chah-nulth people of the west coast of Vancouver Island use one classification for when this fish lives in the ocean and one for when it lives in fresh water" (p. 66). Additional and more in-depth examples of Indigenous classification systems and language terms would have illuminated an intimate knowledge of plants, animals, and environmental relationships.

Although the McGraw Hill-Ryerson publications fall short of the ideal science textbooks for both Indigenous and non-Indigenous students, the publisher took a giant step forward by involving Elders in the development and presentation of the text and by including information that explains interactions between Aboriginal people and the ecosystem in which they live, respecting the wisdom of Elders, and respecting other cultures.

While there has been progress made in creating Canadian textbooks that more accurately reflect IS and culture, those changes have involved very few publishers and provinces. Teachers continue to complain that: "You don't have individual units made up like you do for the regular science units. Resources are hard to find." There are some resources that look at Indigenous health and foods, traditional use of plants and traditional stories, but overall the teacher has to work hard to find materials to supplement lessons. While this is less of a problem in Indigenous communities, the demand for Elder visitations in the classroom, Elder-led fieldtrips, and hands-on experiential learning in mainstream schools increasingly stresses a dwindling population of Elders and knowledge keepers. Success on most topics continues to depend on teacher creativity, resourcefulness, and endurance.

Although some textbooks have included Indigenous examples, these continue to be presented as short items of interest and not cohesively. As Simpson (1999) describes, TEK has often been presented as primitive or of least importance, while WS and other contributions of western society are represented as industrialized, modern, and advanced. Many textbooks and ministry documents still contain language that privileges WS simply by what they leave out, that being terms such as "Indigenous Science" or "Native Science" and using terms such as "Indigenous Knowledge," "cultural knowledge," or "traditional technology." Textbooks need to be sensitive to the fact that language is a currency of prestige and power. One way for textbooks (and teachers) to reduce this power imbalance is to acknowledge that it exists, and to use terms such as "Indigenous Science" or Native Science" to promote greater equality with terms such as "Western Science," "Modern Science," or "Eurocentric Science."

These findings are similar to those of Michie (2005) who reviewed Australian science textbooks and concluded, “The representation of indigenous knowledge tends to be piecemeal, frequently inserted for its exotic nature (or to fill an editor’s whim to be inclusive), and often as an isolated illustration and not as a cohesive whole” (Michie, 2005, p. 2). Similarly, Ninnes (2000, 2001; Ninnes & Burnett, 2001), reviewed Canadian, Australian and New Zealand textbooks and identified three main issues: the masking of diversity within the Indigenous population, the representation of Indigenous people as “traditional,” and the location of indigeneity through past tense when describing Indigenous Knowledge.

The Collaborative Approach to Successful Implementation

The will to implement cross-cultural school science is being accomplished in several provinces in Canada, especially in the province of Saskatchewan. Beginning in 2005, the Ministry of Education embarked on an ambitious program to enhance the quality of school science for non-Indigenous students (Aikenhead & Elliott, 2010). A key element was piloting a draft curriculum in schools across the province, including First Nations band-schools and rural and urban schools with Aboriginal teachers. Indigenous Knowledge content was introduced in ways that relate to the required science topics at each grade. A separate committee was formed to examine how place-based Indigenous Science could be applied within the established school curriculum (Michell et al., (2008). The results informed a rewrite of the overview to Science 6-9, particularly the section on science, technology, society (STS), and the environment relationships. Indigenous groups were asked to find connections between a scientific topic and Indigenous Knowledge that could be associated with the pre-determined topics. In this way, the Indigenous people of Saskatchewan negotiated what Indigenous Knowledge would be appropriate for the renewed science curriculum, and this new content was included in Ministry documents (Aikenhead & Elliott, 2010, p. 16). As well, the *Pearson Saskatchewan Science* textbook series was developed to emphasize Indigenous perspectives and support cross-cultural science curricula (Aikenhead & Elliot, 2010). Clearly, transformation of schools does not happen on the initiative of teachers alone; it happens when teachers, curriculum developers, Elders, textbook companies and government work in partnership.

International Science Curriculum Innovations

The last two decades witnessed an international renaissance in which Indigenous cultures began to assert their human rights and sovereignty (McKinley, 2007; Niezen, 2007). In the realm of education, this movement has called for the inclusion of Indigenous Knowledge in science courses and curricula for all students. There are many examples where changes have been made and some are detailed below.

In the United States, some jurisdictions have placed Indigenous Knowledge in their science curricula. The Alaska Native Knowledge Network (ANKN, 1996) has produced an impressive set of cross-cultural teaching materials for Yupiaq students and beyond, whose standardized test scores uniformly improved over four years to match the US national average (Barnhardt et al., 2000). Units include: “Observing Snow,” “Village Science,” “Tools Project,” and “Birds Around the Village”; all units that can be easily integrated into the British Columbia science curriculum. Chinn (2007, 2008) used Hawaiian traditional knowledge as a foundation to develop an environmental literacy program for K-12 science curricula that met standards-based expectations. Importantly, when culturally responsive instruction included outdoor science instruction, rather than indoor instruction, standardized science test scores improved significantly for Indigenous students, and became on par with their non-Indigenous counterparts (Zwick & Miller, 1996).

In 1992, the Aotearoa, New Zealand science curriculum was translated into Māori and taught in designated schools (McKinley, 1996). A Māori version of their country's science curriculum was developed in 1992 and was implemented in a network of Māori bilingual and immersion classrooms in elementary and high school (Wood & Lewthwaite, 2008).

Australian national curriculum policies explicitly support including "Indigenous Science" in school science (Michie, 2002). The policies inspired collaboration between science educators and Indigenous family groups across Australia to produce a high school textbook *The Kormilda Science Project*. A second approach produced "Australian Indigenous Science" as chapter 1 in a junior secondary textbook *Science Edge* 3 (Sharwood & Khun, 2005).

In Africa, several studies and curriculum projects have integrated Indigenous Knowledge systems into school science programs. For example, in South Africa, Eurocentric science content was embedded in local cultures, and student interest and achievement increased (Jegede & Okebukoa, 1991; Pabale 2006). As a result, South Africa established the goal of teaching local African knowledge of nature in science classrooms (Keanne, 2008).

Canadian Science Curriculum Innovations

In Canada, a number of science-related curriculum projects recognize Indigenous ways of knowing nature to be foundational content in school science. In British Columbia, *Forests and Oceans for the Future* (Menzies, 2003) combined IK and WS by developing teaching materials that facilitate the sharing of knowledge and understanding of the issues, controversies, and concerns related to forestry and natural resources. The materials were inspired by the experiences of students and community members living in the Tsimshian territory. Additionally, the Saanich Indian Band School published the teachers' guide *Reef Net Technology of the Saltwater People* (1994), by Earl Claxton Senior and John Elliott Junior. This well-written curriculum covers sacred beliefs of the W̱SÁNEĆ (Saanich) people, the origin of the reef net, reef net technology, ceremonies, moons and tides, the arrival of the first immigrants, and breaking historical ties to the land.

Songwriter and singer Holly Arntzen has produced several curriculum handbooks and CDs focusing on west coast environments, with an emphasis on environmental education and Traditional Ecological Knowledge. The resources include: *Running from the Mountains CD* (1999), with lyrics describing First Peoples' view of the natural world; *Salish Sea: A Handbook for Educators K-7* (2000) includes lessons and lyrics based on the creation myth of the Cowichan Tribes; *Cycles of Life/Recycle Handbook: K-6* (2003) includes a story about the Haida tradition of taking reusable utensils to a feast and lyrics portraying how First Peoples survive the harsh Arctic ecosystem; *Shade of Our Trees CD* (2006) includes lyrics about the significance of the cedar in Aboriginal culture; and *The Watershed Song Education Handbook* (2016) includes lessons and lyrics calling for action to help protect habitats, waterways and ecosystems. Arntzen emphasizes the importance of wild salmon and waterways to First Peoples, incorporating a discussion of Aboriginal worldview. The CD *I Am the Future* (2010) includes First Nations place names, villages, rivers, and a holistic view of the world.

Oceans Network Canada, a major initiative of the University of Victoria, is actively building Ocean Sense education programs that embrace diversity of ocean sciences for Grades 6 – 12. Students discover the changes that are being witnessed in our ocean through underwater tools like cameras, hydrophones, water property sensing, and remote operated instruments. Ocean Sense aims to make ocean sciences more relevant to Aboriginal students by including place-based knowledge and by promoting cross-cultural learning for non-Aboriginal students alike. For example, outreach teams are introducing the latest community observation site on Nuu-chah-nulth territory.

Strong Nations Publishing, located in Nanaimo, BC, is considered to have one of the largest selections of Indigenous books on-line. Strong Nations specializes in First Nations, Inuit, and Métis stories and topics of interest. In 2012, they started their own publishing house with the launch of their first set of readers, *From the Mountains to the Sea*. Students are invited to come along on the journey of a river-ecosystem. Each title targets the Aboriginal Learning Standards in both science and social studies: in Kindergarten—*We Live Here*, Grade 1—*We Share the Seasons*, and Grade 2—*We are a Community*.

In Saskatchewan, the project *Rekindling Traditions* integrated Eurocentric science into the Indigenous Knowledge of northern Saskatchewan communities to produce six cross-cultural science units for Indigenous students in Grades 6-11 (Aikenhead, 2000, 2002). The units include: "Wild Rice," "Nature's Hidden Gifts," "Survival on the Land," "Trapping," "Snowshoes," and "The Night Sky." In addition, a major research effort at the University of Saskatchewan produced a comprehensive book *Bridging Cultures: Indigenous and Scientific Ways of Knowing Nature* (2011), by Glen Aikenhead and Herman Michell. The primary audience for this book is science teachers and Native Studies programs, ministries of education, and other policy makers facing the challenges of implementing Indigenous Knowledge into curriculum.

Saskatchewan-born singer Buffy Sainte-Marie sponsored the *Cradleboard Curriculum* as a means to develop teaching materials from a Native American perspective. The *Science Trough Native Eyes* (2002) CD series for school science addresses scientific concepts from within Native American culture. For example, the first CD addresses the scientific principles underlying sound, friction, and lodge construction. The "Principles of Sound" unit explores how instruments work. Students explore frequency, amplitude, decibels, and wave-lengths through interactive media, audio, text and animation. Students listen to Native American flutes, drums, rattles, mouth bows, and the Apache violin. A second series of CD ROMs is underway that will contain astronomy, botany, and ideas for careers in science for students of all ethnicities. Students are tested and automatically graded on-line.

In the Northwest Territories, *Inuuqatigiit: The Curriculum from the Inuit Perspective* (Northwest Territories Education, Culture and Employment, 1996) is the foundation document informing curriculum development for Inuit in the Northwest Territories and Nunavut. It advocates that in all subjects, including science, students should learn about Inuit history, knowledge and traditions, and practice Inuit values and beliefs in order to strengthen their education and enhance personal identity (Lewthwaite & McMillan, 2007).

In Ontario, the Native Access to Engineering Program at Concordia University was established in 1993 by the Faculty of Engineering and Computer Sciences to look at ways to address the low participation rate of Aboriginal people within the pure and applied sciences. This groundbreaking program offers science camps for Aboriginal youth and professional development and conferences for teachers that focus on how to encourage and support more youth into the sciences.

In Cape Breton, an initiative called "Integrative Science" is an integrated program involving Cape Breton University, a small group of people on the island of Cape Breton (Unama'ki) in northeastern Nova Scotia and the traditional territory of the Mi'kmaw Nation. The initiative is guided by the principle of "two-eyed seeing" offered by Elder Albert Marshall (Eskasoni Mi'kmaw First Nation) and refers to learning to see from one eye with the strength of Indigenous Knowledge and from the other eye with the strengths of Western knowledge. "Their co-learning journey is committed to using the best of Indigenous ways of knowing and the best of Western (or Eurocentric) ways of knowing to talk and walk together in an ethical, respectful, and productive manner … as per the millions of people around the world who desire healthier communities and a healthy Earth Mother" (Bartlett, et. al., in press, p. 2).

I have attempted to provide a window into the representation of IS in Canadian textbooks, curriculum resources and government documents. I haven't analyzed every textbook and there is a possibility that I have provided a somewhat incomplete data analysis for each territory and province. Although cross-cultural science education projects are increasing in numbers, they tend not to be widely publicized. Thankfully, many projects have websites and free downloadable resources. (See Appendix B: Selected Curriculum Websites).

Possibilities for Transforming the Science Curriculum

Clearly, most governmental jurisdictions across Canada fall seriously short in providing teachers with adequate examples of prescribed learning outcomes that integrate IS examples, procedures and teaching strategies for exploring a pluralistic view of science, and above all, a mandated requirement to teach IS in the classroom. It appears that, with the exception of Nunavut and Saskatchewan, jurisdictions have abdicated responsibility by leaving it up to individual school districts and locally-based curriculum projects to provide guidance and resources. Of concern is that Canada has yet to initiate a comprehensive Pan-Canadian Framework that mandates all provinces and territories to integrate proper representation of IS along with WS in government documents.

It would appear that the most inclusive curriculum resources that provide in-depth coverage of IS examples and philosophy are those that are funded in whole or in part by grants, foundations, universities and ministries or territorial governments. Unlike textbook publications which attempt to receive province-wide adoptions, these curriculum projects are largely free to include Elders in the development and presentation of materials, are place-based, and provide in-depth coverage from an Indigenous perspective. The challenge of designing teaching strategies and curriculum that enables students to understand scientific ideas and practices without destroying identity and religion is great, and the resolution may differ in different contexts and communities.

We have to expand all the programs that work to all public schools Canada-wide and to the 633 reserves across the country and look at new strategies. However, a culturally appropriate science curriculum is much more than building a curriculum around the local interests and culture of the learners. Such a local focus can become limited to the science the students want to study. While this local perspective is critical, such an approach can overlook the organization of scientific ideas and preclude the development and teaching of the general curriculum. Thus, an appropriate approach to curriculum focuses on mastery of a broad range of science content at specific grade levels, using examples from both IS and WS that are meaningful and relevant to the students.

Science textbooks need to provide examples of the contributions of Indigenous Science that enabled Aboriginal peoples to live in environments over long periods of time. Similarly, more needs to be done to present Indigenous Science in a modern context; for example, by showcasing Aboriginal engineers, biologist, geologists, environmentalists, or nurses, and by highlighting cases where IS and WS work together, such as combining the use of ancient Nisga'a fish wheel technology with modern satellite tracking and statistical methods to provide more accurate fish counts, thus enhancing salmon river returns (see Chapter 6). Examples from the history of Western Science can be used to illustrate how the purposes, theories, and methodologies of WS have changed. Teaching materials need to show the limitations of WS, as well as the limitations of IS. When these are omitted, the result is a distorted, romanticized view of WS, which further leaves the students without the necessary concepts and vocabulary for thinking about the complexities and contradictions that characterize science, technology, and society issues.

More needs to be done to understand the role of prior beliefs in concept formation, and to include information related to teaching strategies and the science related beliefs of Canadian Indigenous children in government curriculum documents and teacher guides for science textbooks and curriculum materials. If, for example, teachers understand that many Indigenous children bring to the science classroom ideas about classification that are different from the WS Linnaean system of classification, and that many of their ideas have important ecological implications, then the study of classification systems can have relevance for all students.

There is an urgent need for science curriculum writers to make themselves familiar with the vast body of science literature (papers, research reports and academic books) that provide excellent examples of TEK and IS. By incorporating well-chosen and descriptive examples of IS, curriculum development can become the meeting place of differing worldviews. In this way, future generations of children, who will be the recipients of the new curriculum, will have a broader and more encompassing understanding and knowledge of science, and of what the Indigenous community has to offer in terms of sustainable environments and communities.

Students reading science textbooks are confronted with an ocean of information, and the tide will constantly rise. Typically, reading science textbooks is a passive, individual activity, with simple experiments that the teacher may or may not do, and questions to answer at the end of the chapter. This makes it quite different from hearing Elders speak or listening to a legend or traditional story. Many science textbooks have failed to engage both Indigenous and non-Indigenous students because of the use of technical language and the lack of metaphors. The number of metaphors included in language arts and social studies textbooks is greater than in science books that tend to be literal examples of science achievement and history. Science, like all subject areas, is a way of telling a story; it is a process and structure of thought that is a natural part of human thinking. What is lacking in science textbooks is the use of sufficient metaphorical structures: visual images, metaphorical stories, and metaphorical analogies as bridges to meaning. In short, curriculum writers need to use creativity in presentation, drama, and personal insight in telling the stories of science.

Clearly, there is demand for more culturally responsive science textbooks and resources, and we expect that demand to grow. Including IS in a culturally responsive way can be particularly meaningful for Indigenous students because it engages them in ways that honour their identities, languages, cultures, and values. A co-existing strategy benefits science curricula and pedagogy not only for Indigenous students, but also for all students because it makes science more humanistic and explores the nature of science itself. While the transition to incorporating more IS content and pedagogy into government curriculum documents, science textbooks and curriculum resources might be difficult, the struggle to succeed is worth the effort. What can be more important in education than enabling teachers to nourish the minds and spirits of *all* children?

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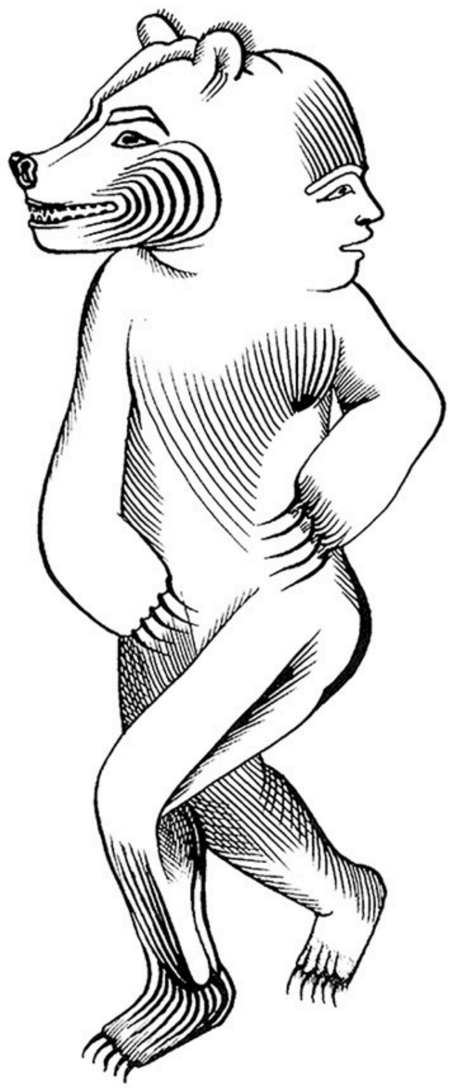
PART II
UNDERSTANDING AND ACKNOWLEDGING INDIGENOUS SCIENCE



"Untitled." Drawing by Laura Corsiglia. Reprinted with permission from (2001) Our Thang, p. 72. Victoria, BC: Ekstasis Editions. CC BY-NC

Chapter 6 - Indigenous Science: Proven, Practical and Timeless

Gloria Snively and John Corsiglia

Indigenous Science (IS) in this book refers to the science knowledge of all peoples who, as participants in culture, are affected by the worldview and interests of their home communities and homelands. Ogawa (1995) proposes that every culture has its own science and refers to the science of a given culture as its "indigenous science" (p. 585). Ogawa quotes Yamada (1970), a Japanese historian of Oriental science, who writes, "every culture and every society has its own science, and its function is sustaining its mother society and culture" (p. 585).

The traditional wisdom component of IS—the values and ways of decision-making relating to science knowledge—is particularly rich in time-tested approaches that foster sustainability and environmental integrity. Western Science (WS) is the most dominant science in the world today and is widely thought of as "officially sanctioned science." However, because WS has been implicated in many of the world's ecological disasters—pesticide contamination, introduced species, dams and water diversions that have impacted salmon and other indigenous species—it seems that reliance on Western Science alone can be seen as increasingly problematic and even counterproductive.

Cultural diversity suggests that Western Science and Indigenous Science should be viewed as co-existing or parallel. Westerners freely acknowledge the existence of Indigenous art, music, literature and drama, and of political and economic systems in Indigenous cultures, but many fail to apprehend and appreciate the concept of Indigenous Science. Thus, when Western Science is taught without acknowledging Indigenous Science, this can be construed as assimilative science education.

This chapter explores different versions of what science is, and what counts as scientific. It provides many examples from the Americas of Indigenous peoples' achievements in a broad range of science disciplines, and describes a rich and well-documented branch of Indigenous Science formally known to many biologists and ecologists as Traditional Ecological Knowledge (TEK). The stories and testimonies of Indigenous peoples provide educators with important information about Indigenous knowledge, wisdom and accomplishments that can be used to develop new innovative curriculum resources for science education.

We take the view that since Indigenous cultures have made significant achievements in a broad range of science disciplines, then surely there are different ways of arriving at legitimate science knowledge claims. Since IS generally incorporates wisdom and holistic values, it raises opportunities to consider the long-term costs and benefits of actions that may affect the environment. Not surprisingly, instances of IS can be found imbedded in numerous existing knowledge categories: Indigenous Knowledge (IK), TEK, and Traditional Ecological Knowledge and Wisdom (TEKW). Without knowledge, there can be no science. Thus, the definition of science should be broadened to include IS as science. The intention of this chapter is to identify a vast body of Indigenous Science and science literature drawn from cultures other than Eurocentric western society that provides great potential for enhancing our ability to develop more relevant science education programs with which *all* students can identify.

Terminology: Indigenous Science, Western Science and Traditional Ecological Knowledge

In education literature there are numerous descriptions of what science is, and of what counts as scientific. The Latin root, *scientia*, means knowledge in the broadest sense. The standard account of science can be called "Western," given its historic origins in ancient Greek and European cultures. Terms such as "Western Science," "Modern Western Science," "Standard Science," and "Official Science" have been in use only since the beginning of the 20th century. Western scientific theorizing began toward the end of the 19th century, when scientists began to grapple with abstract theoretical propositions—for example, evolution, natural selection, and the kinetic-molecular theory. What confidence would one have in theoretical statements built from or based on unobservable data? Care was taken to develop logically consistent rules outlining how theoretical statements can be derived from observational statements. The intent was to create a single set of rules to guide the practice of theory justification (Duschl, 1994). Following accepted scientific definitions, science educators defined WS as people's attempt to search out, describe, and explain in natural terms generalizable patterns of events in the world (Good, Shymansky, & Yore, 1999). Yore (2008), further describes the process of scientific inquiry:

> The search is driven by inquiry, limited by human abilities and technology, and guided by hypotheses, observation, measurements, plausible reasoning and creativity, and accepted procedures that try to limit the potential influences of non-target variables by utilizing controls. (p. 11)

Educators in the west popularly like to say that scientific theorizing began towards the end of the 19th century, but the history of science and technology is both long and rich. In antiquity, independent of Greek philosophers and other civilizations such as those of Egypt, India, and Iran, the Chinese made significant advances in science, technology, mathematics, and astronomy. Among the earliest inventions were the abacus, shadow clock, hot air balloon, fireworks, iron casting, and the first flying machines such as kites. The four great inventions of ancient China—the compass, gunpowder, papermaking, and printing—were among the most important technological advances only known in Europe at the end of the Middle Ages.

In sharp contrast to the exclusivist definitions of science made by Yore (2008) and others, Ogawa (1995) defines science rather simply and inclusively as "a rational perceiving of reality," where "perceiving means both the action constructing reality and the construct of reality" (p. 588). The word "perceiving" gives science a "dynamic nature," and acknowledges "science can experience a gradual change at any time" (p. 588). Ogawa further contends that "rational" should be seen in relativist terms.

Cajete (1999), a Tewa educator and scholar, defines Indigenous Science as:

> a broad category that includes everything from metaphysics to philosophy to various practical technologies practiced by Indigenous peoples past and present … [and, like western science] has models which are highly contextual to tribal experiences, representational and focused on higher order thinking and understanding. (p. 81)

Cajete contends that IS includes exploration of basic questions, such as the nature of language, thought and perception, the nature of time, human feeling and knowing, interconnectedness and proper relationships to the cosmos. It is a philosophy that gives rise to a diversity of technologies such as hunting, fishing, plant cultivation, navigation, architecture, art, and healing. Hatcher, Marshall, and Marshall (2009, p. 15) describe IS metaphorically as a "living knowledge" that requires less dependence on knowledge transfer from books and requires "knowledge gardening with living knowledge keepers," which differs from WS.

The process of generating or learning Indigenous ways of living in nature is *coming to know* (Cajete, 2000; Peat, 1994), a phrase that connotes a journey. *Coming to know* differs from a Eurocentric science process *to know* or *to discover* that connotes a destination, such as a patent or published record of discovery. Indigenous *coming to know* is a journey toward wisdom or a journey of wisdom in action, not a discovery of knowledge (Aikenhead & Ogawa, 2007). For Michell (2005), *coming to know* includes the goal of living in harmony with nature for the survival of the community. "Nature provides a blueprint of how to live well and all that is necessary to sustain life" (Michell, 2005, p. 39).

We extend our discussion of terminology to include Traditional Ecological Knowledge (TEK), described by many scientists as a sub-section of Indigenous Knowledge or Indigenous Science. The term is in flux, and some authors use the term interchangeably with IS or IK. TEK combines current observation with wisdom, knowledge and experience that has been acquired over thousands of years of direct human contact with specific environments. A leading Canadian researcher in this field, Fikret Berkes (2012), defines TEK as:

> … a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment. (p. 7)

McGregor, an Anishnabe scholar, goes further and defines TEK as "more than a body of knowledge … TEK also encompasses such aspects as spiritual experience and relationships with the land." It is a "way of life, rather than being just the knowledge of *how* to live, it is the actual *living* of that life" (2004, p. 78).

TEK interprets how the world works from the cultural perspective unique to a particular group of Indigenous peoples. Although the term TEK came into widespread use in the 1980's, TEK itself is timeless and predates written record (Corsiglia & Snively, 1997). The stories and testimonies of Indigenous peoples are usually related to a home place or territory. TEK embodies both remembered sensory information built upon repeated observation, and formal understandings that are usually transmitted orally in story form or ceremonial form with abstract principles and important information encapsulated in metaphor (Cruikshank, 1991; Turner, Ignace, & Ignace, 2000). Perhaps the most useful way to think about Indigenous Science is that it is complementary to Western Science and not a replacement for it. Rooted in different worldviews, Indigenous and Western Science are not easy to combine, and it may not be desirable to meld the two. Each knowledge system is legitimate in its own right. The two kinds of knowledge may be pursued separately but in parallel, enriching one another as needed (Berkes, 2012).

Thus, approaches to science seem to have proceeded along two fundamentally different courses: a) by the timeless procedure of relying on observation and experiment, and b) during the past two centuries through the theoretical examination of queries and assertions. We agree with Ogawa (1989) that "every culture has its own science … something like its own way of thinking and/or its own worldview" and that Western Science is only one form of science among the sciences of the world.

Because the labels "Indigenous Science" and "Western Science" often obscure the great richness and diversity found within each knowledge system, they can unfortunately lead to misunderstanding and stereotyping. The labels also mask important similarities. For example, both knowledge systems were developed from culture-based ways of experiencing and making sense of nature, and each knowledge system in its own cultural way relies on empirical data, observation, curiosity, experimental procedures, rationality, intuition, predictability and knowing of cause and effect relationships.

We agree with Vickers (2007), that Indigenous people have guiding principles that are passed down through the generations to assist humans in their relationship with each other, with animals, the land and water, and the supernatural world. As Vickers (2007) states, with respect to Western thinking, "Our method of relating to the land and the sea is 'scientific'. The missing component in the teaching of science today is an intimate connection to the 'subject' that benefits the well being of the community" (p. 592). These principles will not only assist us to restore individual and collective balance, they will also assist the school system to deliver knowledge in a respectful way.

While we recognize the rich and important literature of TEK examples compiled by working scientists, we also acknowledge McGregor's (2000, 2005) concerns regarding the power imbalance used by some scientists to enforce a Western cultural bias that controls decision making over local land, resource and animal issues. This issue of power associated with knowledge imbalance is often enacted outside the academy, that is, in the real world of economic progress, corporate profits, and political ideologies.

Although we agree with the above concerns related to how TEK is defined and enacted, for the purpose of this book, we believe that what counts is not so much the label, but more the content, intent, and practice, whether or not the information is correct and was obtained with permission, and that the information and ways of knowing be respected. We believe it is critical that educators become sufficiently familiar with ways to access the rich body of TEK knowledge compiled and indexed by Indigenous scholars and working scientists, many of whom have spent a lifetime respectfully learning from the Elders. Elders and knowledge holders are not always accessible and their numbers are dwindling. Teachers, Elders, curriculum developers and Ministry of Education officials may need to be able to locate and access sources of TEK and IS literature in order to introduce the world of Indigenous Science to all children in the science classroom. Increasingly, educators can access critical Indigenous concepts and information through literacy and digital storage translations, thus adding ancestral knowledge and wisdom to our understanding of how to live in harmony with Mother Earth.

The Wisdom Aspect of Indigenous Science

Traditional wisdom may be thought of as an aspect of IS that focuses on balancing human needs with environmental requirements. As Corsiglia and Snively (1997) note:

> Traditional wisdom usually begins with an understanding that spiritual essence infuses and defines all forms, and that all life forms must be respected as conscious, intrinsically invaluable, and interdependent. Respecting an animal's body means honouring its spirit and using every part of an animal's body. In practical terms, traditional wisdom extends the caring relationships associated with "family" life to communities and even to the environment. We are all related, it is wrong to exploit other life forms or take more than one's share. The deep interest our children feel in animals, plants, water, and earth should be trusted and encouraged. All creatures can be our teachers and while humans may readily affect other life forms, we need not see ourselves as superior. (p. 29)

The proper forms of human conduct are set out in an elaborate code of rules. Deference is shown for everything in the environment, through gestures of etiquette and thanks, and by avoiding excessive use in the Nuu-chah-nulth culture (Atleo, 2004). Among the Nisga'a, for example, wolves and bears may be considered superior life forms because they "do not need to talk to communicate" (Harold Wright, personal communication, 1977). All life forms are conscious. Among the Kwakwa̱ka̱'wakw, when the first salmon (coho) were caught by trolling, the fisherman's wife met her husband's canoe at the beach and said a prayer of welcome to the fish. Even today, some families continue to say a prayer to the first fish caught, while others honour the first fish by pulling their seine boat into a cove and enjoying a special family meal (Gilbert Cook, personal communication, July, 2001). Harmony can be preserved through respect, justice, and diligence. Wealth achieved without the respect for sustaining harmony or sharing simply indicates greed and selfishness. The truth of situations will always become known. As the Elders have often said, "there are no secrets" (Deanna Nyce, personal communication, 1989). Thus, IS can be thought of as the joining of the technical aspects of traditional knowledge with the values and ethics of traditional wisdom.

In a backlash against excessive claims for the ecological wisdom of Indigenous peoples, some researchers point out examples of tribal people and ancient societies who did overexploit local resources (Smith & Wishnie, 2000). However, some ecologists, notably Dasmann (1988) have pointed out that a distinction must be made between invaders and natives. When humans invade a new and unfamiliar ecosystem, their impact on the environment may be substantial initially. As Nisga'a chief Eli Gosnell related to John Corsiglia (1979), "When are the white people going to start behaving as if they live here?"

This initial relationship may change as the people develop a knowledge base, learn from their mistakes, and realize the limits of their new environment. Long-settled natives tend to co-evolve with their environment, and they often achieve a level of symbiosis with their environment (Berkes, 2012; Dasmann, 1988; Corsiglia & Snively, 1997). On the whole, this chapter takes the view that long-resident Indigenous peoples generally developed a relationship with their land and animals involving sophisticated systems of resource stewardship and respect.

Indigenous Science in the Americas

Numerous traditional peoples' scientific and technological contributions have been incorporated in modern applied sciences such as ecology, biology, medicine, architecture, engineering, geology, pharmacology, agriculture, horticulture, agronomy, metallurgy, navigation, astronomy, animal husbandry, fish and wildlife management, nautical science, plant breeding, and military and political science (Berkes, 2012; Turner & Peacock, 2005; Deur & Turner, 2005; Turner, 2014a, 2014b; Weatherford, 1988, 1991).

The ethno-pharmacological literature and anecdotal traditional knowledge reveals that many Indigenous peoples have a vast knowledge of the medicinal qualities of plants. Traditional American healers discovered and used quinine, Echinacea, Aspirin® (A.S.A) and Ipecac® (a drug still used in traumatic medicine to expel stomach contents), as well as some 500 other important drugs (Weatherford, 1988, 1991; Cajete, 2000). Studies have shown that the Mayans targeted specific illnesses using plant compounds that have now been corroborated using laboratory tests, for example, that plant species used to target gastrointestinal ailments actively do treat the symptoms (Berlin, et. al, 1996). In fact, "over 70% of all western drugs have come from isolating the active ingredients in plants and animals that the world's Indigenous people had already been using for medicinal purposes for centuries [prior to contact]" (Ross, 1966, p. 63). "Obviously," according to Berlin et al. (1996, p. 348), "experimentation is not exclusive to western science."

In the Americas alone, traditional knowledge and wisdom systems sustained populations estimated to be as high as 100 million (Wright, 1992), one-fifth of the world's population at the time of contact in 1492. To feed and clothe an expanding population, Meso-Americans developed some 3,000 varieties of potatoes (suited to different soil types, elevations, and climatic conditions), as well as squashes and pumpkins, yams, tapioca (cassava), vanilla extract, chili peppers, corn, sunflowers, tomatoes, quinoa, amaranth, wild rice, Jerusalem artichokes, avocados, peanuts, chocolate, strawberries, blueberries, papaya, pineapples, maple sugar and maple syrup, tobacco, cotton, and several varieties of beans (Cajete, 2000; Weatherford, 1988, 1991). Meso-American mathematicians and astronomers used base 20 numeracy to calculate calendars more accurate than those used by Europeans at the time of contact, even after the Gregorian correction (Kidwell, 1991). In the past four centuries, western Europeans appropriated and improved vast quantities of agricultural and medicinal products indigenous to the Americas, but this transfer of knowledge has largely gone unrecognized.

Weatherford (1988) describes how the Indigenous peoples of the Andes had been cultivating the potato in their mountain slope gardens for at least 4000 years. “Even before the Incas, these natives produced high yields of potatoes from small plots of land, and they developed different kinds of potatoes for every type of soil, sun, elevation and moisture condition. Colors ranged from whites and yellows through purples, reds and browns” (Cajete, 2000, p. 135). The date of the introduction of potatoes into Ireland is unknown, but according to Cajete (2000) they were a field crop before 1663.

According to Weatherford (1988), Andean farmers invented the first freeze-dry method of preserving potatoes by putting the potatoes out to freeze at night. The sun thawed out the potatoes and the farmers squeezed out the excess moisture, repeating this process several times. The result was a white chunk of potato the texture of Styrofoam. The Incas could easily store large quantities of dried potatoes for five or six years. Cooking the potatoes required soaking them in water, and the preserved chunks could be used in soups and other dishes (Weatherford, 1988).

Corn, a member of the grass family, was first domesticated about 9000 years ago from a wild grain by the Mayan Indians in south central Mexico. The first corn was a loose-podded variety that looked like the seed head at the top of wheat stalks. Historians believe the crop spread throughout Meso-America by 2500 BC. Central and South American peoples came to depend so heavily on corn that they devised some of the earliest calendars just to keep track of their corn planting and harvesting schedules (Dolores, 2011).

As a truly cultivated plant over thousands of years, corn cannot be propagated using other plant parts, can only propagate by its seeds, requires tending, and cannot survive in the wild. Unlike wheat and rice which have obvious relatives, the precise origin of corn remained a mystery to Euro-Americans ever since they first observed the plant in the new world in the late 14th century. We now know from DNA typing that corn was domesticated in southern Mexico from grasses as early as 9000 to 10,000 years ago. Teosinte is the common name for a family of grass plants that grow taller and have broader-leaves than most other grasses. Ancient farmers noticed that some teosinte plants were larger than others or had more kernels, or some kernels may have tasted better or were easier to grind. The farmers saved kernels from plants with desirable characteristics and planted them for the next season’s harvest, a process know as selective breeding (Carroll, 2010). Before they were domesticated, corn plants only grew small—25 mm (1 inch) corncobs and only one per plant. Many centuries of breeding and domestication resulted in the development of plants capable of growing several cobs per plant that were several centimeters long (Vigouroux & Marsuoka, 2013). The Spaniards called it maize. In the late 15th and early 16th century European explorers and traders carried maize back to Europe. Maize spread quickly to the rest of the world because of its food value and its ability to grow in diverse climates and soils. Today, more maize is produced annually worldwide than any other grain (Dolores, 2011).

Indigenous practices of planting some crops were superior in comparison to European techniques of sowing seeds. Indigenous farmers learned that planting individual seeds for particular qualities, rather than strewing handfuls of seeds on the ground, enabled them to control the genetic diversity of their crops, resulting in a large variety of staple crops. “They thus became masters of plant hybridization long before the nineteenth-century botanical researchers George Mendel and Luther Burbank demonstrated the technique to the rest of the world” (Landon, 1993, p. 9).

Centuries before the arrival of Columbus, people of Meso-America and the Amazon Valley created stone ball courts and played games with rubber balls. Spanish conquistadors were astonished when they saw the remarkable way the rubber balls bounced. By treating the sap of several kinds of rubber, the Indigenous Americans developed a range of articles including waterproof bags and the original gumboots (Walker, 1943, cited in Cajete, 2000, p. 137). Traditional scientists were the first to discoverer the use of rubber, vulcanizing, the use of asphalt for waterproofing plank-hulled boats, petroleum jelly and also platinum metallurgy (Weatherford, 1988, 1991).

The Yup’ik people of southwest Alaska have an extensive technology for surviving the harsh conditions of the tundra. According to Kawagley and Norris-Tull (1995), “Their technology could not have been developed without extensive scientific study of the flow of currents in the rivers, the ebb and flow of tides in the bay, and the feeding, sleeping, and migratory habits of fish, mammals, and birds” (p. 2):

> Yupiaq people have an extensive knowledge of navigation on open-seas, rivers, and over snow-covered tundra. They have their own terminology for constellations and have an understanding of seasonal positioning of constellations. They have developed a large body of knowledge about climatic changes—knowledge about temperature changes, the behavior of ice and snow, the meanings of different cloud formations, the significance of changes in wind directions and speed, and knowledge of pressure. This knowledge has been crucial to survival and was essential for the development of the technological devices used in the past [and many still used today] for hunting and fishing. (p. 2)

The truth is, directly or indirectly, we are all benefiting from Indigenous scientific and technological innovations every time we dine, clothe ourselves, travel or go to the doctor.

Combining Traditional Ecological Knowledge and Western Science

TEK provides invaluable time-tested resource management practices that can be used alongside WS to develop more workable and effective approaches to current resource management strategies than either could accomplish alone. In fact, it has become a policy requirement in Canada, and in particular Northern Canada, that TEK be incorporated into environmental assessments affecting wildlife management including: migratory birds, species at risk, forest practices, and fisheries management (Usher, 2000). The authors can only report on one project, as an example, in some detail.

The Nisga'a people of northern British Columbia live in the Nass Valley near Alaska. Every spring, members of some Nisga'a families still walk their salmon streams to ensure that spawning channels are clear of debris and that salmon are not obstructed in their ascent to spawning grounds. Concerned with the multiple perils faced by their Nass River salmon, the Nisga'a have themselves implemented a salmon protection project that uses both the ancient technology and wisdom practices, as well as modern statistical methods of data analysis to provide more reliable fish counts than electronic tracking systems (Figure 6.1). The Nisga'a project, which earned a Department of Fisheries and Oceans Canada award, is described in the following account by Corsiglia and Snively (1997):

> Observing that electronic fish counters can be inaccurate, the Nisga'a have instituted an ingenious fish counting system in the Nass River that combines ancient fish wheel technology with modern statistical methods. The ancient fish wheel was made of cedar wood and nettle fibre mesh, and the elongated axle of the fish wheel was fitted with three parallel vanes constructed in the form of large, flattened dip nets. The swift moving downstream current turned the wheel by exerting force against the submerged vanes, and as the companion vanes rose in turn, they gently caught and uplifted the fish as they swam upriver. As each vane rose from the horizontal, the fish slid toward wooden baffles that guided them out of the side of the fish wheel and into submerged holding baskets. This technology provided the Nisga'a with an effortless fishing technique as well as a ready supply of fresh salmon. (p. 19)

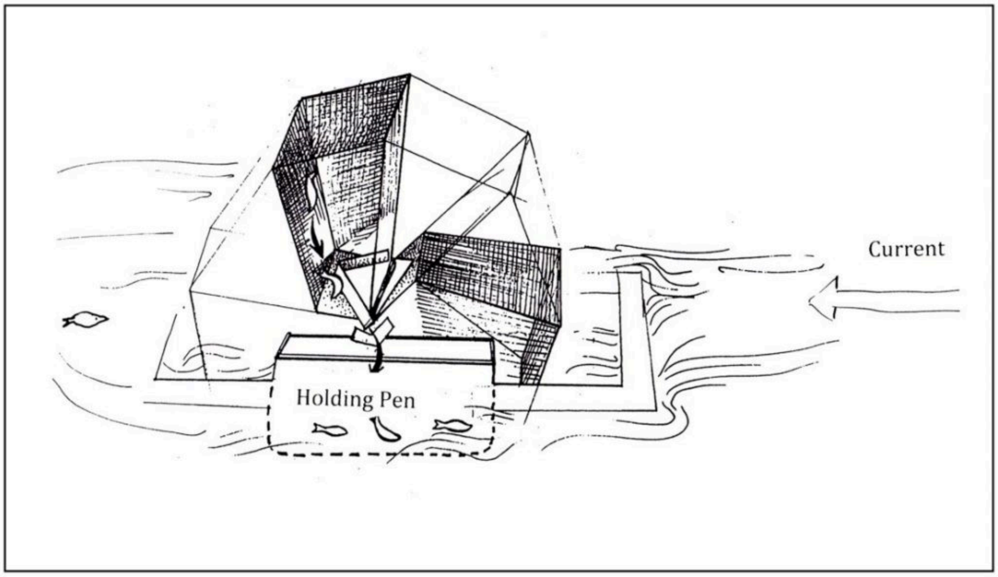


Figure 6.1 ▲ *Nisga'a fish wheel showing holding pen. Illustration by Laura Corsiglia (1997).*

Modern Nisga'a fishing wheels are made of aircraft aluminum and nylon mesh. Like their predecessors, these fish wheels allow fish to be captured live and held in holding tanks. This enables the Nisga'a to tag and count the fish by means of statistical analysis. Returning salmon are first caught using a fish wheel at a lower river station where fish are tagged. Fish are also caught at an upper fish station where the proportion of tagged fish is used to calculate returns. Reportedly, "this system provides more accurate and reliable data than that collected by electronic tracking systems alone" (Chief Harry Nyce, personal communication to John Corsiglia, 1986).

Contributions of Traditional Ecological Knowledge and Indigenous Knowledge Scholarship

Some of the contributions of TEK and IK scholarship to contemporary environmental knowledge, conservation and resource management worldwide (acknowledged by Western scientists) are outlined below:

- Perceptive investigations of traditional environmental knowledge systems provide important biological and ecological insights (Berkes 2012; Houde, 2007; Turner & Peacock, 2005; Turner, 2014a, 2014b; Usher, 2000; Warren, 1997).
- TEK and IK can help locate rare and endangered species and provide cost effective shortcuts for investigating the local resource bases. Local knowledge makes it possible to survey and map in a few days what would otherwise take months, for example, soil types, plant and animal species, migration pathways, and aggregation sites (Berkes, 2012; Usher, 2000; Warren, 1997).
- TEK and IK provide knowledge of time-tested resource management practices, and can be used to develop workable approaches to current resource management strategies (Houde, 2007; Turner & Peacock, 2005; Usher, 2000; Warren, et. al., 1993).
- Provides time-tested in-depth knowledge of the local area (past and present) that can be triangulated with WS resulting in more accurate environmental assessment and impact statements. People who depend on local

resources for their livelihood are often able to assess the true costs and benefits of development better than any evaluator from outside (Houde, 2007; Warren, et. al, 1993; 1997).
- Provides experienced based value statements about appropriate and ethical behavior with respect to animals and the environment (Berkes, 2012; Deur & Turner, 2005; Turner, 2014a, 2014b; Houde, 2007; Usher, 2000).

A key point here is that scientists who do much of their work in laboratories may be unable to understand the complexity of ecosystems, especially northern or distant ecosystems, through sporadic observations, as opposed to lived experience.

Recognition of the importance of incorporating IS and TEK in environmental planning is explicitly addressed in reports and agreements in Canada and internationally. The Brundtland Commission report, *Our Common Future* (WCED: World Commission on Environment and Development, 1987), recognized the role of TEK in sustainable development; and the *Convention on Biological Diversity, Agenda 21* (UN Conference on the Environment, 1993), declared that Indigenous people possess important traditional scientific knowledge. The document *Science for the Twenty-first Century*: A *new Commitment* (UNESCO: United Nations Educational, Scientific and Cultural Organization, 2000), set new standards for respecting, protecting and utilizing Indigenous Knowledge. Working scientists worldwide, associated with hundreds of institutes, are collaborating with Elders and knowledge holders to collect and document examples of TEK and IS knowledge; this includes institutes in the US, Canada, Middle and South America, Africa, Europe, Australia, New Zealand, India, Russia, China and Japan.

Towards Acknowledging Indigenous Science

There are a number of issues that make it difficult for scientists to acknowledge IS. Many scientists view IS as useful, but outside the realm of Eurocentric science. Of the debates which inhibit acknowledging IS and TEK as of the realm of science, two will be briefly articulated here: 1) the portrayal of Indigenous cultures as unscientific because they lack the benefit of Western scientific methodology and empirical observation; and 2) problems associated with recognizing traditional knowledge and wisdom as science because it respects and values all forms of life (its spiritual essence).

Indigenous Science as Science

Many educated people today believe that Indigenous cultures are unscientific because they are based on magical or spiritual beliefs and/or because they lack the benefit of the Western scientific method of empirical observation and experiment. Technology is not considered an applied science but rather people's attempt to address or alleviate issues of human need by adapting to the environment utilizing design and trial and error approaches (Yore, Hand, & Florence, 2004). The argument against acknowledging the legitimacy of IS as outlined by Yore (2008), is as follows:

> History of technology has examples of inventors producing innovations in advance of the scientific explanation. Frequently, the debates about science have not kept the differences between science and technology clear and, by doing so; confound the issues regarding the need for western science to move toward explanation utilizing physical causality rather than magic, mysticism, and spiritualism. (p. 13)

Thus, by defining both science and technology narrowly, and from a western worldview, all Indigenous innovations described in this paper would fall outside the realm of science because they are technologies that lack explanatory power utilizing physical causality. The argument for acknowledging the legitimacy of IS is best summarized by Cajete (1999):

> Whether there exists an Indigenous science in western terms is largely an incestuous argument of semantic definitions. Using western science orientations to measure the credence of non-western ways of knowing and being in the world has been applied historically to deny the reality of Indigenous people. The fact is that Indigenous people are, they exist and do not need an external measure to validate their existence in the world. Attempts to define Indigenous science, which is by its nature alive, dynamic, and ever changing through generations, fall short, as this science is a high-context inclusive system of knowledge. (pp. 81-82)

Central to the issue of the authenticity of IS is the controversial question of the existence of curiosity-driven inquiry among Indigenous peoples. Clearly, according to Berkes, "there is a great deal of evidence that Indigenous people do possess scientific curiosity, and that traditional knowledge does not merely encompass matters of immediate practical interest" (Berkes, 2012, p. 10).

Reconciling the Spiritual Base of Indigenous Science and Traditional Ecological Knowledge

One important point of difference between IS and WS is that Indigenous Knowledge systems include spiritual dimensions (beliefs) that may not make sense to scientists or fall outside the realm of WS. Academics and Western trained researchers generally view TEK as a "body of knowledge," but for Indigenous people, TEK (and IK) is a way of life and is an inextricable combination of knowledge practice and belief, as per the definition by Berkes (2012).

Respect is the fundamental law of Indigenous peoples. This basic tenant was described in the context of the Gitksan and Wit'suwit'en claims to their ancestral homelands by hereditary tribal Chief Delgamuukw to the BC Supreme Court in 1987, as follows:

> …for us, the ownership of territory is a marriage of the Chief and the land. Each Chief has an ancestor who encountered and acknowledged the life of the land. From such encounters come power. The land, the plants, the animals and the people all have spirit—they must be shown respect. That is the basis of our law. (Tyler, 1993, p. 225)

For some, the word "spiritual" is associated with religion or Christianity or some analog thereof. But for many people, spirituality means life with consciousness. Thus, the land, the plants and animals, and people all have their own spirit, integrity, and substance; they must be respected. By extension, spiritual stewardship of resources represents more than securing an economic commodity in order to earn a benefit. Spiritual stewardship represents a way of life, a vital process of socialization, moral education, respect for all forms of life, and responsibilities.

Gitksan and Wit'suwit'en worldviews, as with Indigenous worldviews generally, evolved without Aristotelian logic and Cartesian thinking, which have played a major role in shaping the value systems and conceptual frameworks of Western society. Gitksan and Wit'suwit'en cosmology does not exhibit the Cartesian division between mind (or spirit) and matter. As a consequence, "there is no conceptual separation between the spiritual and natural world, which makes their cultural worldview conceptually and symbolically different from Western thinking" (Tyler, 1993, p. 227).

Importantly, what many opponents of IK and TEK fail to recognize is that spiritual explanations contained in myths and stories often incorporate important ecology, conservation, and sustainable development strategies across the generations (Atleo, 2004; Berkes, 2012; Johnson, 1992). In reference to TEK, Johnson and Ruttan (1991) point out:

> Spiritual explanations often conceal functional ecological and conservation strategies. Further, the spiritual aspect does not necessarily detract from the aboriginal harvester's ability to make appropriate decisions about the wise use of resources. It merely indicates that the system exists within an entirely different cultural experience and set of values, one that points no more and no less valid a picture of reality then the one that provides its own (western) frame of reference. (as cited in Johnson, 1992, p. 13).

Furthermore, the spiritual explanation of TEK is a fundamental component and must be promoted if the knowledge system is to survive (Cruikshank, 1991; Johnson, 1992; Turner, 2005). Criticism of the validity and utility of IS and TEK misapprehend the structure of Indigenous oral information systems. "These systems simply do not assert that mythical-magical forces cause and control nature. Indigenous peoples observe, interpret and orally report nature exhaustively. Rather than writing about their findings, they may use metaphorical stories to compress and organize information so that it can be readily stored and accessed" (Snively & Corsiglia, 2001, p. 23).

Conclusion

In these days of worldwide social, political, and environmental stress, we are all affected by problems associated with resource depletion, increasing human population, climate change, and environmental disaster. Only recently have Western scientists begun to wrestle with approaches that promise to improve our ability to mitigate the impact of human society upon the planet. The world's educators must recognize the paramount importance of the ecological crisis. Our challenge is not so much to seek ever more sophisticated technological solutions to environmental problems, as it is to re-establish a moral, emotional, and perhaps sacred, relationship with the biosphere.

The addition of IS examples into the science classroom allows it to be more widely recognized and respected for its validity and usefulness, adding interest and authenticity to the study of science. What is wrong with Nisga'a, Kwakwa̱ka̱'wakw, Lil'wat and Coast Salish children learning about the science of their own cultures in the science classroom, and why shouldn't all children learn about the science of many cultures? Unless IS is given sufficient recognition in the science classroom, and unless Nisga'a families continue to walk the streambeds each spring, invaluable IS and TEK may be lost forever.

Indigenous Science not only existed in the past, but in numerous cases, it exists today. For many science educators the first step is simply recognition of the validity of IS within the realm of science, and its importance in the science classroom. It is our hope that teachers will introduce both IS and WS as different but complementary ways of understanding the world to all students in the science classroom. Discussion should stress similarities rather than differences, and explore practical possibilities for combining the Indigenous and western frameworks in understanding nature and solving science, technology and environmentally related problems.

DISCUSSION POINTS

- Before reading this chapter, respond in writing to the question: "What is science?" Then share the definition with a neighbour and then share definitions with the larger group.
- Debate the proposition: Scientific theorizing began toward the end of the nineteenth century when scientists began to grapple with abstract theoretical propositions. Hence, "real science" is an exclusive invention of Europeans in the late 19th century.
- In a small group, brainstorm the following:
    - How the Indigenous peoples of Meso-America discovered medicinal uses of aloe vera and quinine.
    - How the Tainos of Meso-America developed corn.
    - How Andean farmers invented the first freeze-dried potato.
    - How Meso-American farmers developed 3,000 varieties of potato.
- Proponents of WS argue that "real science" is testable, evidence based, has explanatory power, and is determined by consensus. When Indigenous peoples of the Northwest coast increased the production of edible root gardens by building rock terraces in the low intertidal zones, was their innovation the result of trial and error only, or can it be included in the realm of "real science?" Discuss.
- On average, 1 bushel of corn is required to produce 3 gallons of gasoline. In 2007, the global price of corn doubled as a result of an explosion in ethanol production. Research the unintended effects of ethanol production on world food production, world economies, environmental impacts, and the Indigenous people of Africa and the Americas.

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Chapter 7 - A Window into the Indigenous Science of Some Indigenous Peoples of Northwestern North America

Gloria Snively and John Corsiglia

The Indigenous peoples who live in Northwestern North America, specifically those who live in present day British Columbia and in southwest Alaska and Yukon Territory adjacent to British Columbia, eastward to the Rocky Mountains and southward to the Columbia River, inhabit a region with a remarkable wealth of natural resources. The northwest coast is home for a variety of land and sea mammals as well as an abundance of edible intertidal invertebrates (clams, mussels, crabs, shrimp, snails, chitons, sea cucumbers, and sea urchins) and seaweeds. Great flocks of waterfowl and teeming hordes of fish migrate from the ocean up rivers and streams to interior lakes. Deer, elk, moose, caribou, mountain goat, black bears, grizzly bears, as well as numerous smaller mammals found shelter and abundant food among the mountains or in coastal and interior forests. However, these riches of nature are not always abundant year-round or entirely free for the taking. Some of them, on the contrary, are exceptionally difficult to access or capture.

It was Indigenous Science and technology, plus the knowledge of its application, that provided the vital means for ensuring a reliable food supply year round, as well as a sustainable range of resources in the area. These techniques and wisdom practices did not suddenly spring into being. They developed slowly and painstakingly as more effective variations were invented or introduced and applied to achieve more effective results. In every community, extending back thousands of years, there have been men and women who were experts in their knowledge of plants, animals, and the environment. The final result produced some of the most elaborate and productive fishing, hunting, agricultural—and on the coast aquaculture societies that knew how to live well, and who knew how to selectively harvest, thus sustaining the resources they used for their own purposes and for future generations.

Many different peoples developed immense knowledge systems, created rich and rewarding cultures filled with strong family and community bonds, artistic expression, ritual and ceremony, and enduring relationships with other species—the plants and animals of their home territory.

One of the roles of Elders and knowledge holders is to find ways of passing on what they learned in their own lifetimes to the next generation so that its members would be able to benefit materially and culturally from this knowledge and wisdom. We must infer that this cycle of learning, observing, predicting, using, inventing, adapting, experimenting and sharing ecological wisdom, technological breakthroughs and cultural knowledge has been occurring in Northwestern North America since time immemorial—since before recorded history (Turner, 2014a, 2014b).

In the school system, however, examples of Indigenous innovations in science textbooks have been largely limited to Indigenous technologies such as fish traps and other fishing technology, carving totem poles and dugout canoes, and weaving cedar bark baskets. In this chapter, we bring to the attention of educators the science knowledge and processes underlying such innovations. In addition, we provide a broader range of traditional wisdom practices and Indigenous Science innovations that can be included in school curricula. It is our hope that teachers, parents, and readers will strive for effective ways to inform and inspire all our children.

Working with Trees and Plants

As a result of working with versatile cedars and other kinds of trees for thousands of years, generations of Aboriginal woodworkers perfected various technologies for felling and transporting trees, splitting and cutting planks, joining pieces of wood together, steaming and bending wood, weaving fibres, sanding and finishing products, patching and repairing products, as well as carving and painting products.

Western red cedar was vital to the life of BC Indigenous peoples. Red cedar grows tall and straight, with straight grain, both strong and flexible, bending under the weight of snow. The inner bark also has strength of flexibility, and in soils without large rocks, the roots run straight and even. But it is the lightweight reddish brown wood that runs straight without knots that gives the cedar its distinction.

Figure 7.1 ▲ Full size northern style Tluu dugout canoe with high, rectangular shaped prow and stern. The outside is painted with Northwest coast designs, the front depicting a dogfish. Artists: Bill Reid, Beau Dick, Simon Dick, and Gary Edinshaw (1984). Photo by Jessica Bushey (2016). Courtesy of Museum of Anthropology, University of British Columbia, Vancouver, Canada.

Made of a single western red cedar log, the dugout canoe of the Northwest Coast was central to the way of life of these ocean-going peoples. “Nowhere else in the world was a dugout developed to such a degree of sophistication; no other people had a dugout that could match the speed, capacity and seaworthiness—or the elegant grace—of the sleek canoes of the Northwest Coast Indian” (Stewart, 1984, p. 48). The earliest European explorers to visit the coast, who knew good boats, marveled that “the construction was so perfect, that not even an expert could detect the least flaw or imperfection” (Rev. Charles Moser, as cited in Stewart , 1977, p. 48). Significantly, the hull designs of big ocean-going Haida dugout canoes were later used for the fastest sailing clipper ships that raced between North America and Europe.

At Fort Langley, many newcomer Europeans were in awe of the quality of canoes that plied the waterways of coast and river. Without the canoes as a means of travel, hunting and transport, few villages could have prospered. Canoes were variously designed for different purposes and environments: large dugout canoes to withstand heavy waves and ocean storms in transport of people and goods (Figure 7.1); long sturdy dugout canoes for whaling (Figure 7.2); slender, simply built canoes for going upriver to hunt, set fishing nets and trade; and, long wide canoes for transporting goods long distances (Figure 7.3).

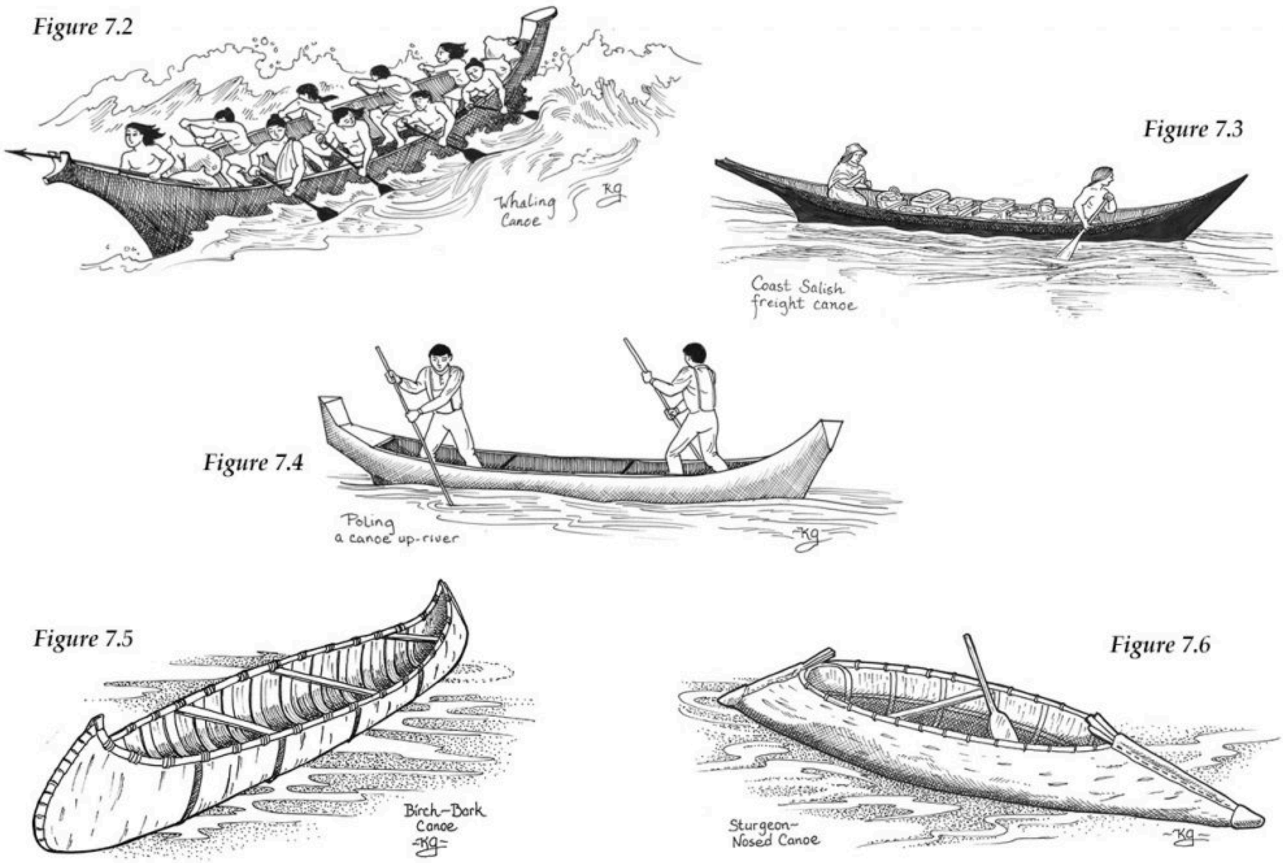

Figure 7.2 ▲ Nuu-chah-nulth whaling canoe. A notch in the top of the prow was designed as a harpoon rest, and was said to take the shape of a wolf's head. Illustration by Karen Gillmore.
Figure 7.3 ▲ Coast Salish canoe for general travel and transport of goods. Illustration by Karen Gillmore.
Figure 7.4 ▲ River canoes enabled trade between the interior and the coast well into the 20th century. Illustration by Karen Gillmore
Figure 7.5 ▲ Birch bark canoe. Illustration by Karen Gillmore.
Figure 7.6 ▲ Sturgeon-nosed canoe. Illustration by Karen Gillmore.

The Makah of the Olympic Peninsula, Washington and the Nuu-chah-nulth of southern Vancouver Island hunted whales and other mammals. Their canoes were virtually identical. The Nuu-chah-nulth canoe was extremely seaworthy. Their flatter bottom allowed for easy beaching and loading, and their flared width gave them exceptional stability as they pitched in ocean swells. Floats of sealskin, blown up like huge balloons, attached to the harpoon line slowed the whale and kept the dead whale from sinking. The Nuu-chah-nulth war canoe (not illustrated), with its flat bottom, "could plane at high speed" (skim along the top of the water) (Ahousaht Chief Edwin Frank Sr. to John Corsiglia, personal communication, 1998).

The rivers of central BC are shallow, but swift, and their navigation required considerable skill. Canoes of somewhat varying shapes played a key part in transporting goods throughout the interior and enabling trade between the interior and the coast. The crew used paddles and long poles to guide the canoes away from violent eddies and in the right direction downstream, and to push or pull canoes upstream (Figure 7.4). The peoples of the eastern BC interior harvested white birch bark to build birch bark canoes for travelling rivers and lakes (Figure 7.5). Cottonwood has some of the same characteristics as red cedar and was used to make dugout canoes in the interior. Small amaal (cottonwood) canoes were left at crossing points along portage trails for travellers crossing in either direction (Nisga'a Bert McKay to John Corsiglia, personal communication, 1979).

Ingeniously, the people of the Kootenay interior (the Ktunaxa Nation) made the sturgeon-nosed canoe that they adapted to a wetland environment. The flat bottom and pointed nose allowed the canoe to easily go through the reeds and high grass of marshlands enabling the people to gather food (Figure 7.6).

One of the greatest achievements of early Northwest Coast peoples was the building of large houses using massive cedar beams. A visit to such a house staggered the imagination of Capt. John Meares, who sailed the coast in 1788, and his journey entry well expressed his sense of awe:

> The trees that supported the roof were of a size which would render the mast of a first-rate man of war diminutive, on a comparison with them; indeed our curiosity as well as our astonishment was on its utmost stretch, when we considered the strength that must be necessary to raise these enormous beams to their present elevation; and how such strength could be found by a people wholly unacquainted with mechanical powers (Stewart, 1984, p. 61).

Figure 7.7 ▲ *Skidegate native village, British Columbia. Photo by George Mercer Dawson (1878). Courtesy of Canadian Museum of History.*

All along the Pacific Northwest Coast, marine-oriented people faced the water. Generally built close to one another, the houses hugged the water's edge wherever there was a beach, fresh water and a means to make a living. Some of the best examples of early large cedar houses were photographed at Skidegate, Haida Guaii by George M. Dawson during his travels in the early 1900's (Figure 7.7). One of the best examples of the framework of a large house with fluted beams is in the Kwakiutl village of Mamalilikulla on Village Island near Yalis (Figure 7.8 and Figure 7.9).

Figure 7.8 ▲ The framework of a large house with fluted beams in the Kwakiutl village of Mamalilikulla on Village Island, near Yalis (Alert Bay). Photographer Unknown. PN 1068, courtesy of the Royal BC Museum (1912).

Figure 7.9 ▲ The framework of a large house with fluted beams in the Kwakiutl village of Mamalilikulla on Village Island, near Yalis (Alert Bay). Photo by E. Curtis. PN 2321, courtesy of the Royal BC Museum.

These early explorers did not know that for centuries, Indigenous woodworkers and house builders had mastered post and beam construction, as well as the technology for raising massive cedar beams some 20 or 30 metres long, weighing more than ten tons, that could span open plan buildings and support roofs that could hold many tons of snow. One method was by moving the beam along an angled skid using levers, fulcrum, ropes and manpower (Figure 7.10).

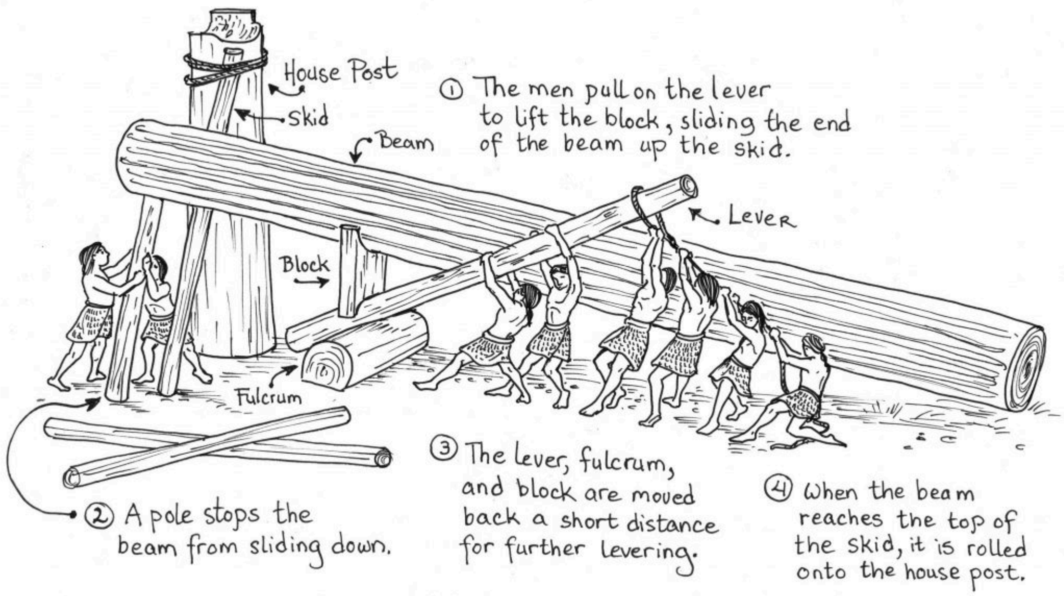

Figure 7.10 ▲ *Raising a massive house beam along a skid using levers, wedges, fulcrum, ropes, and manpower. Illustration by Karen Gillmore (Adapted from Hilary Stewart, Cedar, 1984).*

Harold Wright (Nisga'a Elder) told the author (personal communication, 1977) that the method used to raise a massive house's beams was to build a structural crib—in a fashion similar to the way squared timbers are stacked in alternating pairs to level campers, trailers, and move houses today. A crib of short squared timbers was stacked under a beam's balance point and then a sure-footed man walked to one end of the beam to raise the other end. As the balanced beam was rockered by the weight of a man moving end to end, blocks of varying thickness added to the square crib increased its height and thereby raised the beam incrementally. The process would be repeated with the beam raising a small vertical distance each time as they "teeter tottered" back and forth and new support planks were added. The beam's flat bottom contributed to stability. The energy supplied by one man moving back and forth was sufficient to jack up the beam (Figure 7.11).

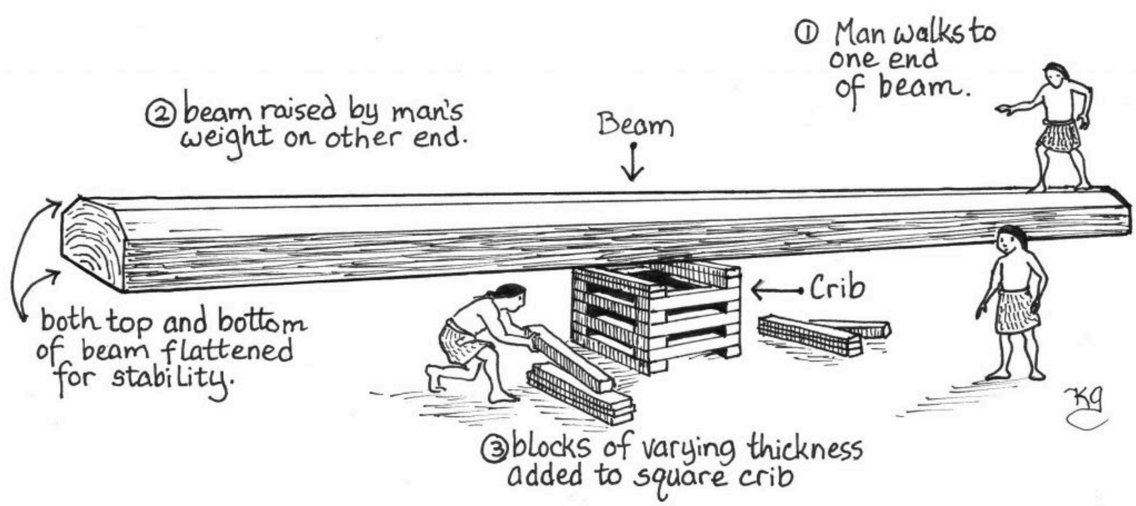

Figure 7.11 ▲ *Crib to lift house beam. Illustration by Karen Gillmore.*

Similarly, the raising of a totem pole can require a hundred or more men and the precise knowledge and skills required to build a strong scaffold and support crossbar, and by resting the pole on a crutch between stages of raising. In most communities, the pole is still raised in the traditional manner, followed by a great potlatch (feast) and speeches. Rattles were fashioned from a wide assortment of materials to accompany such occasions: pectin shells, puffin beaks, deer hooves, mountain goat hooves, bear claws, hollowed wood and pebbles. A variety of single-note whistles and some with two and three notes were used to create the sounds of supernatural and spirit creatures. Food played a major part in any important occasion. Enormous feast dishes, each carved from a large block of wood, and cedar baskets of various sizes and types held great quantities of prepared food for huge numbers of guests (Stewart, 1984).

While harvesting cedar and building large structures was almost the exclusive work of men, women worked almost exclusively with the inner bark and roots to weave a wide assortment of products, but it was only during the spring and summer months when the sap was running that pulling off the bark was possible. The women would look for a tall straight tree with few or no branches on one side. Stripping the bark from only one side allowed the tree to live, thus ensuring a sustainable harvest in the area (Figure 7.12). As with all natural resources, the people expressed gratitude. To show respect was to ensure a good supply in future years. After selecting a tree, the women would address the spirit of the tree in a prayer of respect, thanking it for being a good provider and asking it for some of its dress (bark) explaining why they needed it (Stewart, 1984).

Figure 7.12 ▲ Stripping the bark from only one side of the red cedar tree ensured a sustainable harvest in the area. Illustration by Karen Gillmore.

From the cedar bark and roots, women made baskets, bags, floor mats, clothing, hats, canoe bailers, baby cradles, cooking and serving utensils, berry-picking baskets, snowshoes, and ropes (Figures 7.13, 7.14, and 7.16). For peoples who lived in the rain coast environment, where heavy rain and cold weather were frequent, clothing made from shredded cedar bark oiled with oolichan grease gave protection from wind, rain and cold. The bark's multiple layers of fibre provided good insulation. They used finely shredded inner bark to make tinder, brooms, paintbrushes, string, fishing lines, napkins, baby diapers, and bandaging (Stewart, 1984; Turner, 1998).

Figure 7.13

Figure 7.14

Figure 7.13 ▲ Berry picking basket, coiled and imbricated, woven with cedar root and cedar splints. The red decoration is the natural colour of wild cherry bark, the black is stained wild cherry bark, the white is wild rye grass picked just before it blooms (only available for about 2 weeks a year). The shape of the basket is very difficult to achieve but is the best shape to keep the soft berries from crushing at the bottom. The baskets are waterproof which is necessary for holding the berry juices. Baskets are carried with the leather belt either around the upper shoulders and chest or on the forehead. The small straps are to hold leaves in place to cover the berries from the dust and sun. Basket woven by Seraphine Lester, a Lil'watul of Mount Currie and is now in the collection of her niece Wanosts'a7 Lorna Williams. Photo by Alicia Corsiglia.
Figure 7.14 ▲ Baby cradle. New born babies sleep in these cradles for the first 2–3 months, they are laced in at night, and in the day time when people are working they can be nearby, the cradle can be propped up in a standing position when the baby is awake and people are working nearby. This cradle was made in 1975, by Adelina Williams of Mount Currie for her granddaughter G'emayts'a7 Megan Williams who owns the basket today. Photo by Alicia Corsiglia.

Figure 7.15

Figure 7.16

Figure 7.15 ▲ Birch Bark basket made by Mary Thomas, Shuswap, in the collection of Wanosts'a7 Lorna Williams. Photo by Alicia Corsiglia.
Figure 7.16 ▲ Lil'wat snowshoes for a child by Alec Peters. Photo by Simon Bedford (1970). Reprinted with permission.

Different cultural groups gathered available materials to make baskets and other products at different times of the year depending on the location: the bark and roots of red cedar, as well as white birch bark, spruce roots, reed canary grass, cattail, bull kelp, slough sedge and stinging nettle (Figure 7.15). Both coastal and interior peoples with highly developed understanding of plant materials made many types of baskets for many purposes—from small waterproof drinking cups to large storage baskets. Baskets were important for harvesting as they could be light and strong, shaped for convenient carrying of different foods and materials. Baskets were often decorated with designs and colours produced by developing dyes made from various plants. Cedar bark baskets tended to have less decoration than those made of other materials, with plaid or geometric designs made by overlaying bark strands dyed black or red. For black, dried year old cedar bark was buried in black swampy mud, leaving it for only a few days, otherwise the roots would rot. When the mud was washed off, the bark was stained a permanent black. The Bitter Cherry bark can be dyed black by burying it in iron-rich mud for several months. Today the dying process can be sped up by adding a few tin cans and rusty nails (Stewart, 1984; Turner, 1998). A beautiful red colour is obtained by simply using the natural Bitter Cherry bark.

Over the millennia, the Aboriginal peoples of BC became highly skilled in the arts of working with plant materials. The coiled split-cedar-root baskets with their intricate designs of both coastal and interior peoples are world famous. Beautiful coiled cedar-bark baskets and other products continue to be made by the Lil'wat people of Mount Currie.

Tanning Hides

Ingeniously, Indigenous peoples around the world used brain tanning, an ecologically sound form of aldehyde tanning, to soften and preserve hides. North American Indigenous peoples boiled the brains of bears, deer, moose, caribou, or buffalo to make a broth for tanning hides. Acidic chemicals in the broth soften the hides and alters the nature of the protein fibres in such a way that they resist decay. Hides (usually deer) continue to be tanned to make long-lasting and washable jackets, dresses, and moccasins, only today, the broth is often made by boiling egg yolks. Moose hide is used in making snowshoes. In fact, snowshoes, sleds, and toboggans are Indigenous technologies, as well as parkas and leather mittens.

Medicinal Uses of Plants

There are numerous documented medicinal uses of plants by the Indigenous peoples of BC. For example: tea made from yarrow leaves was used for colds; devil's club for diabetes, arthritis and stomach problems; and ocean spray fruits for diarrhea, to name only a few (Turner & Peacock, 2005). Significantly, Western scientists have acknowledged numerous Indigenous remedies for specific ailments: using seawrack (a common seaweed) on burns and broadleaved plantain on insect bites (Nancy Turner, personal communication, March 2013). The bark of the Pacific Yew was used by the Indigenous peoples of Canada and the United States for treating many ailments, including some forms of cancer. It was not until the 1960's that the anti-cancer agent Taxol O® was isolated by scientists and used in the treatment of cancer (Turner & Hebda, 1990).

Controlled Burning

Indigenous people of Canada (and throughout the Americas) developed highly articulated and effective approaches to grassland management. Most Indigenous people understood plant succession and many employed fire to encourage the growth of valuable plants, foster optimum habitat conditions, and control insect pests and disease (Turner, 1991; Turner & Peacock, 2005; Turner, 2014a, 2014b). In British Columbia, controlled burning was practiced on southern Vancouver Island to optimize the production of edible blue camas, which grows best in an open Garry oak meadow habitat (Figures 7.17, 7.18). The burning released nutrients into the soil and discouraged less useful plants that compete for sun and moisture, maintaining mosaics of grasslands rich in camas, deer forage, wild strawberries, blackcap and trailing blackberries; diversifying habitat and increasing options for food and other resources. When controlled understory burning was practiced, the carbohydrate-rich bulbs grew to the size of small table potatoes. Newcomer Europeans who misunderstood the practice and had very different land use agendas outlawed the Indigenous landscape burning practice. A century later camas bulbs, where they are found, are often significantly reduced in size and they are no longer widely gathered. Thus, according to Turner (1991), "the concept of genetic and ecotypic variability was obviously recognized by Indigenous peoples and was a factor in food gathering" (p. 18).

Figure 7.17

Figure 7.18

Figure 7.17 ▲ Garry oak meadow with blue camas plant. Photo by Abe Lloyd (2014). Reprinted with permission.
Figure 7.18 ▲ Blue Camas roots and bulbs. Photo by Abe Lloyd (2013). Reprinted with permission.

Productivity of a wide range of berries was increased by burning grasslands and hillsides, the pruning of berry bushes, selective harvesting, and the cultivation and transplanting of roots from one location to another. By researching the nature of people-plant interaction on the northwest coast, Turner and Peacock (2005) conclude that the Indigenous peoples were "active managers who promoted and valued plant resources and thus have much more in common with farmers than previously supposed" (p. 148).

Ancient Clam Gardens

Although never lost to Indigenous knowledge keepers, clam gardens have only recently been discovered by non-Indigenous northwest coast scholars (Figures 7.19, 7.20). Coastal habitat surveys of the BC coastline, and specifically of the Broughton Archipelago, reveal hundreds of stonewall features in the lower intertidal area that cannot be explained as fish traps. Through collaboration with Kwakwa̱ka̱'wakw Elders, Clan Chief Kwaxistalla (Adam Dick) and Mayanilth (Daisy Sewid-Smith), researchers have concluded that pre-contact Northwest Coast Indigenous peoples cultivated large quantities of preferred butter clams and cockles in walled sea gardens that may be unique in the world. The structures were created when:

> Indigenous people, seeking to maximize clam production for an expanding population, rolled boulders to the extreme edge of a butter-clam bearing location to create a ridge parallel to the shore. Doing this extended the depth of beach out from the shore, and by integrating a series of small beds, it sometimes greatly lengthened the width of the butter-clam-bearing substrate. (Williams, 2006, p. 10)

Figure 7.19

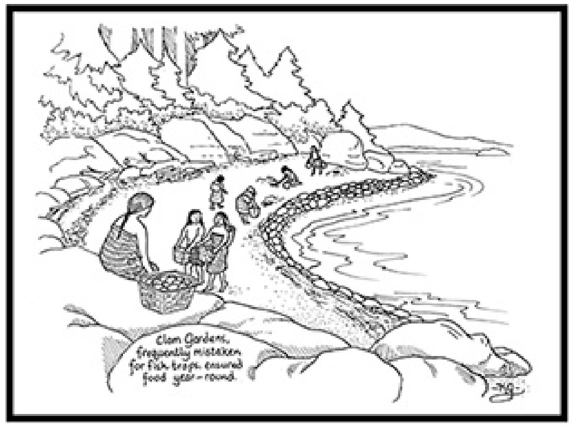

Figure 7.20

Figure 7.19 ▲ Tracey Island clam garden showing raised wall. Photo by Kim Recalma-Clutesi (2004). Reprinted with permission.
Figure 7.20 ▲ Clam gardens belong to individual families. Clams were roasted in their shells at the edge of fires, steamed in bentwood boxes, or braided into chains, smoked, and stored. Illustration by Karen Gillmore.

After building the walls, sediment, mud, and nutrients carried in by high tides would accumulate to create the ideal habitat for clam gardens. Families managed the intertidal plots and passed them down through generations. The tidal farmers would use digging sticks to turn over chunks of seafloor and aerate the sand (Figures 7.21, 7.22, 7.23). They selectively harvested the mature clams and left the smaller ones.

Figure 7.21

Figure 7.22

Figure 7.23

Figure 7.21 ▲ The water boils when hot cooking rocks are placed in the cedar bentwood box to steam the clams. Cedar tongs are used for placing cooking rocks. Deep Harbour. Photo by Kim Recalma-Clutesi (2011). Reprinted with permission.
Figure 7.22 ▲ Cooking butter clams in a cedar bentwood box in Deep Harbour. The water boils when hot rocks are dropped into the box. Box made by Kwaxsistalla. Photo by Kim Recalma-Clutesi (2011). Reprinted with permission.
Figure 7.23 ▲ Clan Chief Kwaxsistella (Adam Dick) digging clams with the kil'luckw (yew wood digging stick) that he made, Deep Harbour, North Coast. Photo by Kim Recalma-Clutesi (2011). Reprinted with permission.

Over 2,000 culturally modified clam gardens have been identified in almost every river estuary and delta from northern California to Juneau, Alaska. Carbon dating suggests clam terraces to be up to 3,000 years old. The number of gardens, their long usage, and the labour involved in rock wall construction indicate that individual and clustered clam gardens were one of the foundation blocks of Indigenous economy for specific coastal people. Evidence of Indigenous knowledge and usage led astonished researchers to the conclusion that "Indigenous systems of sustainable clam production on the BC coast preceded modern shellfish mariculture installations by perhaps thousands of years" (Williams, 2006, p. 12; Caldwell et al., 2012).

Traditional Fishing Methods

Aboriginal peoples of BC devised a great many different styles of fishhooks, lures, traps, spears, harpoons and nets for capturing different species of fish in different environmental conditions. Contemporary photos and Elder accounts show that there are still Indigenous peoples who catch and preserve fish by methods little changed in hundreds—probably thousands of years. While the traditions still serve the people, the major changes are the materials used—a nylon net replaces one of nettle fibre, iron replaces bone for fishhooks, and Styrofoam floats replace inflated seal bladders.

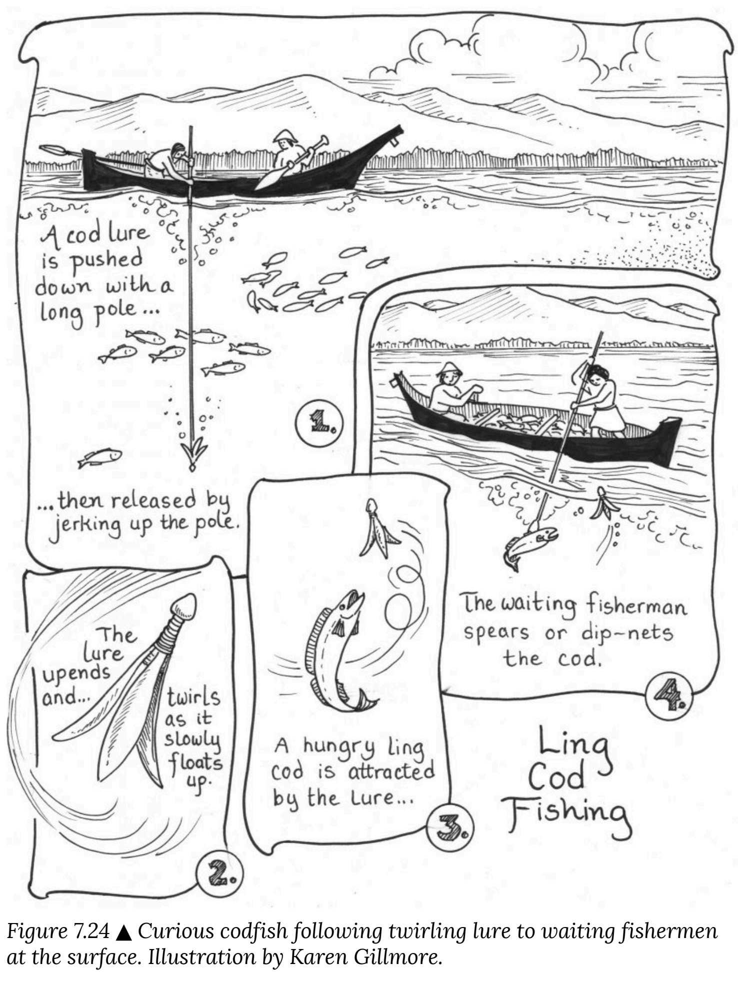

Figure 7.24 ▲ Curious codfish following twirling lure to waiting fishermen at the surface. Illustration by Karen Gillmore.

The traditional Indigenous peoples of the coast used lures in ways that reflected close observation and intimate knowledge of marine life. A sliver of willow—a white wood—carved in the shape of a fish gave a realistic imitation of a swimming fish as it was towed through the water. A piece of abalone glittering in the sunlight caught the attention of the fish.

Perhaps the most cleverly devised lures were those specifically designed to attract bottom fish such as cod and halibut (Figure 7.24). Pushed down into deep water on a long pole, it was designed to rise slowly and enticingly to the surface, where the fish that followed it up, with predictable curiosity, met the fisherman waiting with a spear or dip net in his hand" (Stewart, p. 56). The Nisga'a carved their cod lures from wa'umps (devil's club) because it is a lightweight wood, easy to carve and buoyant (Nisga'a chief Dr. Bert McKay, personal communication to John Corsiglia, October, 1978).

One of the most ingenious methods of sustainable fishing ever devised was invented by Indigenous peoples. The highly selective gillnet catches fish that try to pass through by snagging the gills, thus trapping the fish that can neither advance through the net nor retreat. Gillnetting uses a system of nets with floats and weights. The nets are anchored to the seafloor or steam bed and allowed to float at or near the surface. The lattice allows small fish to swim through the net and large fish to bounce off the net, while fish of the desired size are caught by their gills. The traditional gillnet is an effective method of catching large numbers of fish while allowing small fish to swim through, thus ensuring a fishery into the future (Figure 7.25).

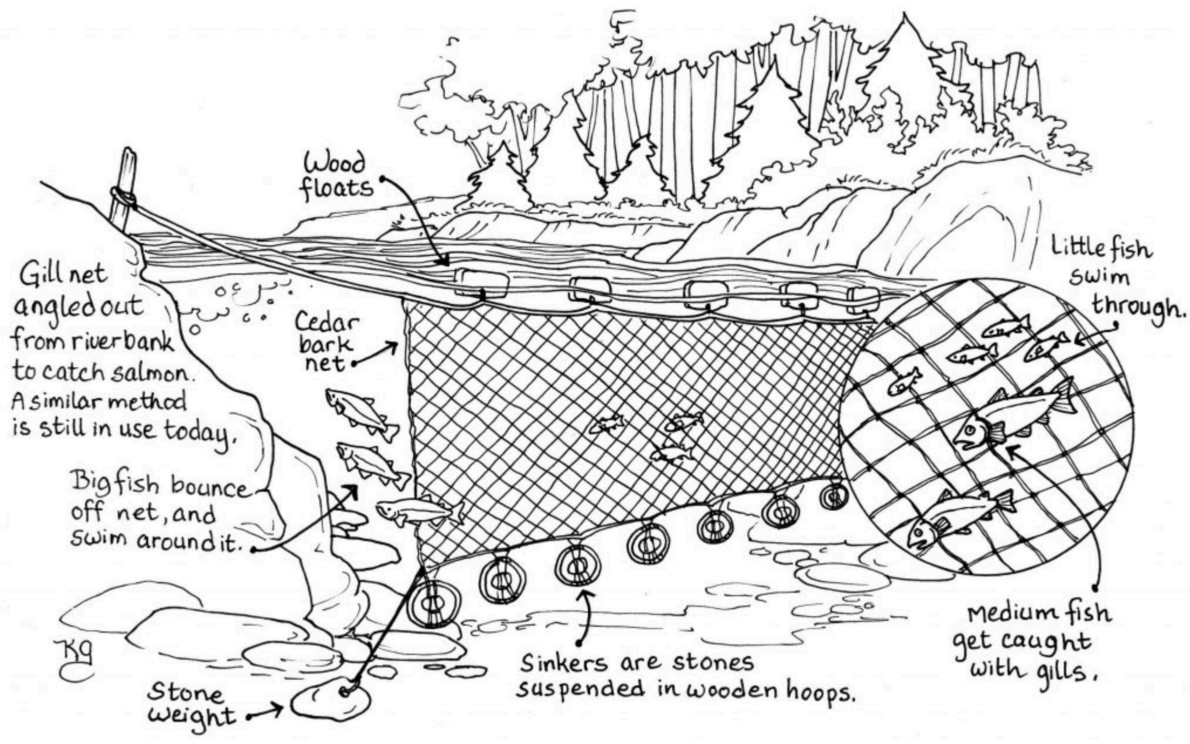

Figure 7.25 ▲ The highly selective traditional gillnet is an effective method of sustainable fishing. Illustration by Karen Gillmore.

Traps and weirs, probably the most productive of any type of fishing device, allowed large quantities of fish to be caught at a time when the salmon runs were at their peak. Weirs—fences through which water flowed—were either built right across a shallow river or angled to guide the migrating fish into traps.

For the W̲SÁNEĆ (the people of southern Vancouver Island, Gulf Islands, San Juan Islands, and across to the Fraser River), the reef net fishery formed the core of Saanich society. The SXOLE—reef net—refers to the material that the net was constructed of—the inner bark of the willow tree, most likely the Pacific willow or the Hooker's willow (Figure 7.26). The method of fishing was an incredibly sophisticated technique that required in-depth knowledge of the salmon, their habits and travel routes, tides, currents, and of plants, among other things.

The reef net consisted of cedar log buoys, cedar ropes to form the sides and the floor of the net, and specifically made rock weights. Dune grass was threaded through the twining of the ropes that formed the floor and the sides, allowing the net to blend with its surroundings. The net was suspended between two canoes, and would hang out with the flow of the tide. After a school of salmon entered the net, the rear anchor lines would be released and the tide would bring the canoes together. The salmon could be rolled into the canoes and brought ashore.

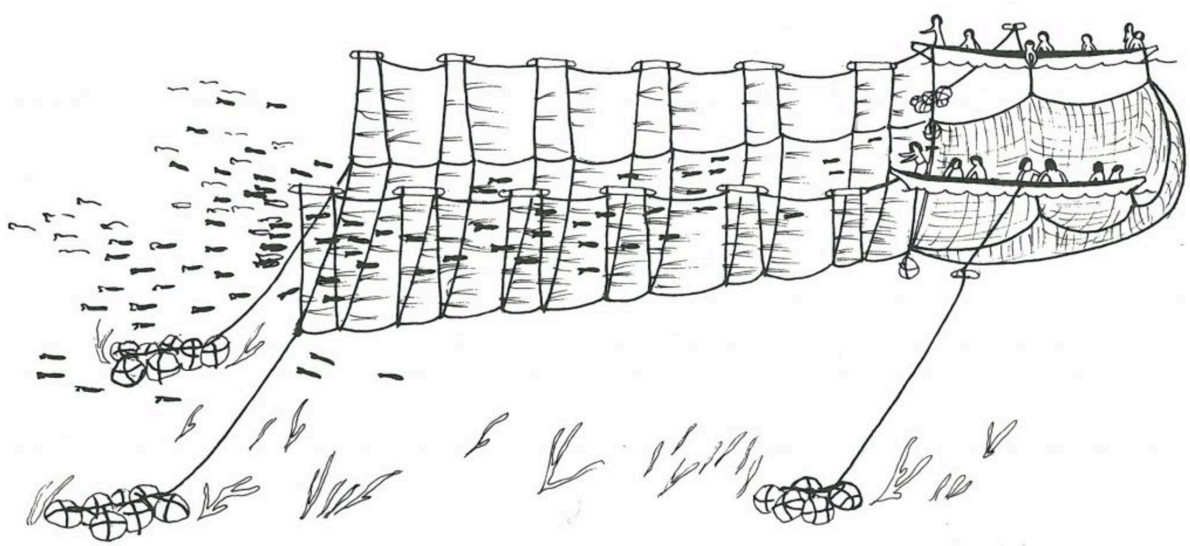

Figure 7.26 ▲ Reef net of the W̲SÁNEĆ (Saanich) Saltwater people. Dune grass threaded through the net would fool the salmon that they were actually safely swimming near the bottom. Illustration by Fran Ertle, Salt Water People, (1983). Reprinted with permission from School District 63, Victoria, British Columbia.

The method of fishing, according to Nick Claxton (2016), reflects a deep respect for the salmon, the earth, and each other:

> It was believed that the runs of salmon were lineages, and if some were allowed to return to their home rivers, then those lineages would always continue. The W̲SÁNEĆ people believed that all living things were once people, and they were respected as such. The salmon were their relatives. All things on earth were to be respected since it is the earth that we all share. (p. 19)

The W̲SÁNEĆ people successfully governed their traditional fisheries for thousands of years prior to contact. This was because the W̲SÁNEĆ people followed strict fishing practices based on respect. For example, at the end of the net, a ring of willow was woven into it, which allowed some salmon to escape. According to Claxton (2016), this fishing method, combined with a profound respect for the salmon, allowed a sustainable fishery over the millennia:

> Out of respect, when the first large sockeye was caught, a first salmon ceremony was conducted. This was the W̲SÁNEĆ way to greet and welcome the king of all salmon. All fishing would cease and the celebration would likely last up to 10 days .... Taking time to celebrate allowed for a major portion of the salmon stocks to return to their rivers to spawn, and to sustain those lineages or stocks. (p. 20)

Claxton asserts that this kind of respect for salmon and all of creation is an integral part of what it means to be a W̲SÁNEĆ person.

Fish Cultivation and Enhancement

Canada's most recent volcanic eruption, dated 260 years ago (about 1750), created a 30km long lava flow that blocked the great Nass River, creating the newly formed Lava Lake and Tseax River (Tseax = "new river" in the Nisga'a language). Traditional Nisga'a stories include graphic descriptions of an eruption that emitted deadly gasses and a flow of fiery lava that buried a village of some 2,000 residents. In 1978, Wii gadim xs̲gaak, the Eagle Tribe Chief and historian, related that when the lava flow blocked the Nass River, it prevented the ascent of spawning salmon. Nisga'a survivors placed spawning fish in bentwood cedar boxes filled with water and packed them past the blockage, thereby ensuring the survival of these stocks (Wii gadim xs̲gaak to John Corsiglia, personal communication, 1977).

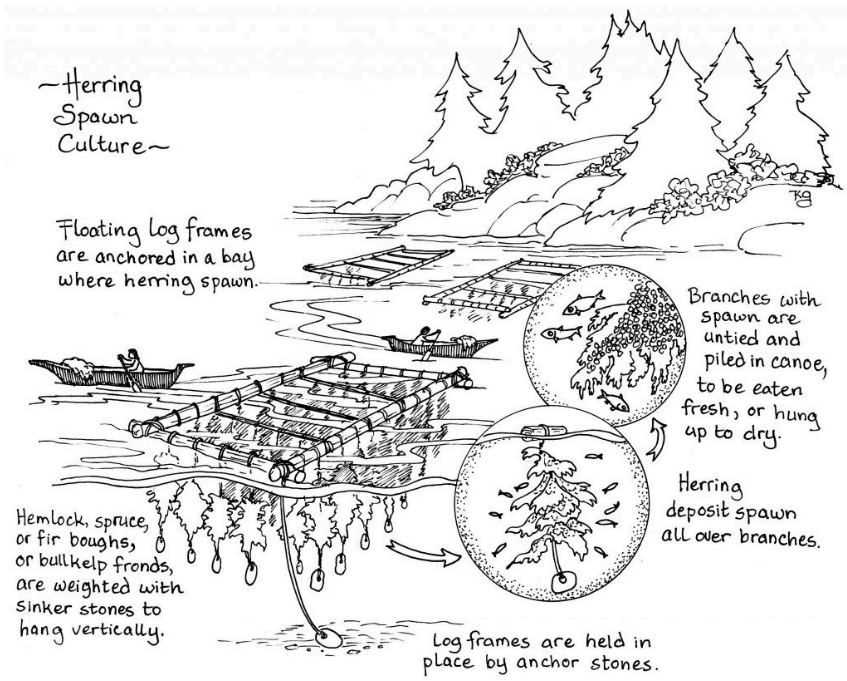

Figure 7.27 ▲ For hundreds and possibly thousands of years the fisherman have anchored floating log frames in quiet bays, allowing the herring to deposit their eggs all over tree branches or kelp hung down from the log frames. Illustration by Karen Gillmore.

Practical cultivation of herring along the BC and Alaska coastline probably began with attempts to improve and concentrate spawning habitat. Interviews and oral history from Elders in southwest Alaska document transplantation as a cultivation technique. Knowing when the herring would congregate in certain bays and coves to deposit their eggs, the fishermen would fall trees or place branches in quiet water or hang branches or kelp from floating log frames for the fish to deposit their eggs (Figure 7.27). This herring roe on kelp fishery continues in some locations to this day. Elders speak of allowing the herring to spawn their eggs on tree branches and "waiting until eyes were almost forming on the eggs" (Thornton, 2010, p. 12). Then they slowly towed the heavily laden tree (or lifted the branches and piled them into canoes for transport) to designated locations. Elders have continued the practice by cultivating herring in places where populations have declined. Harvey Kitka (Sitka tribal leader) explains, “As long as you get them back in the water within three days, they’ll swim away” (p. 12). Clearly, for hundreds and possibly thousands of years the Nisga’a, as well as other tribes, developed forms of fish enhancement that preceded modern fish enhancement practices.

Estuarine Root-vegetable Gardens

According to ethnographic accounts, the demand for root vegetables that grow in the lower zones of estuaries was quite high along much of the northwest coast, specifically silverweed (*Argentina egedii*), springbank clover (*Trifolium wormskjoldii*), and northern rice root lily (*Fritillaria camschatcensis*) (Figures 7.28, 7.29, 7.30). The roots were a primary source of dietary carbohydrates and other nutrients for most pre-contact Northwest Coast peoples (Deur, 2005; Turner & Peacock, 2005, Turner, 2014b) (Figures 7.31, 7.32, 7.33). These Indigenous people understood the differing physical conditions caused by the tide, and that organisms live in certain population zones on the shore. This understanding led to an increase in the production of edible root gardens by taking advantage of optimal tidal estuarine habitats and in some cases building rock or wood terraces in the low intertidal zones.

Figure 7.28

Figure 7.29

Figure 7.30

Figure 7.28 ▲ Northern Rice Root Lily. Photo by Abe Lloyd (2013).
Figure 7.29 ▲ Springbank Clover. Photo by Abe Lloyd (2008).
Figure 7.30 ▲ Pacific Silverweed. Photo by Abe Lloyd (2008).

Figure 7.31

Figure 7.32

Figure 7.33

Figure 7.31 ▲ *Northern Rice roots and seed pod. Photo by Abe Lloyd (2008).*
Figure 7.32 ▲ *Pacific Silverweed roots. Photo by Abe Lloyd (2008).*
Figure 7.33 ▲ *Springbank Clover roots. Photo by Nancy Turner (2005).*

The rock terraces located in the high marsh served to elevate lower portions of the salt marsh on a backfill surface and made the gardens bigger. Importantly, mounding and the construction of durable rock or wood retaining walls allowed the seaward expansion of the very narrow band of the high salt marsh in which the preferred vegetables grow. By raising the position of the planting surface relative to the tidal column, the mounded soils appear to have altered local hydrology and nutrient regimes dramatically, expanding this otherwise narrow portion of the intertidal zone and increasing significantly the production of preferred estuarine plants (Figure 7.34).

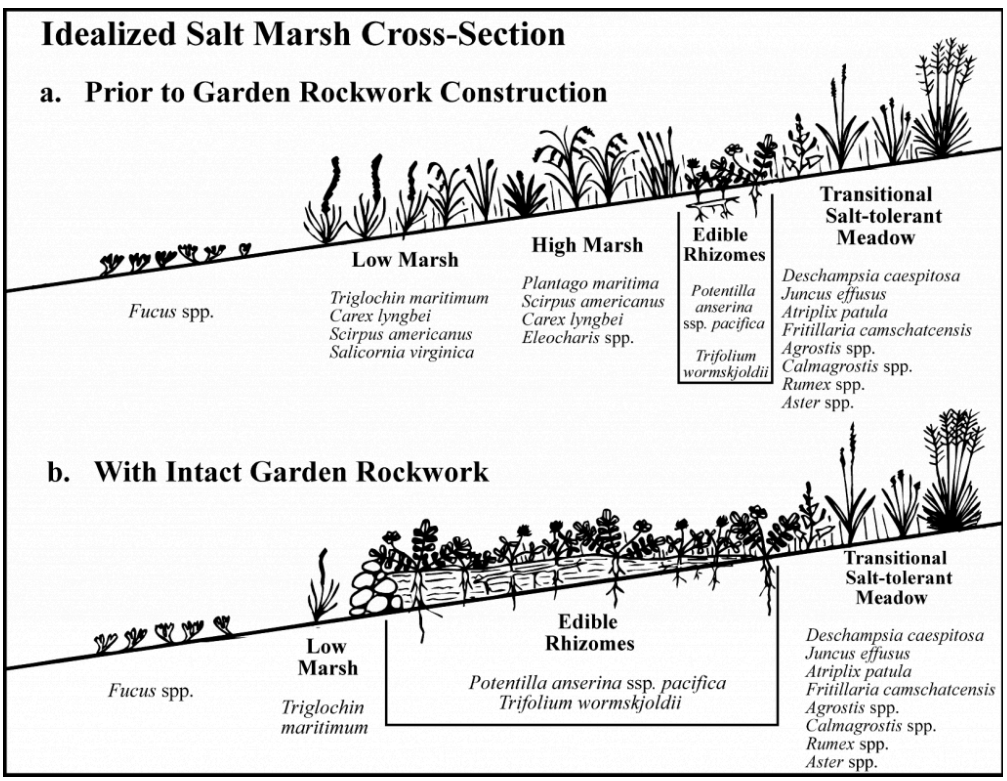

Figure 7.34 ▲ *Idealized salt marsh cross-section. Illustration from Deur, D. (2005). Tending the garden, making the soil: Northwest coast estuarine gardens as engineered environments. In D. Deur & N. J. Turner (Eds.), Keeping it living: Traditions of plant use and cultivation on the Northwest Coast of North America (pp. 296-327). Seattle, WA: University of Washington Press.*

The soils that accumulated in the garden plots were rich in fresh sediments and organic detritus from riverine, estuarine, and marine sources carried to the high tide line by peak tides and floods. It made the garden plots among the most nutrient rich soils, higher in nitrogen, phosphorous, potassium, and such trace elements as calcium than unmodified marsh soils. The area was cleared or "weeded" of competing grasses, sedges and other plants to ensure good growth of the food species using specialized digging tools made of hard yew wood. Deur (2005) describes how Indigenous food producers learned to "engineer the tidal flats" in order to harness its productivity well before their first contact with Europeans:

> The method of root cultivation employed reflected a detailed appreciation of the interplay of cause and effect within environmental systems …. The peoples of this coast repeatedly modified estuarine soils, plants and hydrology in anticipation of a predictable outcome: the qualitatively and quantitatively enhanced output of root foods …. (p. 300)

Plant foods contributed substantially to the diet of Northwest Coast peoples, providing them with essential vitamins and minerals, carbohydrates, and the dietary fibre required for proper digestion (Turner & Peacock, 2005). Large quantities of plant resources were acquired or traded, and were highly prized gifts at ceremonies: boxes of Pacific crabapples, highbush cranberries and bog cranberries, preserved soapberries, salal berry cakes, dried seaweed, camas bulbs, wapato tubers, silverweed and springback clover rhizomes, as well as the green shoots of thimbleberry and salmon berry, to name a few (Turner, 1995; Turner & Peacock, 2005; Turner, 2014b).

By intensifying conveniently located patches of food plants, the people of the coast reduced the risk of fluctuations of other dietary resources. As populations of salmon could fluctuate widely, it is clear that this affected Indigenous peoples and their survival strategies. Thus, the emergence of effective management strategies and the abundance of localized marine and riverine resources enabled the concentration of people together in large villages (Deur & Turner, 2005).

False Assumptions of a Colonial Past

In an attempt to understand the origin of errors, false assumptions and biases about Indigenous knowledge, the authors sketch our colonial past in the Americas. History books and various colonial papers have depicted Indigenous peoples as "hunters and gatherers," "affluent foragers," and "without agriculture." Europeans proclaimed the Americas' as *Terra nullis*, meaning "unoccupied land." The cultural prejudices and the missionary, political and academic agendas of the majority culture since the time of the conquistadores served to undermine actual Indigenous knowledge and claims on the land and its natural resources. The vast majority of documentary information in the Americas was recorded by men of European background and culture—explorers, traders, settlers, colonial officials, and missionaries. It is perhaps not surprising that innovations such as Indigenous estuarine root vegetable gardens, clam gardens, and salmon enhancement practices went unnoticed or unrecognized. The claim of 19th century colonial surveyors that Northwest Coast peoples "have no aboriginal plant which they cultivate, " or BC Governor General James Douglas's (1859) characterization of Indigenous people as "mere wandering denizen[s] of the forest," reveals more about the observers than the observed. Rather, these assertions served to devalue and dismiss Indigenous people's claims to entire regions of land and resources. "Together, colonial claims regarding traditional resource use provided a façade that served the extractive ambitions of colonial and frontier economies and the expansionist territorial agendas of colonial governments and the nation state" (Deur & Turner, 2005, p. 336). In this regard, it is instructive to note that WS grew up in the service of European empire building, which accounts at least in part, for its portrayal of IK as outside the realm of "real science." It also helps explain the emphasis in WS on domination and control of lands, resources and environment.

For Indigenous peoples in Northwestern North America, their complex knowledge systems, built up over millennia, have been threatened since European contact and globalization. Disease, epidemics, colonization, government laws, loss of lands and territory, environmental deterioration, mission and residential schools, and loss of language have all contributed to the loss of traditional knowledge systems. The result has been alarming declines in local ethno-ecological and science knowledge.

The refusal of many school jurisdictions to acknowledge IS as science, and the lack of well-funded Indigenous science curriculum projects continues to erode our understanding of the cultural knowledge and practices that sustained long-resident Indigenous peoples for thousands of years. As a result, Indigenous people in many cases have lost touch with the traditional wisdom and knowledge that sustained them for thousands of years in their homelands. Yet, Indigenous Elders and knowledge holders, as well as scholars in anthropology, ecology, biology, geology, geography, education and environmental studies agree that retaining and building on Indigenous and local knowledge systems helps support people's capacity for social and economic resilience, food security and over-all well being (Berkes, 2012; Turner, 2014 a, 2014 b).

A fundamental focus of future curriculum development is to try and better understand how Indigenous people's systems of knowledge developed, disseminated, adjusted, and evolved across great landscapes. What were their legacies? How did old and new practices combine and shift? What can we learn from the ancient clam gardens? Did they observe, infer, predict, theorize, evaluate, and adapt? Of importance in these times of global declining biodiversity and environmental stress, what lessons can be learned from these knowledge systems?

In writing this chapter, we sincerely hope that we have done justice to the Elders and knowledge holders who have passed on their knowledge and experiences to younger generations. We hope that all students will realize that Indigenous peoples are not simply vestiges of the past, but rather, are alive today and have much to share. We hope that in the future teachers, curriculum developers, book publishers and educational jurisdictions will develop a range of culturally appropriate Indigenous Science lessons and curricula. The best way to ensure greater accuracy is to involve knowledgeable Elders and knowledge holders in some stage of the production of those resources. Only then will generations to come, both Indigenous and non-Indigenous students, benefit from the teachings of the Elders and understand a little more clearly the richness and significance of their time-proven perspectives, knowledge, and wisdom.

This chapter provides only a brief glimpse into the vast storehouse of knowledge that developed across the great landscapes and seascapes of Northwestern North America. For a more in-depth discussion of Indigenous knowledge and wisdom examples in Northwestern North America, see selected resource books, Appendix C.

DISCUSSION POINTS

In a small group, brainstorm the following:

- How Northwestern North American Indigenous peoples discovered medicinal remedies that work (using seawrack on burns and broadleaved plantain on insect bites).
- Proponents of WS argue that "real science" is testable, evidence based, has explanatory power, and is determined by consensus. When Indigenous peoples of the northwest coast increased the production of edible root gardens by building rock terraces in the low intertidal zones, was their innovation the result of trial and error only, or can it be included in the realm of "real science?"

- To a considerable extent, culturally appropriate Indigenous Science curricula must be place-based. Discuss.
- Choose a topic such as fishing, raising house beams, tanning hides or clam gardens. Refer to Appendix A, B and C, and develop a science lesson or unit of study at a desired grade level.

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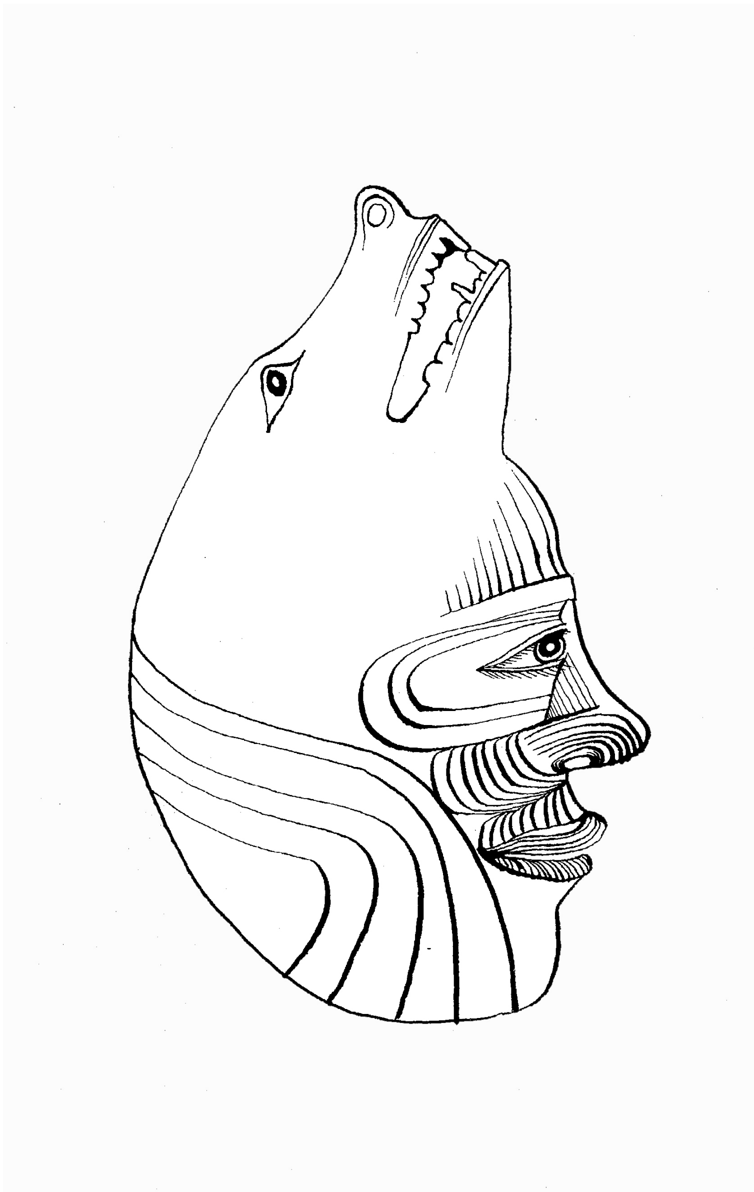
PART III

UNDERSTANDING CHILDREN'S IDEAS, BELIEFS AND WORLDVIEWS



"Untitled." Drawing by Laura Corsiglia. Reprinted with permission from (2001) Our Thang, p. 28. Victoria, BC: Ekstasis Editions.

Chapter 8 - When Uncles Become Killer Whales: Bridging Indigenous Science, Western Science and Worldviews

Gloria Snively

One foggy spring morning in 1978, I walked along the long wooden dock in ‘Ya̱lis (Alert Bay), Cormorant Island, BC, looking for the seine boat that would take a group of teachers and myself through Johnston Strait to Hansen Island where we would explore the seashore. For millennia, the oceans, mountains, and forest of this region have set the stage for the rich cultural history of several First Nations in this region, collectively known as the Kwakwa̱ka̱‘wakw—those that speak the Kwak’wala language.

I had recently published a field guide to the seashore, *Exploring the Seashore in British Columbia, Oregon and Washington* (1978), and had been asked by G̱a̱‘ax̱sta̱las (Flora Cook), the principal of the local school, to conduct a two-day beach workshop with North Vancouver Island teachers. The workshop would include a beach walk and talk. I came equipped with my camera, plankton net, several binoculars, and a backpack filled with identification guides. I expected 15-20 teachers, and was surprised when 35 or so very cheerful local folks walked onto the boat, including children, teenagers, parents, and grandparents. The captain, who was a local fisherman of Kwakwa̱ka̱‘wakw ancestry, explained that he had invited members of his family to hitch a ride from ‘Ya̱lis to a nearby island location.

As the seine boat chugged out of the harbour and began the two-hour trip through Johnstone Strait, the fog lifted revealing breathtaking views of snow-capped mountains in the distance, and a magnitude of islands, quiet coves and winding waterways. Just as spectacular as the landscape was the amazing diversity of life found in tidal areas and offshore waters. The abundance of food attracted a diversity of water birds, as well as dolphins, harbour seals, sea lions, humpback whales, and killer whales. Although the population has dwindled, the area continues to be home to the largest number of killer whales on the planet.

All went as planned until someone yelled, “killer whales on the starboard bow!” Immediately, the captain turned the seine boat in the direction of the 30 or more whales, then slowed the engine as we neared the pod. I grabbed my camera hoping to get some spectacular photographs when suddenly several of the captain’s relatives yelled, “Uncle Jimmy! Uncle Jimmy!” At first, I thought that Uncle Jimmy had fallen overboard, but I could not see Uncle Jimmy anywhere in the water. Surprisingly, there was much laughter and cheering, with several people pointing to a single majestic killer whale. I had no idea of what was unfolding. A kind elderly lady tapped me on the shoulder and explained that Uncle Jimmy had passed away the previous year. Uncle Jimmy was an important Elder in the village. Before he passed, Uncle Jimmy said that when he died, he would become a killer whale. They would know him because he would be bigger and more powerful than the other killer whales, and he would rise higher in the water. There was no mistaking Uncle Jimmy. One of the most impressive features of a swimming pod is the size of the dominant bull’s dorsal fin that sometimes stands taller than a man.

I recall this incident here because it has both a real and a symbolic bearing on most of what I shall present. Geographically speaking, ‘Ya̱lis is not very remote anymore––starting from Victoria, one can drive the Vancouver Island highway to Campbell River, then through a mountain pass to Port McNeil in about 10 hours, then take a small ferry to Alert Bay (‘Ya̱lis), located on Cormorant Island—altogether a journey of 10 to 12 hours. Culturally, the voyage is considerably further, for it involves a long journey across cultures and through time and history, or backwards through several centuries of our own culture––in my case, of German and Dutch descent. Because a journey across continents or oceans is so easy, we tend to forget the real distance that separates us and assume that the cultural journey too will be easy.

On that day, no further mention was made of the significance of Uncle Jimmy, but I was wondering what others were thinking while we watched the whales and I supposed that they were wondering about my thoughts too. I had gone to ‘Y<u>a</u>lis with the intent of sharing the knowledge and love that I have of intertidal organisms and ocean life. However, the knowledge, wisdom and inspiration that I received from the Kwakw<u>a</u>k<u>a</u>‘wakw over the next 38-year period of working with teachers and Elders from the community, seems far more valuable than the knowledge that I shared with them.

It is good for us to realize that cultural distances exist within this country we call Canada. The continuing struggle to achieve opportunity and equal justice for all critically depends upon our ability to provide rich and culturally appropriate educational opportunities for all students. We are finding that this is a tricky business not only because of the resources it requires, but because it involves us in an effort to explore and respect cultures whose existence most of us have given too little attention.

Against this backdrop, let us consider a few of the problems that can arise in teaching science to children whose view of reality may be different from that of a science teacher steeped in Western Science (WS). We like to think that properly taught science will give us understanding of the real world, but which “real world?” People everywhere believe they know what is real and what is not, and most of them fit their knowledge of reality into a coherent structure of ideas, beliefs, and values that serve their needs.

I come from a position as a Euro-Canadian female, with a history of teaching at the elementary, secondary, and university levels, and a focus on science, marine, and environmental education. In this chapter, I outline the concerns I have with how we as educators disadvantage Indigenous students who may hold a worldview that is different from the Western scientifically accepted worldview.

How Children Learn

An exploration of cross-cultural science begins with clarifying four important terms: *constructivism*, *worldview theory*, *Indigenous worldview*, and *Eurocentric worldview.* This clarification creates a step towards understanding how children learn, as well as towards bridging Western Science and the science of Indigenous peoples worldwide.

Constructivism

Central to research activity in science education is constructivism, which is defined as the social construction of meaning for an individual (Cobern, 1991, 1996, 2000). It is based upon two basic principles: (a) that knowledge is not passively received and that learners build or constructs knowledge for themselves, and (b) learners do not discover truth, but rather construct viable explanations of experience (Wheatley, 1991). In terms of constructivist epistemology, we interpret our reality through symbolic conceptual filters and sensory experience; “Children try to make sense of their world through active exploration of their environment and social interchange with people around them” (Atkinson

& Fleer, 1995, p. 7). Students approach the world with some degree of mental organization, not a blank mind. Researchers have been able to identify and describe a range of intuitive explanations for specific phenomena, but they have also established that such explanations can be remarkably persistent.

Traditional teaching methods focus on assimilation (Aikenhead, 1996; Aikenhead, 2006; Aikenhead & Jegede, 1999). The main goal of science instruction through assimilation is for the teacher to present the correct information that is then reinforced by the textbook and an examination. By contrast, teachers who use a constructivist model of teaching listen to the students' views without making judgments or trying to correct answers. Knowledge resides not in bulging books, but in individuals, and that knowledge cannot be transferred from the teacher to a student intact. This strategy of instruction encourages students to take risks and develop their own ideas without fear of being incorrect. Thus, constructivism is useful to teachers because it helps makes sense of what children think and how they learn in the science classroom.

Worldview Theory

Simply put, a worldview can be thought of as the way people experience and make sense of the world. Cajete defines a worldview as "a set of assumptions and beliefs that form the basis of a people's comprehension of the world" (Cajete, 2000, p. 62). A more detailed definition comes from Cobern (2000), "A worldview refers to the culturally dependent, implicit fundamental organization of the mind. This implicit organization is composed of predispositions that predispose one to feel, think, and act in predictable patterns" (p. 8). For example, a teacher who has a Eurocentric view of science might assume that all children have a predisposition to learn science from a Eurocentric viewpoint.

Informal learning plays a part in the process of shaping a child's worldview. The toys children manipulate, TV and books, video games, the activities of the adults that they watch and imitate, the conversations they listen to, the ceremonies they attend contribute to the attitudes, values, and beliefs they develop about nature and natural phenomena. In everything the child does in the science classroom, there is an echo of his or her home environment and culture.

The meanings of worldview are crucial to our discussion of Western Science (WS) and Indigenous Science (IS) in the science classroom. Importantly, Aikenhead and Michell (2011) note that the terms *scientific worldview* and *Indigenous worldview* are misleading because they create a stereotype of each group; they ignore variations of worldview within both the scientific community and among Indigenous peoples (p. 27). Thus, terms such as a *scientifically accepted worldview* or *a worldview held or recognized by an Indigenous group* are more accurate.

An Indigenous Worldview

Although there is great diversity within IS systems, long-resident Indigenous cultures share common features that are valuable starting points for teaching school science. For example, Indigenous people share a strong connection to the land due to their fishing, hunting, trapping, gathering, harvesting, and producing products from their homeland resources. Out of this intimate relationship with the land, they developed a worldview in which humans are interdependent with the natural world. Nature can exist without humans, but not *vice versa*. Indigenous people learned to work with nature and be part of it; they believe in close, harmonious relationships between humans and nature, rather than humans in control of nature (Allen & Crawley, 1998; Atleo, 2004; Cajete, 1999, 2000; Deloria, 1997; Hampton, 1991; Kawagley, 1990; 1995).

According to Little Bear (2000), in Aboriginal philosophy, existence consists of energy:

> All things are animate, imbued with spirit, and in constant motion. In this realm of energy and spirit, interrelationships between all entities are of paramount importance, and space is a more important referent than time … The idea of all things being in constant motion leads to a holistic and cyclical view of the world. If everything is constantly moving and changing, then one has to look at the whole in order to see the patterns. (pp. 77-78)

Language embodies the way individuals and societies think. Through learning and speaking a particular language, an individual absorbs the particular thought processes and worldview of a people. As Little Bear (2000) points out, Aboriginal languages are for the most part "verb rich" or "action-oriented" languages and are generally aimed at describing happenings rather than objects. Thus, "the languages of Aboriginal peoples allow for the transcendence of boundaries" (p. 78). The categorizing process does not allow for the use of dichotomies such as "either/or," or "black/white," or "saint/sinner." There is no animate/inanimate dichotomy. Consequently, Aboriginal languages allow for talking to trees, birds, and rocks. For Little Bear, "if everything is animate, then everything has spirit and knowledge, and all are like me" (p. 78).

Arising out of the philosophy of constant motion is the value of wholeness or totality. "Wholeness is like a flower with four petals. When it opens, one discovers strength, sharing, honesty, and kindness. Together these four petals create balance, harmony, and beauty" (Little Bear, 2000, p. 79). The value of wholeness speaks to the totality of creation, the group as opposed to the individual, the forest as opposed to the individual trees. Wholeness has implications for learning. If a person is whole and balanced, then he or she is in a position to fulfill his or her individual responsibilities to the whole (Little Bear, 2000).

A Eurocentric Worldview

One can summarize Eurocentric value systems as being linear, singular, static, and objective (Aikenhead & Michell, 2011; Cajete, 2000; Deloria, 1997; Little Bear, 2000). Singularity often manifests itself in concepts such as the one true God, one right answer, one true science, and the superior importance of a person as an individual. Plants and animals are ranked in terms of higher and lower intelligence. If something is not measured, then often it is not scientific.

Reductionism describes a general approach to scientific thinking that assumes scientists can understand "the structure and function of the whole in terms of the structure and function of its parts" (Irzik, 1998, p. 168). They investigate the parts to try to explain the whole. This is the dominant theory that became grounded in academia and is in opposition to the more holistic and integrative traditional thinking widely favoured by Indigenous peoples.

The Indigenous worldview sees people, plants and animals, the land and water, and living resources as elements of a conscious spiritually connected whole. In contrast, WS approaches seek greater understanding through breaking apart the whole and analyzing or reducing it into its smallest parts. These cultural differences can create confusion for students in classrooms dominated by a WS perspective.

In order for students to appreciate meaning systems and the processes of knowledge construction in another culture, the two cultures must come together and exchange worldviews. Teachers must work towards an understanding of the prior ideas and beliefs of their students, and assemble a tool kit of teaching methods that enables all students to explore their own assumptions and search for meaning on all sides.

Children's Beliefs about Nature

Since students bring to the classroom ideas based on prior experiences in their physical and cultural world, these ideas or beliefs affect the ways students respond to and interpret instruction in science. For example, if a child thinks the phenomenon of electricity is about electricity being alive and attacking people to shock them (the beliefs some children have), then any learning will be interpreted in this way, yet this mini-theory is not helpful in understanding how electricity works. Knowing that children think this way will help teachers plan, listen, ask thoughtful questions, and pay attention to the children's thinking during instruction (Fleer, 1999, 2007).

There is clear research evidence that understanding (or explanation making) in science is a gradual process and that at certain ages children seem to have similar "alternate conceptions" regardless of where they live in the world. For example, Guest (2003) identified young children's thinking as follows:

- Ice formed on a pond in winter has been added the way that we add ice to a drink (p. 11).
- The same weather goes around the world and we get it when it is our turn (p. 12).
- Magnets stick to objects because they have magical powers or some kind of glue (p. 14).
- Night happens because the sun has gone to Australia (p. 15).

Research evidence reveals that understanding is a continuous process that goes on through life as the brain develops the neurological connections needed to make sense of experiences (Greenfield, 2000). Think of the different understanding a 6-year-old, a 15-year-old, and a 29-year-old research scientist would have for temperature. From birth onwards, children react to the temperature of their environment. Young children (ages 5-6) tend to think of "heat" and "cold" as particular substances that flow in and out of materials, like a river. Children have difficulty thinking of heat and cold as parts of the same continuum. They have even more difficulty thinking in terms of the more abstract kinetic theory that explains heat is a form of dynamic energy or molecules in motion. Five and six-year-old children tend to think that water is magical––the water just disappears. Young children rarely are exposed to the idea that water changes from a liquid to a gas. Some children visualize a cloud as a sponge, letting out water through its holes as a result of wind moving the clouds about. Later, some children (aged 11-15) know that clouds are created when vapor becomes cold, and that rain falls as a result of water droplets becoming big and heavy. Many of the ideas illustrated here relate to Western Science and what children from a western heritage background may say or think (Fleer, 2007).

Although Indigenous children worldwide have many ideas in common, and many ideas that are different between those cultures, major differences between Indigenous and Euro-American and Euro-Canadian children have also been documented. Children of Indigenous cultures, e.g., the Māori in New Zealand, Australian Aborigines, African-Caribbean, African-American, South African, Native American, and Inuit may have very different beliefs about the concepts of time, life cycles, seasons, growth, death, taxonomy, heat, energy, evolution, tidal cycles, weather (lightning, hurricanes), day and night, and causation (Davis, 2009; Fleer, 1999; George & Glasgow, 1989; Jegede & Okebulola, 1991; Mahapa, 2002; Ogunniyi, 2000, 2007; Okere, Keraro & Anditi, 2012; Pabale, 2006; Snively, 1990, 1995).

Generally, compared to their Eurocentric peers, students from Indigenous backgrounds are more likely to hold views in which supernatural forces, spiritual beliefs, or myths have significant roles in natural phenomena (Kawagley, 1995; Cobern, 1991; Snively, 1990; Aikenhead & Michell, 2011). For example, research illustrates that some Kwakwaka'wakw children think that animals can communicate with humans, and that thunder and lightning is caused by supernatural beings (Figure 8.1):

> Seagulls can talk. They show the fisherman the way home. (Kwakwaka'wakw student, personal communication to Gloria Snively, 2000)

> The Thunderbird is the ruler of the skies. The Thunderbird breathes thunder and lightning from its eyes. (Snively, 1990, p. 46)

Figure 8.1 ▲ *Memorial pole by master carver Hilamas (Willie Seaweed) portrays Thunderbird and Wild Woman of the Woods, Dzunuk'wa 'Yalis, Alert Bay. Photo by Gloria Snively* (1982).

Children often give explanations for natural phenomena that originate in cultural stories. For example, to account for earthquakes, a student in Panga, Napal explained:

> The earth is supported on the back of a fish. When the fish grows tired it shifts the weight, and this shakes the earth. (Dart, 1972, p. 51)

To account for the rise and fall of the tide, one Kwakwaka'wakw child explained:

> It's like the legend of the tides. The wolves looked after the tide a long time ago…The wolves wouldn't let the tide go out. Then some people got mad…They had no food, so the wolves let the tide out. (Snively, 1990, p. 52)

Traditional spiritual or teaching stories typically portray animals as fellow creatures. Humans are not separated from nature, but are connected with it. "Everything is one" (Atleo, 2004, p. 117) means a holistic network of spiritual relationships exist (Figure 8.2).

Figure 8.2 ▲ School students march in full regalia. Salmon Festival, 'Yalis, Alert Bay. Photo by Gloria Snively (1982).

Different cultural groups worldwide have developed such accounts over hundreds and thousands of years. Many beliefs have been designed to serve a particular purpose with respect to society. Mqotsi (2002) contends that such beliefs have social functions and constitute a manner of adapting to the environment. They are a reality in their own right and have logic of their own which provides those who espouse them with a philosophy of life and a theory of psychology (2002, p. 169). Hence, the cultural context is critical as it provides a basis for further understanding of why certain beliefs are held and regarded as important, even in instances where their behaviour is seen as strange by those who are not part of the community. For example, Turner (1997, p. 282) reports that coastal Indigenous peoples watched the behaviour of certain animals on the shore to know when shellfish poisoning was present:

> Saanich (Straits Salish) shellfish harvesters watched the crows on the beach closely; if the crows stopped coming down to the beach to forage for food, the Saanich people stopped their own foraging, assuming that the shellfish would not be safe. (Elsie Claxton, personal communication to Nancy Turner, 1990).

According to Lil'wat scholar Wanosts'a7 Lorna Williams, "It is not so much that the crows themselves give the harvesters a message, or that the seagulls knowingly show the fisherman the way home, but that humans can learn to 'read' signs in nature and abide by their stories" (personal communication, December 2012).

Although considerable research into children's thinking about science phenomena has been conducted, Fleer (1999) points out that this research has largely been carried out from within a WS perspective. The conceptions being sought are those that relate to WS. Those views that do not fit within a western framework are labelled as "errors," misconceptions, or alternate conceptions, and may exclude other worldviews from being considered in ways that are equally valid. Partington and McCudden (1992) argue that Indigenous children know a great deal, however it is difficult to tap into their understandings because of the western focus on verbal explanation through the use of "how" and "why" questions. This is supported by Fleer's (1997) study into rural Australian Indigenous children's understandings of night and day. When children were asked on a one-to-one basis a series of questions about their understandings of night and day, very little Indigenous Knowledge was evident. However, when children were interviewed in a group, children's responses were much richer and more readily given. Similarly, Snively found that when Kwakwaka'wakw children were interviewed using metaphor choices and student drawings, (1986, 1990), children's responses revealed much richer knowledge and were given more freely. Although the number of research projects into children's prior beliefs about nature has grown significantly over the past four decades, there have been scant studies into the beliefs and values of Canadian Aboriginal students.

With regard to science teaching, the link between a community's perceptions of science, its values and beliefs in concert with or in opposition to WS, and the pre-conditions and worldviews which occupy the minds of children entering the science classroom, are some of the features of a culture which interact with the content, teaching methods and forms of assessment of the science classroom. The task of reconciling different and sometimes incompatible ideas poses challenges for some children from cultures in which WS does not play a central role (Aikenhead, 2006; Cobern, 1991, 2001; Stanley & Brickhouse, 1994, 2001).

So how can teachers talk about spiritual ideas in the science classroom? How can teachers help students who hold spiritual beliefs about nature learn in the science classroom? These questions seem almost too absurd to ask, but think—when was the last time you spoke to colleagues about how these students learn?

Cross-cultural Science Education

A key aim of school science has been to enrich students' lives by conveying how scientists understand nature. Many science education professors and teachers have interpreted this aim as getting students to think like a scientist. However, this assumed superiority of WS limits the range of ideas, perspectives, and ways of understanding and experiencing nature. Research shows that science teachers also possess a strong allegiance to WS and the values and attitudes associated with it (Aikenhead, 2001; Aikenhead, 2006).

For many students, the attempt to convey how scientists think has not been successful as some students may resist, or because of their worldview, have difficulty relating to a WS mindset. These students often experience school science as a "foreign culture" and feel alienated by it. In fact, they comprise a very large majority of students in a typical classroom (Aikenhead & Michell, 2011).

Driver and Oldman (1986) and McNaught (1993) stated four alternatives that may occur when an individual is faced with competing worldviews. These four alternatives are:

- retain their own perspective and reject other perspectives;
- hold onto the original idea and adopt another perspective temporarily i.e., hold two conceptions simultaneously;
- reject their original perspective and adopt a new perspective; or
- they may reject their original perspective and those put forth by others, and instead adopt an alternative which goes beyond any of them (as cited in Binda, K. & Calliou, S., 1999, p. 15).

The experience that Indigenous students may bring from home or community is quite different, and if they are exposed to only one worldview, it can lead to disregarding their own worldview in the classroom. Hence, none of these alternatives are likely to lead to interesting and engaging experiences in the science classroom, which may help explain the low participation rates of Indigenous students in upper level science courses and science-related careers. If, on the other hand, teachers expose both Indigenous and non-Indigenous students to other worldviews, *all* students may draw strength from both, and develop new ideas and new problem solving skills. As such, there may be a fifth alternative beyond those proposed by Driver and Oldman, students could retain their own cultural worldviews, come to understand a new worldview (the WS worldview), and learn when each worldview is useful and for what purpose.

A discussion of how such adaptations take place is provided by Aikenhead and Jegede (1999), who recognize transitions from a student's life-world into the world of the science classroom as "cultural border crossing" (p. 271). The smoothness of this transition determines the degree of science learning achieved by the student. If the transition is smooth (when the culture of science harmonizes with the student's worldview), then science instruction will support the student's worldview, and a process of "enculturation" tends to occur. However, if the culture of science and the student's worldview are at odds with one another, science instruction will tend to disrupt the student's worldview, "trying to force that student to abandon or marginalize his or her life world concepts and reconstruct in their place new (Western) scientific ways of conceptualizing. This process of assimilation can alienate students from their Indigenous worldview culture causing a range of social disruptions" (Aikenhead & Jegede, 1999; Aikenhead, 2006, p. 271). Alternatively, assimilation teaching methods can alienate students from science, causing them to develop clever ways (school games) of passing their science courses (memorizing) without learning the science content, or simply coping, which can include passive resistance behaviours such as silence, evasiveness and manipulation (Atwater, 1996).

Rather than replicate the predominance of WS in the classroom, we must come to see that there are multiple legitimate ways of knowing that must enter the science classroom. The epistemologies and science of tribal nations have enabled them to live a good life in their home territories for thousands of years, and this knowledge is relevant to contemporary science learning (Atleo, 2004; Battiste, 2000; Cajete, 1994, 1999, 2000; Corsiglia & Snively, 1997; Kawagley, 1990, 1995; Kawagley et al., 1998; Snively & Corsiglia; 2001). These authors maintain that every effort has to be made to assist students to negotiate the science being taught with the students' life-world culture, including their first language.

Differences between English and Aboriginal Languages

Language is by far the most significant factor in the survival of Indigenous knowledge systems, and contains within its grammatical structure the values and teachings of the people that construct them (Armstrong, 1995; Battiste, 2002; Snively & Williams, 2008). An exploration of cross-cultural science begins with an understanding that conflicts often arise when we translate from one language to another. The culture of WS is to classify the world according to biotic (living) and abiotic (non-living) systems based upon specific criteria that involves exchange of gases, reproduction, etc. The Linnaean worldview categorizes plants and animals according to physical structures (vertebrate, warm-blooded, bears live young, etc.), genetics, and position on the evolutionary tree of life. It further places plants and animals into families. For example, all plants having similar characteristics to the carrot are placed in the carrot family. Within these categories, the world is assumed to be equally and neutrally classified. The teaching of these categories is conducted as if they were separated or removed from their derived cultural background.

Indigenous people classify plants by describing what part of the plant can be used for food or medicine or shelter, etc. during a particular season. The reason plants are classified this way is that if one were lost in the woods, knowing the use of the plant for food would be more useful than knowing the family to which it belongs.

An example of what gets lost in translation is illustrated when we identify an animal, such as a killer whale as *Orcinus orca* (toothed whale) or a plant, such as a western red cedar as *Thuja plicata* (folded in plates)—the phrase "folded in plates" is Greek and refers to the arrangement of overlapping leaves. The Linnaean worldview is useless in the context of survival based on knowledge of the diverse use of which is embedded in many stories, legends and prayers about killer whales and cedar trees. In some Indigenous cultures, the important question to ask is "Who is killer whale?" or, "Who is

Grandmother Cedar Tree?" The western red cedar is called Simgan in the Nisga'a language and means "royal tree," just as SimGigat means "royal people." In the Kwak'wala language, the killer whale is known as max̱'inux̱w which translates into "side by side," and refers to their family grouping and the way they travel. The cedar tree is known as Dana'mas, "the tree of life." Amongst Indigenous people where ever the cedar tree grows, it is considered a gift from Creator because it provides so much to the well-being of the people: homes in both winter and summer, cooking pots and implements, carrying and storage containers, canoes, water-proof clothing, mats, bedding mattresses, ceremonial regalia, medicine, spiritual practices and infant cradles. Killer whales and cedar trees are held in high respect and are considered to be people, just like us, except that they are much more generous (Snively & Williams, 2008, p. 114-115).

For Indigenous students familiar with the myriad of images and concepts associated with killer whales and cedar trees (as with salmon, wolf, raven, bear, frog, butterfly, and rocks), this feeling or state of balance is at the heart of Indigenous Science. These ideas are very different from the ideas and concepts that science teachers want students to associate with *Orcinus orca* or *Thuja plicata*.

In addition to grouping plants and animals into families, a Linnaean system places families in a hierarchy with humans at the top as being the most complex and intelligent (and thus most important), and organisms with the simplest body structures at the bottom. By sharp contrast, an Indigenous system views plants and animals, and all of creation as equals. Humans are not the controllers of nature, but coexist with nature, and can even be of lesser importance. According to an Ojibwe view of the world:

> Mother Earth and her lifeblood the waters is in first place for without them there would be no plant, animal or human life. The plant world stands second, for without it there would be no animal or human life. The animal world is third. Last, and clearly least important within this unique hierarchy come humans. Nothing whatever depends on our survival. (Basil Johnston, "Ojibway Heritage," p. 21, 1984, as cited in Ross, 1996)

In classrooms, students who have different worldviews from standard science, or who come from different language communities, use their knowledge to make sense of what is being discussed and explored. Wanosts'a7 Lorna Williams recalls visiting a Grade 4 class of Aboriginal students where she observed a situation that illuminates what happens when students' prior knowledge and experience is not taken into consideration:

> The students were working on a categorization activity. While the students were doing their independent work, I was going from student to student along with the classroom teacher. I noticed an interesting pattern on their worksheets. The top of the page had pictures of items (flower, mushroom, bird, boy, butterfly, rock, faucet, owl, fence, building, cat), and the task was to label each item before putting the items into a given category: animate, inanimate, or vegetation. There were just enough blanks under each heading to put the pictures above. I noticed that 'rock' was at the bottom line of the inanimate category for many of the students, and some students had erased something from the animate category. When the class teacher began the discussion of the page, I asked the students what was the level of difficulty of the page – easy, medium, or hard. They answered 'easy' and I asked what made it easy. They had several reasons. Then I asked was there any item they had difficulty categorizing. There was a long pause. Some responded 'no'. I waited just a little longer. Finally, a student answered that he had difficulty with 'rock' because in his traditional indigenous teachings 'rock' is animate. Once the students offered this view and the students saw that I was interested in his response, a rich dialogue followed on the differences in worldview we are confronted with in school. For this group of students, it may have been the first time that they could bring their cultural world into a classroom and to be accepted and understood. (Snively & Williams, 2008, p. 114)

Clearly, the talk in science classrooms involves a specialized use of the English language where student are expected to individually construct their own understandings of the concepts and language used. Scientific inquiry in classrooms also favours questioning, explaining, hypothesizing, debating, verifying and sharing results. For many Aboriginal students, these language conventions contravene their social rules of discourse.

In the context of teaching, Aikenhead and Michell (2011) postulate that when comparing different perspectives, there is a distinction between understanding and believing:

> A science teacher should feel comfortable teaching the existence of Indigenous spirituality so students can understand it. Understanding, but not necessarily believing, is the teaching objective. Such a classroom environment often resolves the fear some parents may have with Indigenous ideas, and it usually makes Indigenous students feel more included and less alienated in the classroom. The fact is, Modern Western Science and indigenous science share common ground and they do co-exist, and this should be emphasized in school science. Teaching students to believe Indigenous spirituality is the role of families, communities, and Elders. (p. 128)

In Indigenous Science, thousands of seemingly unrelated pieces of information are organized through complex webs and levels of metaphor that are utterly alien to western taxonomies. Both classification systems are valid, depending on the context and purpose for which they were constructed, and thus, both should be presented to students in the science classroom. By exploring both systems, students would better realize the context in how classification systems are designed and the purpose for developing them.

By teaching science as if it operates in a vacuum, western cultural hierarchical notions of what is worthy of respect or protection, and what is not, is consciously and subconsciously taught alongside the science. As Western scientists and science teachers rarely address what is worthy of respect and/or sacred, science students are taught about the interconnections of life from a technical point of view, but not from a reverence point of view. A growing number of scientists and science teachers argue that this technical approach to understanding the world is part of the reason why western lifestyles are so destructive to the planet. There are good reasons to engage students in exploring different ways of understanding the world.

Cross-Cultural Science Education

"Two-eyed seeing" is a metaphor for a guiding principle for one's journey here on Mother Earth. The principle, put forward by Elder Albert Marshall (Eskasoni Mi'kmaw First Nation, Cape Breton), refers to learning to see from one eye with the strengths of Indigenous knowledge and ways of knowing, and from the other eye with the strengths of western (or Eurocentric) knowledge and ways of knowing, and to use both these eyes together, for the benefit of all (Bartlett, 2005; Bartlett et al., 2012; Hatcher et al., 2009). Such thinking underlies cross-cultural approaches to science teaching referred to as "walking in both worlds," (Battiste, 2000; Cajete, 1999) "two-way learning," (Fleer, 1997) "both-way education," (McTaggart, 1991) and "border crossing" (Aikenhead, 1996, 1997). Using both the holistic IS and a WS perspective would challenge students to process information and solve problems in different ways. Hopefully, this approach would challenge students to respect alternative perspectives and build tolerance for different worldviews.

One way for teachers to begin a unit on cross-cultural science is to have the class brainstorm what they know about WS and IS as well as questions they have about the two perspectives. Together, the teacher and students should identify a set of related concepts, such as knowledge of life cycles of animals, migration routes, weather and climate change, how the environment was and how it is changing, and how humans are changing migration routes. The class could be divided into two groups—one group to assume the role of traditional science practitioners researching the knowledge contributions made by IS, and the other group to assume the role of Western scientists researching the contributions made by WS to climate change and our knowledge of changing migration routes. The groups can identify information sources and specific tasks, and begin the data collection process. As students complete their assignments, the teacher can ask each group to list the explanations and interpretations generated by their perspective, and present their findings to the class. In small groups, students could make comparisons, explore similarities and differences as well as advantages and disadvantages, and consider practical applications for combining the two perspectives.

A critical thinking approach to teaching science can be used to confront and eliminate racism, ignorance, stereotyping, prejudice, and feelings of alienation. However, designing activities that explore the two perspectives can be a challenge. Teachers need to be mindful that a balanced approach is necessary to reduce stereotyping. WS information is readily available in science textbooks, resource books, films, and the Internet, whereas IS examples may be difficult or impossible to access. In some situations, critical thinking activities can be problematic in that they can create conflicting feelings as diverse worldviews clash. “For some indigenous people, being critical can denote a lack of respect for the other and thus violate relationality, which is based on inclusive relations and acceptance of diversity” (Metallic & Seiler, 2009, p. 125). Thus, both Indigenous and non-Indigenous students must be willing and open to explore their own assumptions; there is a reciprocal relationship and a search for meaning on all sides.

Many science educators who possess strong allegiance to the superiority of WS express skepticism regarding the ability of students to produce coherent science explanations from what they learn from both systems. In terms of educational learning theory, students can produce hybridized knowledge from what they learn, creatively combining parts of both WS and IS as a situation may require (Sillitoe, 2007). From the theoretical perspective of Aikenhead & Jegede (1999), students can achieve “secured lateral learning” by holding onto both schemata even though the schemata may appear to conflict (p. 278). Some people who feel more comfortable drawing on only one of the two knowledge systems at a time, depending on the situation, can experience an alternative to hybridized understanding or secured collateral learning. This is called “parallel collateral learning,” when neither knowledge system is rejected (Aikenhead & Jegede, 1999). It seems likely that most of us live for the most part in one worldview and understand to some degree the others.

Science teachers need to be open and accepting of students’ worldviews and experiences. Instead of seeing these as liabilities, teachers can tap into the holistic and experiential worldviews of students and treat them as valued catalysts for learning. There is urgent need for more research into the ideas and beliefs of Indigenous children about nature, and how these ideas are supported by students’ culture. Teachers need to know more about worldviews other than the WS worldview they likely developed as a result of enculturation in mainstream Eurocentric society. Teachers need to understand what goes on in the minds and hearts of students when they learn science. Curriculum writers can include this new information into curriculum guides so that two worldviews can become more accessible to both Indigenous and non-Indigenous teachers. It is important to keep in mind the enormous diversity in different communities; hence, curriculum developed for one community may not necessarily transfer to another community.

It becomes imperative for us to know our students well for the purpose of building relationships that work, and for the purpose of designing pedagogical strategies that are responsive to, and honouring of, our students’ lived experiences. To enter into relationship with students whose worldview is 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.

DISCUSSION POINTS

- Have you had a difficult experience in school science when your ideas and beliefs were different from the standard account of science? What was your experience?

- Can you describe a cross-cultural science lesson that you have experienced?
- In your experience, can you describe the culturally related ideas and beliefs of students that are different from Western Science? How might a student with such ideas experience learning in a classroom where only the standard account of science is acceptable? What teaching strategies might be responsive to, and honoring of, the students' experience?

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Chapter 9 - Changing Students' Perceptions of Scientists, the Work of Scientists, and Who Does Science

Gloria Snively

Over the past two decades, several studies have focused on what children imagine scientists to be and do. The outcomes were predictable in many ways. Most children's drawings and written responses were about white male scientists dressed in white lab coats with protective glasses working alone in laboratory settings. Since the pioneering work of Margaret Mead, investigators have found pervasive, but questionable, preconceived ideas of scientists among all levels of students (Barman, 1997; Bodzin & Gehringer, 2001; Eugster, 2013; Jarvis, as cited in BBC News, 2000; Mead & Metraux, 1957). In all studies, most of the students wrote about white male scientists—a pattern that in large part continues to reflect reality. The author sought to find ways for students to see scientists as individuals in a variety of settings and times, roles, and ethnic backgrounds.

Recognizing that teachers' impressions of scientists are conveyed in the classroom and affect students in profound but subtle ways, Mosley and Norris (1999) and McDuffie (2001) explored teachers' perceptions of scientists and how those perceptions might impact student thinking. To address this question, written and pictorial data were collected among practicing and pre-service teachers. The teachers' drawings extended the longstanding view of scientists as middle aged (71%) and male (84%). About half of the sketches included scientists wearing glasses and 36% with unconventional hairstyles. Over 50% were drawn wearing laboratory coats, 40% of which had pocket protectors; and 48% of drawings showed a very serious or crazed (9%) face. One finding that received little notice elsewhere was solitude. In the drawings, scientists stood alone in an environment surrounded by objects of research (54%) or knowledge (15%); their environments almost never included other people. Scientists were described as "intelligent, hardworking, and theoretical, but also as impersonal, boring, and nerdy. They were generally depicted as stern, older white males with unkempt hair and unfashionable clothes" (p. 18). McDuffie concluded that teachers' stereotypes were the same as that of their students on most significant characteristics; their drawings of scientists did not evolve with professional maturation.

In response to the above findings, Bodzin and Gehringer (2001) used student drawings to determine if a teaching strategy, engaging a female engineer scientist in the classroom could change students' perceptions of scientists. The post-instructional data revealed a decrease in many stereotypical features after the female scientist visited the classroom. The students' drawings depicted fewer scientists wearing lab coats and glasses, and there were fewer indications of danger. Also, more female figures were drawn after the instruction. The researchers concluded that exposing girls to female scientists in an elementary school classroom may have a positive influence on their perception of careers for women in the science and engineering fields. It would appear that in many cases, teachers are unintentionally communicating a biased viewpoint and promoting a male-dominated view of science.

A study by Jarvis (2000) of over 4,000 children in Britain and Australia over eight years concluded that the "mad scientist" stereotypes continue to persist, at least among six to eight-year-olds. Alarmingly, this same study also revealed that children of Asian and African-Caribbean descent generally held the same opinions and drew similar drawings as their white peers; "boys never drew women and only very occasionally would a girl draw a female scientist....

It was also rare for a black or Asian student to draw a black or Asian scientist" (p. 2). Such findings lead us to the question: Why do children of diverse ethnic backgrounds rarely envision themselves as pursuing science related careers?

Students' drawings have continuously been analyzed to explore their impressions of scientists, but the impressions of students regarding Indigenous Science and how IS and WS are different but complementary ways of understanding the world have not. To address this void, this chapter extends the work of those above quoted authors who used student drawings to describe students' perceptions of scientists. I became interested in this idea and wanted to investigate what effect a classroom inquiry exploring Indigenous Science (IS) would have on students' perceptions of scientists, the work of scientists, and who does science.

Overview of the Study

This case study took place within the context of one week in January 2007 for the high school students, and one week in May 2007 for the middle school students. During this time, I took on the dual role of workshop provider and educational researcher. One day was required to collect the pre-workshop data, three days to present the Indigenous Science workshop, and one day to collect post-workshop data. The study was designed to investigate and describe the following before and after instruction:

- the students' perceptions of scientists
- the students' perceptions of the work of scientists
- the students' perceptions of who does science
- the students' perceptions of Indigenous Knowledge as a productive form of science

The study took place in two schools located in Victoria, British Columbia (BC): one class in an elementary school consisted of 23 students (11 boys and 12 girls) at the Grade 6/7 level, with one student of Aboriginal ancestry and one student who was a recent immigrant from South Korea. The second study took place at a high school and consisted of 22 students—6 boys and 16 girls. The population is of special interest because seven of the students were of Aboriginal ancestry—1 male and 6 females; all were from British Columbia and from a range of life experiences—from those who had grown up in urban centres such as Victoria to others who had lived in traditional rural communities until entry into high school. The students were taking the First Nations Studies 12 course, which explored the history and culture of the Aboriginal peoples of Canada.

The study methodology consisted of the students' scientist drawings, tape-recorded class discussions, post-instructional drawings, and tape-recorded teacher interviews. To understand the students' perceptions of scientists, I asked students to draw a picture of a scientist and write a sentence explaining what the scientist was doing. I added questions directed at revealing the students' perceptions of science, the work of scientists, and what type of person does science. Each class completed this activity prior to the instructional workshop and then completed a modified set of questions and drawings after the workshop.

I developed a set of criteria for analyzing the students' drawings: e.g., lab coat, gender, laboratory setting. In addition, I developed a set of questions to explore the students' perceptions of Indigenous Science knowledge and their interest in pursuing science-related careers.

Students were asked to identify as male or female, but they were not asked to reveal their ancestral identity. Because several high school students were of Aboriginal ancestry, they were asked to make up a name (a pseudonym), thus to some extent limiting our understanding of the thinking of the Aboriginal students as a group. The researcher felt that by not requesting their ancestral connections, the students would be provided a safe research environment, thus enabling some students to reveal their often hidden viewpoints. However, the researcher was able to identify four Aboriginal students by recalling the drawings they drew during the workshop and data collection sessions.

The teachers were interviewed both prior to and after instruction. In addition, I took notes and recorded my reflections following my teaching. Interpretive analysis using students' drawings, word-for-word discussions, and responses to questions seemed appropriate because it focused on documenting what and why things happen in a particular context from the participant's perspective.

I presented a three-day workshop (3 X 80 minutes) for students at both schools. The workshop provided a basic overview of Indigenous Science, as well as science-inquiry activities illustrating Indigenous Science examples.

Students' Perceptions of Scientists Prior to Instruction

The students' drawings extended the long-standing view of scientists as male with lab coats, most often wearing glasses, and working in stereotypical lab settings. Fifty-seven percent of the Grade 5/6 students and 85% of the Grade 11/12 students drew male scientists. Forty-three percent of the Grade 5/6 students drew a female scientist and the majority of those drawings depicted young female scientists. Eight of the 12 elementary girls drew female scientists, and all 11 boys drew male scientists. Significantly, from post-instructional interviews with the middle school teacher, it was learned that two months prior to my visit, a female biologist had visited the classroom. It appears that a visit by a female scientist may have contributed to the large proportion of girls who drew female scientists. The high proportion of Grade 11/12 students who drew male scientists is alarming given the high proportion of females in that study (16 females and 6 males).

Figure 9.1 ▲ *"He is at a lab making chemicals and writing down the results. He is Albert Einstein." Drawing by Grade 5/6 male student* (2007).

As in previous studies where the great majority of students drew scientists with stereotypical symbols of research, 91% of the Grade 5/6 students and 75% of the Grade 11/12 students drew stereotypic features such as laboratory tables, flasks, test tubes, microscopes, chalk boards, formulas, clocks, and so on. Compared to previous studies, fewer students in both 2007 studies drew scientists as mythic figures. One high school student referred to Frankenstein in the caption and one middle school student drew Albert Einstein (Figures 9.1 and 9.2).

Figure 9.2 ▲ *"This scientist is hard at work with a new invention. He is in his office putting together formulas and cooking up new concoctions." Drawing by Grade 11/12 female student (2007).*

As in previous studies 55% of the Grade 11/12 students depicted indications of danger, but only 22% of the Grade 5/6 students included indications of danger. Indications of danger included the use of fire to bring about chemical change, chemicals that could explode, and robots that could go out of control. This smaller percentage of middle school students could reflect the greater proportion of female scientist drawings where danger was not a significant influence.

Similar to previous studies where the great majority of students depicted scientists as Caucasian, 100% of both the Grade 5/6 and the Grade 11/12 students appeared to depict scientists as Caucasian (nothing in the drawing or caption suggested a person of ethnic ancestry other than Caucasian). Fifty-two percent of the Grade 5/6 and 55 percent of the Grade 11/12 students depicted scientists as middle aged to elderly.

As in previous studies where the great majority of students drew their scientists indoors, 96% and 90% respectively drew their scientist indoors. Two exceptions were one Grade 5/6 male who drew his scientist outside "collecting rocks to study, or trying to find new specimens," and one Grade 11/12 male who drew his scientist outside making a dugout canoe. Although a small proportion of students in previous studies viewed scientists as secretive in nature, zero percent of the 2007 students appeared to view scientists as secretive.

Of the eight Grade 5/6 girls who appeared to draw female scientists, the hairstyle or dress suggested female and/or the caption specified female, three depicted engagement in making medicines to find cures for diseases such as cancer or AIDS (Figure 9.3), one was "making vitamin pills," one was "inventing new types of foods," and one was "experimenting with surface tension." One female scientist was "taking a test to help stop global warming. She is doing it so that her kid can live in a non-polluted world." One female student stereotypically appeared to mimic the boys and drew a female scientist "mixing chemicals to see what would happen."

Figure 9.3 ▲ "My scientist is making medicine to stop all kinds of cancer." Drawing by Grade 5/6 female student (2007).

Of the two high school students who appeared to draw female scientists, one was "making fire," and one was "making medicines from herbs." Additional captions included "finding a way to burn garbage instead of putting it underground" and "doing an experiment on a rock that fell from space."

In short, prior to the instructional workshop the image of the "mad scientist" was alive and well amongst boys in both the middle school and high school classroom. Boys much more frequently than girls favoured the "mad scientist" stereotype, and much more frequently depicted scientists doing chemistry experiments. Girls, far more frequently than boys, viewed science as a tool for curing diseases, enhancing foods, or protecting wildlife and healing the earth.

Similar to previous studies, a significant majority of middle school boys and high school boys and girls thought of scientists stereotypically as Caucasian, male, middle-aged or aging, working alone indoors in a lab setting, surrounded by beakers, test tubes and microscopes, and most often performing chemistry experiments. Since seven of the Grade 11/12 students were of Aboriginal ancestry, this stereotypical image of scientists, the work of scientists and who does science was of particular concern.

Students' Perceptions of Science

Prior to instruction, I asked the students to respond in writing to the following question: What is science? The following word-for-word student responses reflect the students' thinking about science:

- "An activity for discovery. Doing experiments. The nuclear bomb." (Grade 5/6 male).
- "A mad scientist. Doing chemistry." (Grade 5/6 male)
- "Science is the truth, like things that scientists have proved." (Grade 5/6 male)
- "Science is a logical explanation or formula for why and how things happen and creating new ways to make things happen" (Grade 11/12 female).
- "Science is a mathematical or logical way of looking at the world. It seeks to find the truth." (Grade 11/12 male)

Not surprisingly, high school students, far more frequently than middle school students, defined science as subject areas: biology, chemistry, earth science, and physics.

In addition, the students were asked to respond to the question: "What do scientists do?" Or, in different words, "What is the work of scientists?" Some of the students responded:

- "scientists' jobs take them from blowing things up to writing essays." (Grade 5/6 male)
- "science proves things are right or wrong." (Grade 5/6 female)
- "takes things apart to give us better knowledge." (Grade 5/6 female)
- "makes life easier by inventing stuff." (Grade 5/6 male)
- "looks for cures for diseases." (Grade 5/6 female)
- "science tests theories and develops new technologies." (Grade 11/12 male)
- "tests DNA and medicines." (Grade 11/12 female)
- "makes sure the ecosystem is sustaining." (Grade 11/12 female Aboriginal)
- "make robotics, do chemistry and exploration activities." (Grade 11/12 male)
- "if you don't understand something, you can control it." (Grade 11/12 male)

Students' Perceptions of Indigenous Science

Prior to and after instruction, I asked the students to respond in writing to two additional questions: Is Indigenous Knowledge science? Or, in different words, do Indigenous peoples have their own science? Of the 23 Grade 5/6 students, eight responded "yes," 12 responded "no," and three responded "I don't know." Of the Grade 11/12 students, 10 responded "yes," six responded "no," and four responded "I don't know." If students responded "yes" that Indigenous Knowledge is science, they were asked to explain their reasoning. The following responses represent the thinking of these students prior to instruction:

- "They had the first science on the continent." (Grade 5/6 female)
- "They have science because they created medicines." (Grade 5/6 female)
- "Jessie is a Native student and he does science." (Grade 5/6 male)
- "They had some awesome medicines even when the first European explorers came." (Grade 11/12 female Aboriginal)
- "They used theory and geometry to make canoes." (Grade 11/12 male)
- "They did because their observations in the environment helped them survive before the Europeans came." (Grade 11/12 female)
- "The Elders are the ones with knowledge of certain plants that heal injury." (Grade 11/12 male Aboriginal)

The following represent the students who responded "no" to the question, "Do Indigenous peoples have their own science?"

- "I don't think they did have science, no offense, I think they just dance around fires all day." (Grade 5/6 male)
- "I haven't heard of any." (Grade 5/6 female)
- "Indigenous knowledge is not science even though it is helpful to society. Everything has been researched or discovered. There is nothing new to learn." (Grade 11/12 male)

The students who responded "yes," that "Indigenous people have science," were asked to draw a picture of an Indigenous person doing science and to write a caption explaining their illustration.

Figure 9.4 ▲ *"The girl is cooking dinner by starting a fire and drying fish. She is waiting for the men to come home from hunting." Drawing by Grade 5/6 female student (2007).*

Prior to instruction, the great majority of both Grade 5/6 and Grade 11/12 students' drawings of Indigenous Science depicted traditional knowledge in outdoor settings much of which would be typical of the traditional past: "harvesting plants for medicines," "making a canoe," "carving a fishing spear," "making a net," "rubbing a rock and stick together to test out fire," "looking at the sky to determine the weather," "using a harpoon on a string trying to get fish," and "picking berries," and often stereotypically with teepees in the background, a head band with a feather, and in outdoor settings. Interestingly, four drawings featured teepees even though teepees are not typical of traditional Aboriginal housing in most of British Columbia—only southeastern BC (Figure 9.4).

It would appear that prior to instruction, the great majority of Grade 5/6 students did not view Indigenous Knowledge as science and did not think Indigenous people had contributed to the body of knowledge that we commonly refer to as "science." The fact that eight of the 23 middle school students acknowledged Indigenous Science likely reflects the recent changes to the BC science program that includes at least some examples of Indigenous Science knowledge in the elementary program. Interviews with the Grade 5/6 teacher after instruction revealed that these students had been exposed briefly to examples of Indigenous Science knowledge as part of the new BC science curriculum. The fact that eight students who acknowledged Indigenous Science depicted traditional examples suggests that much work needs to be done to bring the inclusion of IK and IS into a modern context.

The fact that 10 of the 22 high school students acknowledged Indigenous Knowledge as science is an indication that many students of Indigenous ancestry enter high school science classes with the anticipation that cultural science will be recognized. Many of these students came from communities with strong traditional cultural connections. This prior understanding of cultural science suggests that teachers need to acknowledge that Indigenous peoples have and continue to participate in science, and incorporate examples of Indigenous Science into the discussion.

Indigenous Science Workshop

Students in both classes were visited by the researcher and invited to participate in the Indigenous Science workshop. I was introduced by the teacher as a non-Indigenous university professor in science and environmental education who had engaged in Indigenous education for 35 years.

On the first day of the workshop, I engaged the students in a discussion about what they thought about science, the work of science, and who does science. I asked the students if they knew of any examples of Indigenous Science. One Indigenous student was a recent immigrant from India and shared his knowledge of the Neem tree as an ancient source of medicine. Several Aboriginal students shared their knowledge of medicinal plants, fishing and harvesting methods, and Aboriginal astronomy.

After a 15-minute introductory discussion, I presented a powerpoint interactive talk illustrating and describing many additional examples of IS knowledge such as food cultivation, fish enhancement and transplanting practices, medicinal examples and the Nisga'a fish wheel. As well, wisdom practices that result in sustainable communities and environments were discussed—such as not taking more fish than you can eat and saying a prayer of thanks to the salmon for providing abundant food.

On day two, I began the dentalium inquiry activity by showing a powerpoint presentation that described the intriguing story of dentalium shell money; how the dentalia shells were used as a true currency by Indigenous peoples across much of North America prior to contact with Europeans, and as a currency during the Pacific fur trade.

I posed the question: "If the dentalia lay as deep as records indicate—100 to 150 feet below sea level, how did the traditional Ehattesaht and Quatsino people of Vancouver Island, BC locate and harvest the dentalia?" The students soon realized that this was a depth too deep and the water too dark for traditional divers to see and hold their breath, and the water too cold to sustain a diving operation.

After much discussion, I challenged the students to work in groups and design on paper an implement and/or procedure for harvesting dentalia shells in sufficient quantities to sustain a far-reaching currency trade. The students were intrigued and had many ideas and questions.

Figure 9.5 ▲ *"The Super Catcher. A. 200 ft seal rope. B. 100 ft wood stick. C. 14 cm long/wide wood cage. D. Dentalia. E. Bait. F. Canoe bottom. Put bait in the cage. Close the door and grab the rope. Drop the cage till it hits the bottom. When you think there's a dentalia, drop the stick that closes the door and pull the rope to get the cage." Drawing by Grade 6/7 student (2007)*

Day three of the workshop had the student groups reporting back to the class their method for collecting dentalium shells (Figure 9.5). A more complete description of the dentalia shell money story and the instructional strategy is described in Chapter 11.

The Students' Perceptions after Instruction

After instruction, I again asked the students to respond in writing to the same question: Is Indigenous Knowledge science? Or in different words, do Indigenous peoples have their own science? Table 9.1 below represents the students' responses prior to and after instruction.

Table 9.1 The Student's Perceptions about Indigenous Science

Do Indigenous peoples have their own science?				
Pre-instructional:	Yes (8)	No (12)	I don't know (3)	Grade 5/6
After Instruction:	Yes (16)	No (1)	I don't know (4)	Grade 5/6
Pre-instructional:	Yes (10)	No (6)	I don't know (4)	Grade 11/12
Post Instruction:	Yes (14)	No (2)	I don't know (2)	Grade 11/12

The following "yes" responses illustrate the students' thinking after instruction:

- "Indigenous people have science too, but a different kind of science." (Grade 5/6 female)
- "They had to have science to survive in the woods." (Grade 5/6 male)
- "They made observations and built models like the dentalium catcher." (Grade 5/6 male)
- "They have to make observations and assumptions like scientists." (Grade 11/12 female)
- "The Aboriginal people are full of genius science and wisdom." (Grade 11-12 female Aboriginal)

The students who responded "yes" after instruction were asked to draw a picture of an Indigenous person doing science (Figure 9.6). Several Grade 5/6 students continued to draw illustrations of Indigenous people in traditional situations in the past. However, a greater proportion of students in both classes drew Indigenous people involved in Western Science activities, or some combination of traditional and Western Science, and more often in modern settings. For example:

Figure 9.6 ▲ "The Aboriginal scientist is mixing herbs and chemicals to see what will happen." Drawing by Grade 5/6 female student (2007).

Additional pictures and captions include the following:

- One student drew a girl (with a feather in her hair) in a cornfield and wrote, "My picture is about an Aboriginal girl harvesting the corn. She is trying to discover why the corn isn't growing as tall and as sweet as it had done last year. She is taking soil samples back to her village so they can test it for nutrients." (Grade 5/6 female)
- One student drew a person in a lab setting and wrote "The Aboriginal scientist is picking up a new chemical and is about to send it to the company that decides if it's OK to drink." (Grade 5/6 female)
- One student drew what appeared to be a female walking along a seashore and wrote: "Discovering new species, looking and observing, taking notes about animal behaviour." (Grade 11/12 female)
- One student drew a male scientist in a lab setting and wrote, "This Aboriginal person is making medicines from plants. Maybe he would like to study dinosaurs or go on geological digs." Grade 11/12 male)
- One student drew what appeared to be a female Aboriginal person (with black pigtails) in knee-high rubber boots and wrote "A marine biologist is looking at a shell." (Grade 11/12 female Aboriginal)
- One student drew a female in a kitchen and wrote, "She collected some leafs from the forest and now she is about to test it. She is making a traditional medicine which is used for malaria." (Grade 11/12 female Aboriginal)

- Another student drew seaweeds, plants, and a pot on the stove with the caption: “Studies of plant technology and traditional medicine.” (Grade 11/12 Aboriginal female)

A male Aboriginal 11/12 student drew a stereotypical Caucasian male scientist in a lab setting prior to instruction. After instruction, he drew a male scientist in the forest and wrote, “The scientist this time is an Aboriginal, or scientist, who studies trees and their effect on the environment.” When asked if he had participated in some way with Indigenous Science prior to the workshop, he wrote:

> My grandmother and my mother taught me some years ago how to recognize herbs used for cooking and medicine. ‘Best advice: eat only what you have seen a bird or another animal eat before.’ I would like to be involved with Indigenous Science because it comes with knowledge and experience that modern scientists are only beginning to understand.

The post-workshop data revealed an interesting mix of drawings and captions. Fewer students in both groups continued to draw stereotypical features of the “mad scientist.” All boys in both groups continued to draw what appeared to be male scientists (nothing indicated femininity), and the majority of girls in both groups appeared to draw female scientists. Significantly, a much greater proportion of drawings depicted examples of IS in modern settings—more often in the outdoors and in community situations, researching solutions to current environmental or health-related problems.

As part of the post-workshop data collection, I asked the students where they got the idea that scientists “wear white lab coats,” “blow things up” and are connected to images like Frankenstein. The students recalled watching cartoons or movies that were about scientists in white lab coats, working in science labs, with hair and glasses like Einstein, inventing bombs or Frankenstein-like images.

Lastly, I asked if any of the students had or would consider a science-related career. The following table represents the students’ responses:

Table 9.2 The Student’s Interest in Pursuing Science-related Careers

No Response	Yes Response	Maybe Response	Grade
(18)	(2)	(1)	5/6
(18)	(0)	(0)	11/12

Science was frequently viewed as “too much work,” “too boring,” “too complex to understand,” “I’m not intelligent enough,” and “I wouldn’t enjoy it.” One student wrote, “scientists do horrifying things like create climate change,” and one wrote, “scientists are very anti-religious.” Two students wrote positive comments: “It’s a lot of fun” and “You might be the first to discover something.” This finding is consistent with the work of Jarvis (2000), who concluded that many children do not want to be scientists because “scientists never have fun.” Although increasing students’ interest in science careers was not an intended outcome of a 3-day workshop, the lack of interest in science careers from both middle school and high school students was disappointing, although not surprising.

In analyzing students’ drawings, we have to ask ourselves whether they drew scientists as eccentric nerds working alone in a lab because that is what they think scientists are really like, or because that is what they think we expect them to draw. We must also ask whether students refrained from drawing Aboriginal people involved in science activities prior to the workshop because they thought we expected them to draw Caucasian scientists. Many students have learned to "play the game" of school science and this caveat must be acknowledged.

Nonetheless, it appears that the Indigenous Science workshop influenced the students' perceptions regarding scientists, the work of scientists, and who does science. The workshop provided students the opportunity to explore science from a multi-science perspective, engage in an Indigenous Science/technology problem-solving activity (the dentalium activity), and identify science knowledge required by the successful Indigenous practitioner. Their beliefs about science and science stereotypes were challenged. The workshop showed students how Indigenous peoples have always practiced forms of science and are involved in the world around them. Students enjoyed doing science from an IS perspective, and there were some serious, thoughtful changes in their ways of thinking.

Points of Resonance

Clearly, scientists have an image problem. The scientist all too frequently has an extremely intelligent, nerdy, and condescending personality. The question arises, where does this image problem come from? Research has shown that there are a number of influences on an individual's perceptions of what a scientist is, including school curriculum, children's literature, television, movies, cartoons, comic books, and the print media (Eugster, 2013). A bad image hurts scientists on many levels. Students with a poor image of scientists may be dissuaded from pursuing science as a career, and they might not see the relevance of science to their everyday lives.

Long and Steinke (1996) analyzed four children's science television shows: *Breakman's World*, *Bill Nye the Science Guy*, *Mr. Wizard's World*, and *Newton's Apple*. They found that these shows presented mostly a positive view of scientists by showing a wide variety of people (including women and minorities) taking part in science, and that it can be fun. They also avoided evil or dangerous images of scientists that are often found in children's literature. They noted however, that white males were still the predominant main characters and some characters had eccentric and antisocial characteristics.

One recent television study of Grade 7 female students showed a surprising shift, with 50% of the participants drawing a female when asked to draw a scientist (The Scientist on Camera, 2006). This is in sharp contrast to Barman's 1996 work on children's images of scientists. The authors suggest that TV programs such as CSI, which show male and female scientists as equals and science careers in positive light may be responsible, at least in part.

After reviewing the literature (Eugster, 2013) concluded that despite efforts to modernize the curriculum, elementary school children still see scientists as white, male and eccentric, and children's literature generally reinforces this stereotype. Interestingly, researchers gave television the greatest credit for portraying scientists accurately and positively. As Eugster (2013) suggests, "the majority of scientists are intelligent, passionate, dedicated, amusing people, and if the portrayal of scientists continues to become more and more accurate, then the general public's perception of who scientists are and what they do will only become better" (p. 3).

Much research has illustrated that most students become "turned off" to science around the middle grade years and thus, fewer and fewer individuals later enter science and science-related careers. The perceptions students hold of scientists and the work they do are often cited as significant contributing factors to this situation (Finson et al., 2006, p. 13).

Thus, students' perceptions of scientists are developed early, and although they may change with significant life experiences, they are often resistant to change. We might rightly conclude from such studies that in order to capture children's interest in the sciences, it would be important to capture their imagination prior to the age of 11 or 12, before they have made up their minds not to cultivate an interest in science.

We should not be surprised that students of Indigenous ancestry find it difficult to envision themselves as future scientists. They are told, directly or indirectly, from an early age that Indigenous people have never had science, that Indigenous people don't "do" science, and that scientists are an elite group of privileged nerds wearing white coats who spend their days alone, inside in a laboratory, conducting boring research and blowing things up: the message is inculcated––science has nothing to do with their lives.

Cultivating a Multi-Science Approach

Teachers play a central role in sharing and creating perceptions and stereotypes about science and scientists. Teachers need to be made aware of the stereotypical images they hold and may convey to their students. Examining students' drawings of scientists is one way of enabling teachers to become aware of their students' stereotypes in a time-efficient manner while reflecting upon avenues of possible instructional change. In addition, teachers must abandon their own stereotypical views of science and scientists if we hope to encourage girls, Indigenous students, and other minorities toward careers in the sciences.

Using Indigenous role models, teachers should provide information and help to design experiences to build more realistic, multi-cultural images of scientists and their work. Some instructional enhancements include providing knowledgeable guest speakers (Elders, Indigenous scientists, female scientists, and scientists from a range of backgrounds—Chinese, Japanese, East Indian, Christian, Hindu, Muslim, etc.) who are able to communicate with teachers and students. Exploring how science (including WS) is practiced in different societies provides students with a more diverse orientation to science.

Another less direct level of intervention includes research projects involving scientists, the study of science-related Indigenous biographies, and more investigation involving the science of different cultures. Additional strategies include role-playing, discussions, reading and writing about scientists at work. Also, direct discussions about stereotypes in the media are also valuable.

An additional consideration for teacher educators is career awareness. There are many jobs in which science and engineering are important, including: car mechanic, dental hygienist, veterinary, electrician, landscape gardener, master chef, wildlife conservationist, nurse, fire chief or weather forecaster. Helping children of Indigenous ancestry understand that Elders want their children to pursue science-related careers, and that Indigenous communities are critically short of Indigenous science teachers, as well as biologists, engineers, geologists, nurses, etc., may help create positive images of scientists. Internet connections with scientists (both Indigenous and Western scientists) and working on collaborative projects with scientists are other ways students can engage in doing science. Such activities help students understand that Indigenous and Western Science are distinct yet equally valid paths that can be walked upon in order to generate understanding. Also, students need to understand that scientists are ordinary people—intelligent, humorous, with a range of hobbies, often with deep family ties, and engaged in serious and important work in the lab, on the land and in the community.

DISCUSSION POINTS

- Before reading this article, ask the students to draw a picture of a scientist at work. Write a caption explaining what the scientist is doing. Share their drawings with a partner. Analyze the drawing in relation to symbols, gender, ancestry, indications of danger, working indoors, etc.
- Explore ways teachers may influence perceptions of scientists as ordinary people rather than nerds.
- Draw a picture of a scientist at work. Then invite a scientist into the classroom (a female scientist, an Indigenous scientist, etc.). Draw a picture of a scientist after the visit to the classroom. Discuss.

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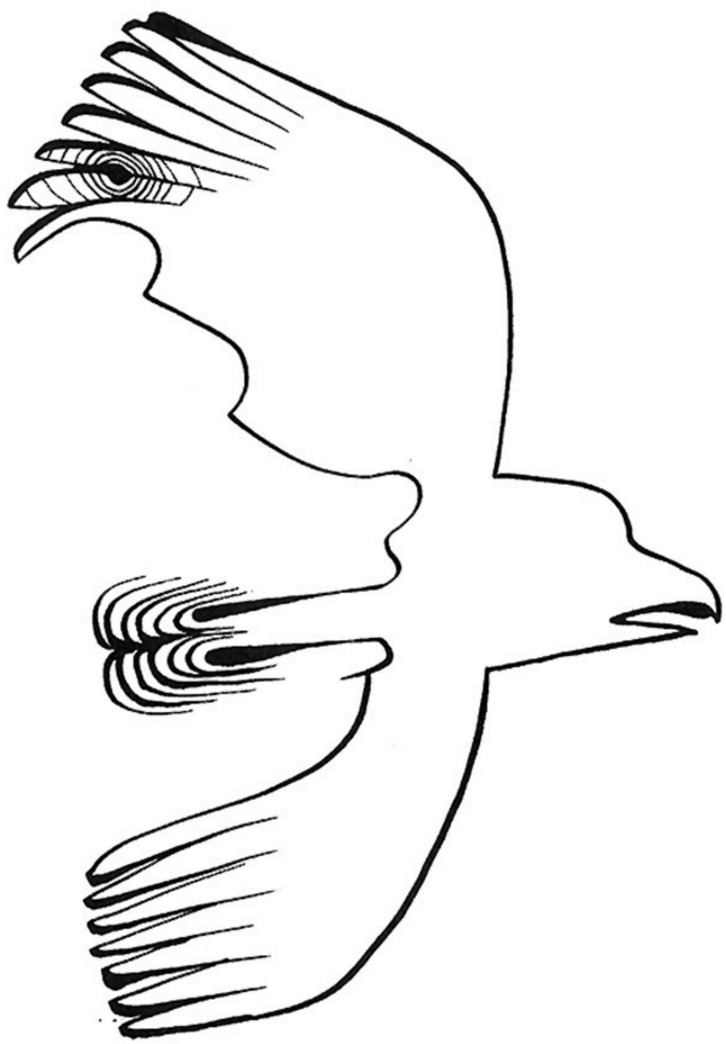
PART IV

INDIGENOUS SCIENCE CURRICULUM



"Untitled." Drawing by Laura Corsiglia. Reprinted with permission from (2001) Our Thang: Several Poems, Several Drawings, p. 87. Victoria, BC: Ekstasis Editions.

Chapter 10 - Seasonal Wheel

The Kwakwa̱ka̱‘Wakw Ebb and Flow of Life

G̱wixsisa̱las Emily Aitken

One of the most influential messages that Indigenous Knowledge carries for all of us is to create and sustain bonds of kinship with the place where we live—the land, rivers, forest, oceans, water, rocks, fire, and air around us. The berry-picking season, the return of the salmon, the birth of a child, the blossoming of wild crabapples, are just a few examples of natural events that humans celebrate through dance, music, ceremony and stories. Every place has its own set of seasonal events that nature unfolds every year, and creating a seasonal wheel is one of the easiest and most effective teaching tools to help students have a relationship with their home-place. Developing a seasonal wheel is a highly adaptable project suited for classes of various sizes, grade levels and cultural backgrounds.

A Kwakwa̱ka̱‘wakw Seasonal Wheel

A Kwakwa̱ka̱‘wakw seasonal wheel includes four seasons, which in Kwak’wala is mu’a̱nx̱. Within the seasons is a specific time for what is being harvested such as wa’a̱nx̱ (herring season). **A̱‘a̱nt** (herring roe) is gathered when the herring spawn, either on **sa̱ya’sa wawadi** (kelp hair)—the old ones referred to herring on kelp as **ḵa̱xk’a̱lis a̱‘a̱nt**—or on hemlock or cedar branches purposely placed along the shore or anchored directly in the midst of the spawning area. The gathering and drying of an important seaweed ła̱ḵ‘a̱x̱sta̱n (red laver) takes place during the middle of spring. The harvesting of ła̱ḵ‘a̱x̱sta̱n corresponds with the arrival of the first sac’a̱m (spring salmon). It is then that the fishing season starts and all the other species of fish follow: the małik (sockeye), hənun (pink salmon), g̱a̱xwa (steelhead), and p’o’i (halibut). Many other sea creatures are harvested over the spring, summer and fall, such as a̱m’da̱ma (small sea urchin), a̱‘las (red sea cucumber), and ḵ‘umis (red rock crab).

One of the important shellfish gathered during the spring and fall is gawiq̇anəm (butter clam) and the act of gathering clams is gagawiqa. Clams were kumaci (smoked) or steamed in the shell just as they are now. Many other plants and animals were and continue to be harvested for nourishment, shelter, clothing and art.

The winter was a quiet time of not having to gather and prepare for the winter months, and was a time for celebrating. There were feasts centred on specific foods to celebrate the wealth of the harvest. Of those feasts, the two most important were the t’łinagila (oolichan grease feast), where it continues to be given to the guests (literally “oolichan grease getting”), and t’alsila (high bush cranberry feast), where it is given to the guests (“cranberry getting”). The cranberry feast is no longer celebrated because our bogs have been drained or filled to such an extent that wild cranberries are no longer abundant. Yewixila la̱x̱a c’a̱‘wa̱nx̱ (going to the winter, “giving season”) is how the old people announced the ceka, now referred to as a potlatch. The ceka was most likely the highlight of c'a̲'wa̲nx̲ (giving season) as it was a time for giving away much of what is owned, if not all. There were other feasts called k'wiła (splitting apart or dividing) such as a naming ceremony for a baby and for some tribes it was when the baby reached the age of ten months. The marriage ceremony in Kwak'wala, called k̲adzitła, most often happened at the same time as the winter ceremony.

Seasonal wheels might show how much or how little the seasons may have shifted and this can be illustrated with more than one wheel of the same area from different years. Perhaps if one was to create a seasonal chart for the past two years, the wheel might be quite different from the previous year's wheel, especially dzaxwila, the time of harvesting oolichan. Still, the one constant for all the nations of the Kwakwa̲ka̲'wakw, no matter where they live, is that they have harvested oolichans at Dzawadi (Knight Inlet) since time immemorial.

The seasonal wheel in Figure 10.1 includes the plants and creatures of the ocean, the beach, the river and the forest. Information that informed the seasonal wheel came from tape recordings and written documentation of a generation of Kwakwa̲ka̲'wakw people born in the late 1800's to early 1900's, from research by Turner and Bell (1973), the Kwakiutl District Council, and Turner (2005), from other charts gathered throughout the years and from researching the writings of George Hunt and Franz Boas (1921, 1930).

Developing a seasonal wheel is a good way to introduce the medicinal plants of a home-place. There is an abundance of medicinal plants utilized by the Kwakwa̲ka̲'wakw. One of the most commonly used plants even to this day is pans'ani laxa xak'wama yasa mumuxwda'ams (gum from the bark of the balsam tree), which is used as a cure-all tea. Those who harvest these medicinal plants and prepare them for use believe that medicinal plants are sacred, and the harvesters do not share their craft unless they are mentoring the next generation of medicine practitioners. It would be wonderful for students to have a general idea of the best time for harvesting specific plants and how to make selected medicines.

The original Figure 10.1 of the Kwakwa̲ka̲'wakw Seasonal Wheel was poster-sized and was developed for use with groups of students or with the whole class. Once your students have collected information related to a local Aboriginal culture, you can use chart paper to modify the poster in specific ways to depict animal life or plant life from the forest, ocean or an inland water source. When creating a seasonal wheel, both languages (Kwak'wala and English) could be used, but start with the Indigenous way of marking seasons and then add the English. A lesson could include comparing the differences between bakwa̲m (Indigenous Science) and Western Science, and what is common to both.

One of the most important "plants" of the Kwakwa̲ka̲'wakw that is not depicted in Figure 10.1 is the red cedar tree. There is a cycle for harvesting various parts of the tree depending on the tree's location and elevation on the mountain. In the spring, when the sap runs, is the time of bark stripping and the gathering of its roots. When the ground is dry in late summer and fall, red cedar roots continue to be harvested. The time for making cedar baskets is during the winter months when rain or snow storms blow. A wheel could be created for all the plants on land and sea used by the Kwakwa̲ka̲'wakw with a focus around the red cedar to see the seasonal patterns of life.

Create Your Own Seasonal Wheel

When collecting information for a seasonal wheel, you need to decide what kind of information you want to include and then observe the course of nature and collect the required information. Engage your students in observing nature firsthand and keeping a field notebook to record changes in plant growth, animal migrations, or harvesting times over the course of several weeks or months. You might want to have students interview Elders and knowledge keepers, or invite a knowledgeable Elder into the classroom. When not observing in real time, the students could conduct research on the internet or in local cultural archives to find information on the same topic from years past. Once the class has collected the appropriate information, draw a large circle on chart paper or on the blackboard. Engage the students in discussion, and from the students' comments, place the information on a circle or wheel.

Seasonal wheels can be made to illustrate traditions and ceremonies practiced by an Indigenous family or nation. Ask the students which seasonal traditions they observe, and record their answers on a chart. What kinds of traditions or activities do they do once a year? What do they do in the spring, summer, fall and winter? Why are these activities important? If possible, read aloud a story that illustrates seasonal traditions practiced by an Indigenous family.

Seasonal wheels can be made by all age levels from preschool, throughout middle school and high school. Preschoolers and elementary school students could make a seasonal wheel of the fun things they do during the different times of the year: camping, fishing, swimming, checking trap lines, ice fishing, sledding or carving masks. Photographs of students engaged in these activities add interest and excitement for preschoolers and beyond. Teachers could, with the help of language teachers, add words in the appropriate Indigenous language, and engage the students in speaking the language.

A fun project would be to have each student create his or her own seasonal wheel of the things they do over the year. Remember to always include the year, or create a whole new wheel for each year, recording the life and interests of the students. It's a project that could continue throughout the life of a child. What a great legacy for future generations!

Teachers could make a large mural-sized project of the local community involving an entire class or school and display it in the school or community centre hallway or large wall, or posters could be made by different grade levels.

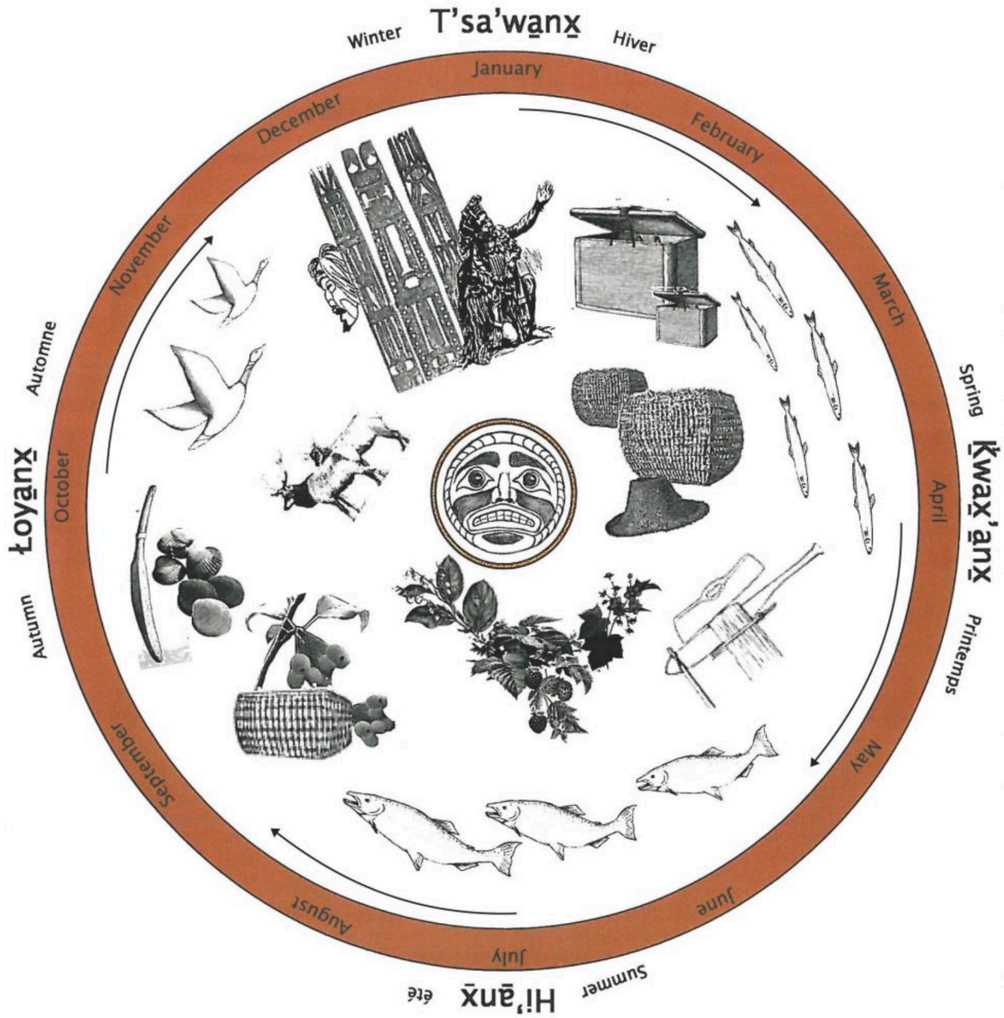


Figure 10.1 ▲ Seasonal wheel chart. Illustration by Emily Aitken (2004).

Seasonal Wheels Depicting Cycles of Nature

Becoming familiar with the local patterns of natural events gives people a greater appreciation of the importance, uniqueness and beauty of their home-place. The best source of information is nature herself. Watching her for an entire annual cycle or two will help sort out what kinds of topics to include in your seasonal wheel. Teach the students to keep their eyes, ears, and noses attuned to the sights, sounds, and smells of nature.

If you live by the seashore, a wonderful project would be to create a seashore seasonal wheel using papier-mâché creatures to depict seashore critters and arranged on a wooden circle, possibly a cross-section of a tree. Older students might create an ocean seasonal wheel illustrating the life cycles of marine creatures from birth to adulthood.

Other seasonal wheels could be made for the seasonal changes in a pond, lake, bog or forest. Young children might make a simple seasonal wheel illustrating the life cycle of a frog, a butterfly, a salmon or the seasonal cycle of an oak tree or maple. The possibilities seem endless.

Cross-cultural and Multicultural Seasonal Wheels

A seasonal wheel often reflects your worldview, what you find important, and what touches your heart. Although this article was created from a Kwakwaka'wakw worldview, all peoples from all walks of life can participate in the making of a seasonal wheel, whether it is created in a group or individually. If you have a mix of students whose ancestry is from different cultures, you might want to have the students create a seasonal wheel that represents customs from other cultures. Such activities enable all students to feel accepted and know that their histories, culture and customs are accepted and appreciated.

Sources of Information

Here is a list of knowledgeable persons and resources that could be of assistance with the creation of your seasonal wheel:

- Elders and knowledge keepers,
- museums, historical archives, libraries,
- tribal, local government office, language and culture teachers,
- local high school biology, environmental education teachers,
- artists, musicians, and drama teachers who can be helpful in designing the final product, and
- local field guides to trees, shrubs, flowers, birds, and forest animals.

A Seasonal Wheel Never Goes Out of Date

A seasonal wheel can be carried over for a number of years or for a much shorter period of time. The finished product never goes out of date and can always be updated in successive years. A seasonal wheel can show the communities' seasonal activities 500 years ago, 100 years ago, 50 years ago, today, and how the seasons are changing. In the past, people knew that the seasonal changes didn't change much from year to year. They knew when to walk the stream beds, what plants would be in bloom, and what animals would be migrating through. In our modern world, change is accelerated and it could be important to discuss how climate change, resource depletion, and changes in ice conditions are significant changes affecting all of us. You might have two or three wheels that you can place one on top of another using clear overlay to see if the past and present are different or if it remains the same. For this type of comparison each layer might be a different colour. Printing them out separately would work too.

La men gwal gwagwixs'ala laxux (I am finished sharing about this).

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Chapter 11 - Money from the Sea: A Cross-cultural Indigenous Science Problem-solving Activity

Gloria Snively

One way of engaging students in authentic cross-cultural science inquiries is to challenge them to solve a science and technology problem that would have presented itself to pre-contact Indigenous peoples. The following fun-filled activity is one of several that I use to engage students in lively discussion on the contributions that Aboriginal peoples have made to the sciences. I introduce the activity by telling the intriguing story known to west coast Aboriginal peoples and historians as "Money from the Sea" (Snively, 2009).

Dentalium Shell Money Story

For 2,500 years, until the early 20th century, North American Indigenous peoples used the dazzling white cone-shaped shell of a marine mollusk as currency. *Dentalium pretiosum* is a 5 to 7.5 centimeter long mollusk of the class *Scaphopoda*, a group also known as tusk shells because of their slightly curved, conical shape (Figure 11.1 and Figure 11.2). Dentalia inhabit coarse, clean sand on the surface of the seabed in areas of deep water, and are often found in association with sand dollars and the purple olive snail (*Olivella biplicata*).

Figure 11.1

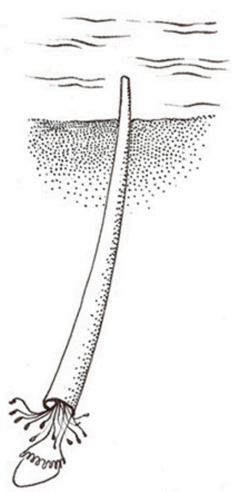

Figure 11.2

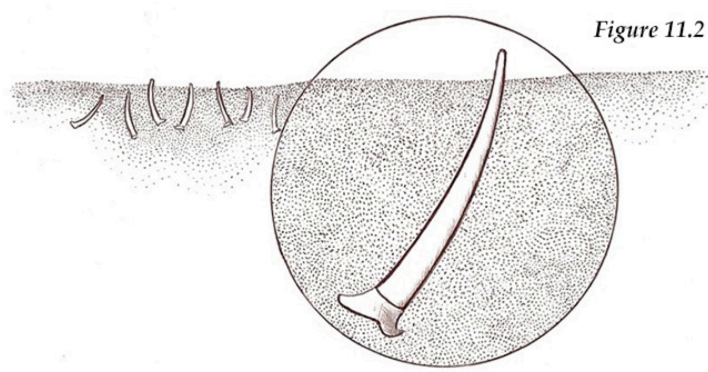

Figure 11.1 ▲ The mollusk's muscular foot and streamlined shell allows it to burrow into sandy bottom sediments. Illustration by Laura Corsiglia (2007).
Figure 11.2 ▲ Cross section of dentalia burrowing into sandy bottom sediments. Illustration by Laura Corsiglia (2007).

As predators, they use their streamlined shape and muscular foot to move surprisingly quickly in pursuit of tiny single-celled prey called forminifera. Aboriginal peoples used many substances as trade goods, but dentalia were the only shells to become currency. Harvested from deep waters off the coast of Vancouver Island, they were beautiful, scarce, portable, and not easily counterfeited.

In 1778, Captain James Cook of the British Royal Navy visited the village of Yuquot (Friendly Cove) on Nootka Island off the west coast of Vancouver Island, BC. The island's fur trading potential led the British East India Company to set up a trading post at Yuquot, which became a focal point for English, Spanish, and American traders and explorers.

Trade between Euro-Americans and Aboriginal peoples was initially conducted under the watchful eye of a powerful chief named Maquinna who acted as middleman, purchasing sea otter pelts using dentalia as currency and then reselling the pelts to white traders in exchange for other goods.

Figure 11.3 ▲ Here, members of an Ehattesaht village, circa 1800, barter strings of dentalia for iron chisels. Illustration by Laura Corsiglia (2007).

Once the white traders realized that shells were used as money, they began trading directly with dentalia harvesters among the Nuu-cha-nulth and Kwakwa̲ka̲'wakw people. The center of the fur trade subsequently moved to Nahwitti, a Kwakwa̲ka̲'wakw village on the northern tip of Vancouver Island (Nuytten, 2008b, p. 23), and dentalium shell money became a currency of cross-cultural trade, called *Hy'kwa* in Chinook Jargon—a trade language spoken as a lingua franca in the Pacific Northwest during the 19th and early 20th centuries (Figure 11.3). The currency was used throughout Alaska, down the Pacific coast as far as Baja California, and across the prairies of the United States and southern Canada to the Great Lakes (Figure 11.4).

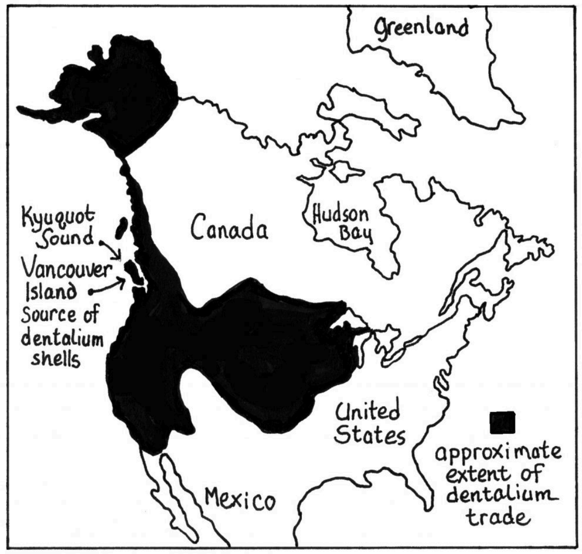

Figure 11.4 ▲ Extent of dentalium trade. Illustration by Karen Gillmore.

In addition to their use as currency, the pearly white dentalium shells also served as decorative wealth. They were fashioned into necklaces, bracelets, hair adornments, and dolls. The shells also decorated the clothing of both men and women (Figures 11.5, 11.6, 11.7 and 11.8).

Figure 11.5

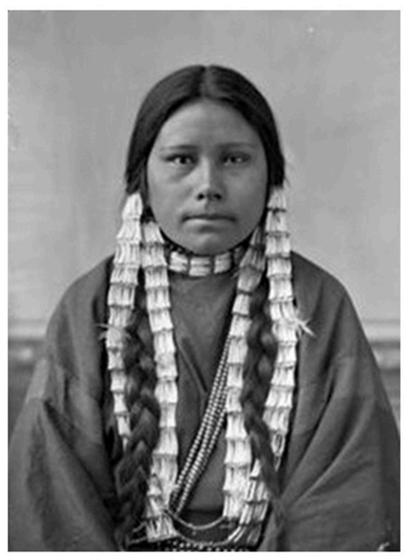

Figure 11.6

Figure 11.5 ▲ Oglala Sioux woman photographed in 1908 wearing a dress adorned with dentalium shells. Photo by Edward S. Curtis (c. 1880). Public Domain.
Figure 11.6 ▲ Braided hair adorned with dentalium shells, Two Bears daughter, Dakota. Photographer unknown. (c. 1880). Public Domain.

Figure 11.7

Figure 11.8

Figure 11.7 ▲ *Doll (c. 1890). Dentalium shells dangle from the braids and form a necklace for a Sioux doll. Making dolls was an important opportunity for young girls to learn to tan hides, sew, make clothing and beadwork. Sioux children used these dolls to play camp, complete with miniature tipis and horses. Photo reprinted with permission, American School, (19th century) / Detroit Institute of Arts, USA. All rights reserved.*
Figure 11.8 ▲ *The headdress belonged to a Tlingit woman in the early 20th century named Anna "Bebe" Doah (Tlingit name Jiyal.áxch), the wife of a shaman named Berner's Bay Jim. It is a rare type of Tlingit headgear similar to beaded headdresses worn by the Yup'ik, Unangax (Aleut) and Alutiiq/Sugpiaq people of Southwest and South Central Alaska. Photo courtesy of Alaska State Musuem, All rights reserved.*

It is generally agreed that the best dentalium shells were those harvested by the Ehattesaht and Quatsino people from shell beds off the west coast of Vancouver Island. These beds lay deep underwater—too deep for divers to hold their breath, too dark for them to see, and too cold to sustain a diving operation—so the Quatsino people designed specialized gear to harvest the money shells. Historical records indicate that a device with a very long handle and a bottom end resembling a "great, stiff broom" was used to pluck live dentalia from the seabed (Nuytten, 1993, p. 114) (Figure 11.9). Three of these implements still exist in museums in Victoria, British Columbia and Seattle, Washington.

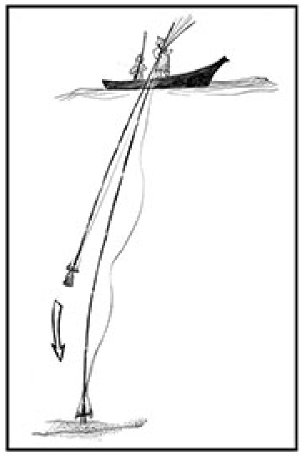

Figure 11.9

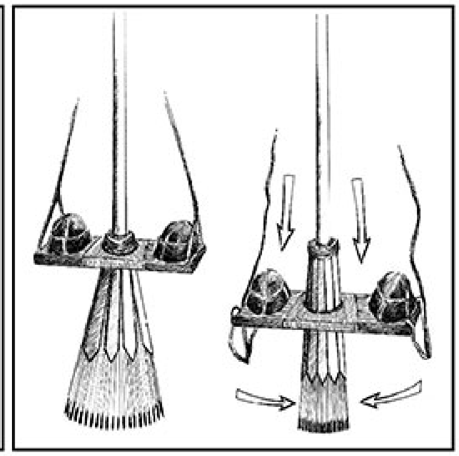

Figure 11.10

Figure 11.9 ▲ *The Dentalium "broom" was lowered to the shell beds by adding extensions to the handle. Illustration by Laura Corsiglia (2007).*
Figure 11.10 ▲ *Phil Nuytten's dentalia-harvesting broom outfitted with a weighted board. Loosening the ropes lowers the weighted board, an action that partially closes the broom head for grasping the shells. Illustration by Laura Corsiglia (2007).*

Some scholars have thought it unlikely that dentalia could have been harvested live, arguing that the broom would be too difficult to handle and that the organisms burrow too deep in the sediment. In 1991, Phil Nuytten—a deep-sea engineer and inventor of a robotic diving suit called the "Newt Suit"—resolved to fabricate a dentalium broom and find out for himself. "What I came up with," Nuytten stated, "was a generic device—a hybrid based on various old descriptions and my own knowledge of how tools work underwater" (Nuytten, 2008a, p. 21). Nuytten enlisted the help of master carver John Livingston, who built the implement from local materials. He made the broom from a hundred sharpened yew splints, scorched to increase their hardness. He then sheathed the bundle in thin slats of springy yellow cedar (Figure 11.10).

Attached to a 70-foot-long handle made in sections, the head would be lowered from the surface and jabbed into the sea bottom. A board, weighted down by rocks and operated by a separate line, would then be eased over the outer slats, thus trapping whatever had been pinched between the inner splints (Nuytten, 1993, p. 114).

Figure 11.11

Figure 11.12

Figure 11.11 ▲ In the Sea Urchin, an eight-foot mini-submarine, Nuytten scans the sandy sea bottom for dentalia. Photo courtesy of Phil Nuytten, Nuytco Research Limited (1991).
Figure 11.12 ▲ Scientist and expedition leader Phil Nuytten is lowered overboard from a winch to land on the sea bottom where he observed the dentalium broom at work. Photo courtesy of Phil Nuytten, Nuytco Research Limited (1991).

In Kyuquot Sound, on the northwest coast of Vancouver Island, Nuytten looked for the underwater shell beds in his high-tech eight-foot mini-submarine—after Native scuba divers had pointed him toward the site. To test the harvesting implement, he then donned his Newt Suit and was lowered overboard by a winch to land on the dentalium beds below (Figure 11.11 and Figure 11.12). Once Nuytten was in a good viewing location, John Livingston lowered the broom over the shell beds and pushed it about 10 centimeters down into the sand and sediment. According to Nuytten (1993), "When he lifted it [the broom] up—jackpot! It worked like a charm" (p. 114).

Strategies for Changing Thinking

In order to introduce students to the story of dentalium shell money, and to excite their interest in a problem-solving activity, I developed a short powerpoint presentation. We began by looking at a 1908 photograph of the shell dress of an Oglala Sioux woman and discussing how clothing adorned with dentalium shells could signify an individual's or family's wealth. Students were then shown a map of the routes of the North American dentalium shell trade. They marveled at the extent of the trade and wondered how it happened that a shell could become a currency. Finally, we looked at 1991 photographs of Phil Nuytten's mini-submarine and of Nuytten in his deep-sea diving suit being lowered from a ship.

The photographs served to heighten the students' curiosity. I asked: "If it takes a mini-submarine for modern scientists to locate dentalium beds, and a pressurized deep-sea diving suit to harvest a few shells, how could Native divers have harvested large quantities of dentalium shells?" It was clear that Native harvesters must have invented a tool, a trap, or some combination of a trap and strategy to harvest the shells. But what implement, and from what materials? To make the problem more intriguing, I informed the class that dentalium shells had not been harvested for over 100 years; hence, the traditional knowledge required to harvest the shells appeared to be lost.

I then challenged the class to invent a means of harvesting dentalium shells—an implement and/or a technique for collecting or grabbing the mollusks. What knowledge would the Quatsino have needed to solve the problem? A Grade 5/6 class to whom this problem was presented brainstormed the following questions as I wrote them on the blackboard:

- How deep are the dentalia?
- What do dentalia eat?
- What are their predators?
- Do they come out of their shells?
- How do they protect themselves?
- Will hermit crabs live inside their shells?
- Can dentalium animals be attracted to bait?
- How do they move? Do they stick to rocks or dig?

Grade 11/12 students asked similar questions, and added the following ones:

- Do dentalia rise to the surface to feed?
- Do they live in sand or on rocks?
- Would weather conditions such as storms make it impossible to harvest?
- Would the tides or time of year affect harvesting?
- Would the life cycle of dentalia be important to harvesters?

In addition, I asked the students to brainstorm what materials would have been available to the Native harvesters for developing their technologies. The Grade 5/6 students posited rocks, cedar trees, shells, hides and bark. The Grade 11/12 students added obsidian, bones, ropes made from cedar strips or kelp, the power of water, and flotation devices made from seal stomachs.

The students discussed possible answers to their questions, as well as how the Quatsino might have answered these questions. The students then worked in groups of three to five to design and draw a dentalium shell-harvesting implement. Each group was provided with large flip-chart paper, coloured crayons and felt pens for representing pictorially the invented implements and harvesting techniques or strategies.

The groups took turns presenting their drawings and ideas to the class, describing their implement, the materials it was made from, and how their implement and/or strategy worked (Figure 11.13). I encouraged the class to ask questions of the presenters, to critically explore practical considerations and to address the question, "Would the implement work?" Most students were skeptical that their newly invented designs would actually work.

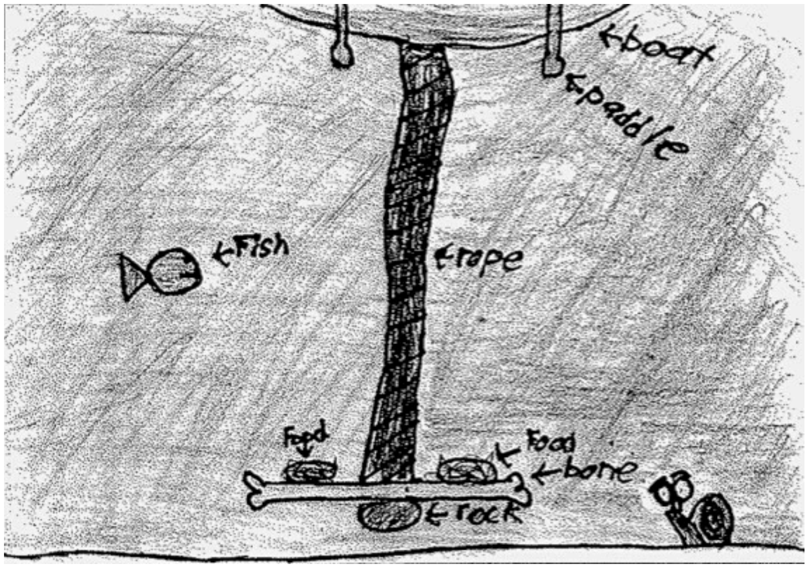

Figure 11.13 ▲ When challenged to design a dentalium-harvesting implement or technique, students came up with a variety of practical and fantastical strategies Drawing by student (2009).

I then showed the students the second half of the powerpoint presentation, which introduced the Quatsino broom. We looked at sketches of the dentalia and discussed the organism's adaptation to coarse, sandy bottom sediments; the long thin shells are streamlined for burrowing rapidly into sand with piston-like strokes of the mollusk's muscular foot.

I then showed sketches of the dentalium broom and explained how the broom worked; its handle was made in segments, and the harvesters would lower the broom head by adding extension poles one at a time. Students marveled at the ingenious implement and the problem-solving skills of the Indigenous harvesters. Our paper-and-pencil drawings had only begun to solve the numerous problems that would have been addressed as the broom was designed, tested, and modified over hundreds and thousands of years (see additional student drawings in Chapter 9).

I asked the students whether, in the process of attempting to invent a dentalium harvester, they had been engaged in science. That is, had they asked questions, inferred, predicted, observed, communicated, built models, adapted, and interpreted information? The students were sure that they had engaged in science because the exercise had been an attempt to solve a difficult problem.

I invited the students to consider these questions: Did Indigenous people engage in science when they developed the dentalium broom? To what extent had they made observations, asked questions, predicted, inferred, speculated, theorized, interpreted, invented and built models? To what extent were the originators of the broom required to understand the tides, ocean currents, adaptations of dentalia, qualities of materials, buoyancy, water pressure, and so on? The students agreed that although the broom was likely developed without knowledge of all of these concepts, the quest to solve the shell-harvesting problem was not haphazard. It was a systematic series of investigations conducted over a long period of time and involving a complex set of science-related concepts and processes. As it turns out, for this purpose, the Quatsino didn't need to understand the dentalium life cycle (egg, larval stages, adult) or predator-prey relationships, but they did need to have a good knowledge of the type of substrate dentalia live in (rock, gravel, sand, mud), the properties of available materials, tides and currents, and which organisms are indicators of the presence of dentalia (e.g., sand dollars and the purple olive snail). We discussed the likelihood that the Quatsino built and tested numerous models of the dentalium broom before perfecting its technology. We also considered the similarity between attempting to build an implement that works in an unseen environment—in this case the deep, dark seabed—and the way scientists build models to represent and understand what we cannot see.

Conclusion

I have conducted similar workshops with pre-service teachers, practicing teachers and graduate students. The result is always a celebration of drawings and strategies ranging from fairly skilled cedar baskets operated with a cedar rope, to variously fashioned nets or hooks designed to capture dentalia in the water column, or a variety of baskets, traps, scoops, rakes, snares and shovels designed to catch dentalia on the seabed. There are also fantastical ideas, such as a hollow cedar tree trunk through which the dentalia are coaxed to the surface with bait, a hollow tree through which a person climbs down to the bottom to pick up dentalia, a collection of hermit crabs that pick up the shells, and a trained shell-collecting octopus. (This activity is guaranteed to produce gales of laughter.) Not once has a student or teacher invented an implement similar to the one described in the historical journals.

Clearly, the introduction of Aboriginal examples adds interest, excitement and authenticity to the science classroom. Similar science and technology activities could be developed around such topics as fishing equipment (the halibut hook or cod lure), dugout canoe, weir, fish wheel, tanning hides and cedar bent boxes. Students might also explore how Aboriginal people in different regions have dealt with the same concept or process. Even small differences in environment can result in surprisingly different ways of tanning hides, harvesting fish or making a canoe.

Educators wishing to incorporate Indigenous Science examples into their teaching practice can begin by consulting Elders and other Aboriginal resource persons or the burgeoning literature on Indigenous knowledge in the areas of natural and earth sciences, medicine, agriculture, botany, ecology, astronomy, aquaculture, navigation, architecture, engineering, climatology and political science.

Cross-cultural science education is not merely throwing in an Aboriginal story, putting together a diorama of Aboriginal fishing methods, or even acknowledging the contributions Aboriginal peoples have made to medicine. Most importantly, cross-cultural science education is not anti-Western science. Its purpose is not to silence voices, but to give voice to cultures not usually heard and to recognize and celebrate all ideas and contributions. It is as concerned with how we teach as with what we teach. Instead of the teacher defining what science is for the students upfront, let students explore what the word "science" means to them. Encourage them to ask: Do traditional peoples have their own science? Have they made contributions to the body of knowledge we call "science?" If our ultimate goal is to have the greatest number of students derive the most benefit from our science lessons, we must plan these lessons to be inclusive. Our choice of wording, readings, experiments, classifications, resource persons and concepts can include and engage all students, or it can risk alienating students who see no depictions of people like themselves and thus receive an unintended message that science has nothing to do with them.

Much work needs to be done to create or revise science education lessons and activities to fit a cross-cultural science framework, but it is not impossible or overwhelming. If teachers can understand how the purposes of scientific activity have varied in different cultures and times, and how different cultures have developed science to meet their needs, then they can work towards developing innovative and culturally sensitive resource materials and teaching strategies that will increase the science literacy of all students.

This chapter was adapted with permission from Snively, G. (2009). Money from the sea: A cross-cultural Indigenous science problem-solving activity. Green Teacher, 86, 33-38.

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Chapter 12 - Dzaxwan (Oolichan Fish): Stories my Elders Told Me

'Nalaga Donna Cranmer

'Nugwa'am 'Nalaga, gayutlan lax 'Yalis, 'Namgiyaxsa'man, wanukws Gwa'ni. Xwanukwes Gwi'mo'las dlu O'waxalaga'lis. I am 'Nalaga Donna Cranmer, *the dawning of a new day*. I live in 'Yalis (Alert Bay), British Columbia (BC). I am a 'Namgis woman from the River Gwani (Nimpkish River), the daughter of Gwi'mo'las Elder Vera Newman and O'waxalaga'lis Chief Roy Cranmer. I am the second of five children and have been fortunate to grow up in a very culturally and politically active family. I have heard our Kwak'wala language all my life, but I am not a fluent speaker. Kwakwaka'wakw have lived on the central coast since the time when K'aniki'lakw (the transformer) was moving through the world changing things. Each one of the 18 tribes within the Kwakwaka'wakw territory has their own origin stories which tell the oral history of the first ancestors. The songs, dances and language recount the Kwak'wala speaking people's connection to and maya'xala (the closest English translation is the word respect) for the land and sea that provided and continues to provide what is needed to live. In pre-contact time there was an understanding that the balance between people and what nature had to provide was to be maintained.

The late Cape Mudge Chief Billy Assu shared the story of how his people in ancient times after the flood came to live near the T'łi'na t'łi'na River for a period of time. This ancestor Weka'yi met a woman named T'łisdak and she had wings on her back on the T'łi'na t'łi'na. The woman T'łisdak eventually allowed Weka'yi to build a house and make t'łi'na (oolichan oil) every spring (Duff, Prior to 1965).

These teachings and creation stories show the next generation how to live, share and maya'xala (treat others and things the way you want to be treated [respect]) all things. In Indigenous cultures, teaching every generation is illustrated in stories, songs and ceremonies. Each listener takes away the teachings and meanings from the stories and songs, and uses the principles to help them in their own lives.

This delicate balance is no longer recognized by all Kwakwaka'wakw. There are Kwakwaka'wakw who have had the benefit of the old people who continued to practice their ways during the dark years when our cultural ceremonies and ways of doing things was outlawed by the Government of Canada. There are Kwakwaka'wakw whose old people rejected their culture when the government created laws that made the practice of our way of life illegal. With the introduction of the English language and Western ways of thinking, a breakdown in language and cultural traditions has occurred. In some families, many traditional teachings are not taught to the young. Many other factors have come to disturb the balance; children spending too much time watching television or playing video games, the breakdown of families because of substance abuse, and families not getting out onto the land and learning about the traditional territories and way of life. Western values and beliefs about lifestyle in general and one's responsibility to the land and to family and community have significantly eroded the traditional values and respectful behaviour of our young people.

When First Nations peoples discuss "culture," this includes all things involved in day-to-day life; origin stories, the interconnectedness of all things, food gathering and preserving methods, child rearing practices, and the passing on of traditional names, songs, dances, ceremonies, and behaviour towards the land. 'Namgis Elder Gloria Cranmer Webster shared that "…Everything is connected, we don't break things up into compartments or categories" (Webster, personal communication, 1994). Circles and cycles are central to the world and we are all connected. This sacredness and interconnectedness, or maya'xa̲la (respect) shown by the people, for the land and the sea resources is what allowed the Kwakwa̲ka̲'wakw to live on the coast for thousands of years.

As a little girl, I remember every summer going to Big Granny's (Gwantilakw Agnes Cranmer, my paternal grandmother's) house and we all worked on processing the salmon. My only thought as a little girl was that I couldn't wait till I was old enough to cut the fish instead of wash the fish. Big Granny made us wash the fish again if we didn't get all the blood out. We would start right after breakfast. The adults cut the fish and filled the cans; usually my dad or uncle sealed the cans. The men were responsible for gathering the wood and keeping the fire burning under the 45 gallon (170 litre) oil drum in which the canned fish were cooked. While everyone was busy working, Big Granny boiled the potatoes, fish heads and tails. She would call everyone in to eat, and after eating would send everyone back out to finish filling the cans. For supper we had barbequed fish with baked potatoes and t'łi'na. Usually the fire was burning under the oil drum where the canned fish was cooked by suppertime. When the water in the drum cooled down it was the job of children to wash the cans. Everyone had their job. It was like a mini cannery out back at my Big Granny's house. This practice continues today, but now we work on the fish at my sister's house since my Big Granny passed on, and instead of an oil drum and fire we use a pot and a propane cooker to cook the canned fish. This process of canning salmon is also shared in Diane Jacobson's recently published book *My Life in A Kwagu'ł Bighouse* (2005). My uncle once told me that our people always adapted (to change)—it made things easier.

As far back as I can remember, t'łi'na has been a central part of my familial, social and cultural life. Since I started my own family and live in my own home, we eat smoked salmon with oolichan oil, as well as salted oolichans when my Dad invites us to my sister's house where he lives. Once, we entered my sister's house and could smell the salted oolichans as soon as the door was opened. My 3½-year-old daughter said, "Emmm I love salted oolichans." I was so proud of her appreciation for our traditional food which our people have been eating since Gwa'nalalis was changed into the river Gwa'ni and before. Despite these changes in how to make the work more efficient, t'łi'na remains a central feature of our gatherings, whether that be the processing of it or the distribution of the precious oil.

To this day my family continues to potlatch (see chapter 13 for a fuller description of the potlatch). My grandparents on both sides of my family continued to potlatch even when a large majority of Kwakwa̲ka̲'wakw gave up this important practice for a number of reasons, not the least of which was a Canadian federal statute. The majority of potlatches I saw when I was younger were memorials for family members who had passed on. My maternal grandfather T'łakwagila Chief Arthur Dick, hosted four potlatches during his lifetime. The last three of his potlatches were T'łi'nagila-T'łi'na potlatches, which means he gave gallons of t'łi'na away to his guests. My gramp used to say, "Giving away t'łi'na was the highest thing for a chief to do, it took a real man to have the means to be able to go and make t'łi'na and then give it away." In the DVD, *T'łi'na: The Rendering of Wealth* (Cranmer, 1999), my uncle Arthur Dick Jr. talks about T'łi'nagila-T'łi'na, "When you give t'łi'na away, you T'łi'nagila and you can't go any higher than that in our tradition."

T'łi'na like the salmon is a staple in the diet of the Kwakwa̲ka̲'wakw and many other First Nations on the BC coast. The oil is rendered from the oolichan by many tribes on the coast. Our people use the t'łi'na to dip our fish into and pour into fish soup. It also has medicinal uses; when people suffer from a bad cold they are told to heat up t'łi'na on the stove, rub it on the chest and then cover the chest with a warm towel. There are stories of chiefs in our area in the 1930's giving away hundreds of five-gallon cans filled with t'łi'na. Giving away large quantities of t'łi'na has long been the practice of high chiefs. Kwakwa̲ka̲'wakw Chief Charlie Nowel discusses the making of and giving away of t'łi'na:

> In the old days everybody used to go oolichan fishing. Now not all go, even though high priced—$15 for 4 (imperial) gallon tin. Don't pit-ripen: make bin of boards on top of ground—if you don't ripen (the oolichan) can't get much grease out of…Bill Matilpi gave grease feast on June 1st past. There was a time hardly anyone went. I (got) 6 cans ($90.00) and wouldn't have to got so many if more people hand gone maybe 3-4. (Chief Charlie Nowel, interview and transcription in Duff [prior 1965])

Today, this quantity of t'łi'na is not given away. A Chief may give away two hundred gallons or as little as fifty gallons. Today, there are few families who still T'łi'nagila.

In the late 1980's my Dad started traveling to Dzawadi (Knight Inlet) to make t'łi'na with his own crew. In 1997 when the *T'łi'na* documentary was being filmed in Dzawadi, my brother Edgar who was 9 at the time and some of his cousins, who were between the ages of 8 and 10 had their own pit and made their own t'łi'na with the help of one of their dads and a few uncles. They each came home with 4 gallons. The importance of this tradition remains strong and has been handed down since time immemorial from one generation to the next. Dzaxwa̲n (oolichan) are preserved by smoking or salting, but the major reason to go to Dzawadi is to make t'łi'na. I have had the opportunity to travel to Dzawadi with my dad and other family members and have participated in the process of rendering the oil from beginning to end. Our people were and are truly amazing, to render oil from these small oily fish. How did this process come about? The knowledge it took to create the nets to fish the oolichan and then to process the oolichan I would consider as Indigenous Science. The preservation of food, taking raw stinging nettle fibre and creating fishing nets are all the result of timeless observations, inferences, experimentation and evaluations of success and failures. In short, we are benefiting from age-old scientific observation, thought and action.

Archival footage from the film *T'łi'na: The Rendering of Wealth* (1999), documents the large amounts of oolichan that were normally caught. Chief Jack Nolie and his wife Dorothy remember a time when there were lots of oolichans and how easy it was to get what you needed:

> Jack: There's lots, from here to that wall, maybe about that thick with oolies.
>
> Dot: I use to walk down to the edge of the river and just pick out what I needed.
>
> Jack: You could just grab it and put it in the pail, there was so much…You didn't use the tagał [cone-shaped net]. You could use the kanayu [dip net] too if you want.

Beliefs about the supply of oolichan being foretold was shared by my maternal grandfather, Arthur Dick Sr. in the documentary film *T'łi'na: The Rendering of Wealth* (1999). He tells about the first moon in the new year—if the crescent moon is lying on its side (looking like a bowl standing upright) then there will be lots of oolichans in the spring, but if the crescent is standing up then the oolichans are all running out, then there won't be many oolichans in the spring (Cranmer, 1999).

Over the past twenty years in my community of 'Ya̲lis the number of families that continue to harvest the oolichan has continually declined. There are a number of reasons for the decline; only a small number of families have fishing boats and are able to go out and gather the oolichan, and the cost to go out on the water has increased considerably. A major reason is the steady decline in the number of oolichan returning to Dzawadi every year. It is easier for some families to get their food from the local grocery store, so the knowledge of how to gather and preserve this resource is slowly being lost by some families.

While growing up I wanted to be an elementary school teacher, integrating our culture and academics so that our children could learn about themselves and their history in our own school, unlike my own school experience that involved very little Kwakwa̲ka̲'wakw history or cultural knowledge. Knowing that much of our own culture and history, Indigenous Knowledge, has been left out of our school curriculum made me want to help educate our children about our history and help them to see what they can become. That is why I wanted to spend time with the Elders to learn more about how they harvested oolichans and processed t'łi'na. From the teachings of my Elders, I developed a science curriculum for our children at our band-operated school, T'łisa̲lagi'lakw, that used the Traditional Ecological Knowledge with Western Science methods.

Research Purpose

In general, this project had a two-fold purpose. The first purpose was to research Kwakwa̱ka̱ʻwakw traditional methods of gathering, preparing and preserving dzaxwa̱n and the making of tʼłiʼna; and in the process of interviewing the Elders to understand how this information was passed on from one generation to another.

The second purpose was to develop and evaluate a science curriculum on the dzaxwa̱n at the Grade 6/7 level that would be respectful to the Kwakwa̱ka̱ʻwakw culture and science knowledge and wisdom practices, and accepted for its value in the BC Science curriculum (Cranmer, 2009) (Chapter 13 describes the development, teaching, and evaluation of the dzaxwa̱n curriculum).

Background to the Study

ʻYa̱lis (Alert Bay) is located on Cormorant Island and is the traditional homeland of the ʻNa̱mgis First Nation. Cormorant Island is a small island three miles long and half a mile wide, just off the northeast end of Vancouver Island. It is known by some locals as “paradise island” and others as “the rock!” There are approximately 1,350 people living in ʻYa̱lis, which is made up of a municipality on one end of the island and the ʻNa̱mgis First Nation reserve on the other. Every other person used to be a fisherman in ʻYa̱lis prior to the drastic changes to the commercial fishing industry, caused by the federal Department of Fisheries regulations and declining returns beginning in the 1980s. Today there are few commercial fishing boats. The major employer in the village is the ʻNa̱mgis First Nation, which operates the: administration office, treaty office, forest management office, health and dental centre, Elders Centre, alcohol and drug centre, Tʼłisalagilakw School, Amlilas playgroup, waste management facility, Lawrence Amber’s Recreation Centre, Gwaʼni Fish Hatchery, and Youth Employment Centre.

ʻYa̱lis is also considered the heart of Kwakwa̱ka̱ʻwakw culture. Our community is home to one of the six traditional gukwdzi (bighouses) where our ceremonies take place. The young are learning the songs and dances that are so important to the culture. There are still a few smoke houses in the back yards of the men and women who still go out and gather the resources which Creator has provided.

The original home of the ʻNa̱mgis is the Nimpkish Watershed and the Nimpkish Valley. The territory extended up to the head of Waʼas (Woss Lake) and up into the mountains.

Gathering Kwakwa̱ka̱ʻwakw dzaxwa̱n took many forms and was obtained from many sources. I recorded informal interviews with Elders and knowledge keepers to gather information on Kwakwa̱ka̱ʻwakw traditional methods of gathering, preparing and preserving dzaxwa̱n. I interviewed the following four Kwakwa̱ka̱ʻwakw (Kwakʼwala speaking Elders): ʻNa̱mgis Chief Oʼwax̱a̱laga̱ʼlis (Roy Cranmer), Lawitʼsis Elder Harriet Joseph, Mama̱liliḵa̱la Chief Tʼła̱ḵwagiʼlakw (Arthur Dick Sr.), and Daʼnaxdaʼx̱w Chief Maxtʼsula̱m Ḵa̱mx̱ʻid (Jack Nolie).

I conducted one interview on my own in English. Three interviews were in Kwakʼwala and my mother G̱wiʼmoʼlas (Vera Newman) who is fluent in Kwakʼwala asked questions. While researching this information I documented many Kwakʼwala words and phrases used during the gathering, preparing and preserving of foods. When interpreting the results of the interviews, common themes and patterns were taken from the transcripts. For example, several individuals shared that their grandparents always said to take care and not throw garbage in the river; the theme of respect and behaving accordingly became an important teaching theme that was explored in depth.

Archival research and document analysis were other methodologies used to gather information. Published information by anthropologists who worked among the Kwakwa̱ka̱‘wakw in the late 1800s and the early 1900s was added to my database.

Maya’xa̱la, Showing Respect

The old people taught the young to maya’xa̱la––treat others and things the way you want to be treated. The old people gave words of thanks when taking things from nature and they made sure that garbage was properly discarded. Today, this caring for the environment is called “conservation.” Mama̱lilik̲a̱la Chief, Arthur Dick (Art) talks about his Ada’s (paternal grandmother) teachings:

> The first thing [when arriving in Dzawadi] that Ada [Minnie Dick] used to make us do was to dig a pit for where the garbage is going to go. So we don’t go and throw our garbage in the river…Dzawadi itself will take care of the garbage, Ada used to say you didn’t cover it up with the sand, you just left it open. We respect the land we don’t own the land, the land owns us, that’s our mother. That’s what the old people said and the ‘blood is the river’. If you put bad things into it, it would not make the heart of our mother do good things.

Harriet also talked about the respect shown to the river:

> I use to hear my mom talk about how the old people use to really take care of the river. We were never allowed to dump our dish wash into the river. We were not allowed to throw garbage into the river.

It is important to note that when talking about “Kwakiutl religion” or “prayer” as anthropologist Franz Boas called it, I use the term “words of thanks” (Webster, 1987). It was explained to me that our people had three ways of giving thanks; the English word prayer is now used for all of them. Boas’ (1930), translation provides examples of words of thanks that were used by Kwakwa̱ka̱‘wakw men and women in day-to-day activities. Giving words of thanks was part of everyday life. The old people, like my grandparents and great grandparents, washed themselves here before entering Dzawadi, and asked Creator to take their sickness away:

> Vera: …Daddy would say, T’suxudaxan t’sit’saxk’ulam ‘Numase’
>
> Art: four times…
>
> Vera: Wash my sickness away ‘Numas, I guess that would be another way of saying Creator or ancestor.

This ceremony took place at Twin Falls (Cascade Point), and was considered an important site to stop on the way up to make t’łi’na. Macnair (1971), described the ritual of “Stopping halfway up the inlet to bathe ritually under the mist of a water fall at Cascade Point to ensure good health …” (p. 169). They were preparing themselves spiritually for the work ahead.

Art also talked about how words of thanks were given daily to show respect when gathering traditional food:

> …When we use to go put the halibut gear into the water and then the halibut would come up into the boat…Dada (paternal grandfather) would turn the halibut’s head towards Village Island and he thanked the halibut for giving his life so we can continue to survive as humans. That’s what Dada use to do; he did that when he shot a deer. Right where the deer dropped he used to run around it four times. Twice I saw the old man do that. Thanking the

> deer for giving his life so we could live. That was the work of the deer, all the animals were human beings…That's the way Dada was.

Rendering Oolichans

The T'łi'na t'łi'na River is the traditional territory of the A'wa'etlala and Da'naxda'x̱w. Although this territory belonged to these two tribes, during oolichan fishing time they allowed fourteen Kwakwa̱ka̱'wakw tribes to have their own camps to harvest the oolichans (Galios, 1994, p. 137).

Oolichan continues to be gathered on two rivers in Kwakwa̱ka̱'wakw territory; the T'łi'na t'łi'na and Kingcome. Once the boats arrived at the flats (where the boats are anchored), the hard work of getting all the supplies up to the village began.

Jack shared how the old man Panxw'idi from New Vancouver told the people how things were to be done:

> He use to stand with his talking stick in the river and he would give the teachings, say we are not going to put our tagał in till it's time. After the oolichans spawn…when he gives the OK 'Wahead now', then everyone goes in the river and puts their poles in for the tagał. You have to wait 'til night time when the tide is coming in (yaxwala—high tide), then the dzaxwa̱n come in the early evening and at night.

Art shared how his grandfather looked for the biggest oolichan and what was done with this oolichan:

> I was very young when Dada went searching through the boatload of oolichans for the biggest, a very long oolichan he took out from the pile—he showed with his hands how big. He asked Ada, 'Can you please go fry this for me? You're the only one who is going to eat this'. I ate it, Dada said 'You will never forget Dzawadi now'. That oolichan had a name, but I don't remember the name. You're a supernatural being…what Dada called 'Nawalakw—supernatural, sacred you don't even talk about it, you just know. 'You'll never forget Dzawadi, you'll always want to come home…You'll never give up on this land, after I ate that oolichan. You're the one that is going to be looking after Dzawadi', Dada used to say, 'It was amazing things that happened when I was a kid with the old people'.

There was a lot of work to do to get ready before going fishing for dzaxwa̱n, especially in the days before seine nets. Art talked about his great aunt, who made the tagał for his family:

> Dad used to say Anit'a [Andy Bean's mother, Ada's sister] used to be the one that used to make the tagał for our family and our tribe…they used the spruce tree, the roots, spruce roots. All winter long wove the tagał net out of spruce root. It's really light. She just held it with her one hand…Nobody knows how it was done before, where they locked up the tagał. We just tie up the tagał now, nobody knows how to do it the way the old people did it.

This special net was placed below the spawning grounds. Once the dzaxwa̱n spawned the current carried them back down the river into the tagał. It allowed only the dzaxwa̱n that had completed spawning to be caught:

> That's why there were lots of oolichans in the old days, because they already spawned before they came down to be caught. That's why the tagałs were used, you don't fish oolichans till they're 'was 'id [spawned].

Wood needed to be cut, nets mended, tools cleaned, and sa̱mgat'si (tanks for cooking oolichans in) needed to be re-corked (caulked). My Uncle Art shared how you clean the tools you're going to use:

> …the k'alayu (paddle split at the end) and awayu (skimmer) the first thing you start working on when you put the fire on under the samgat'si you put less then ½ a cup of soap in the samgat'si to wash the tools, then you just wipe it off, all the things you're going to use when you're making the t'łi'na, then it gets put away till they start to use it.

I asked my Dad to explain what the samgat'si was made of:

> …red cedar and the bottom is galvanized steel or tin…Back in the earlier times I guess they used to be able to get the trees big enough…they could get one chunk, one plank…they used to be able to cut it so the only joints you'd have is the corners…we were lucky that we found a big enough cedar that we managed to get two eighteen inch planks out of them.

When some people in 'Yalis talk about making t'łi'na they say that the oolichans are put in the pit and left to rot. Then the decomposing oolichans are cooked and the oil comes out. I found it interesting how the old people explain things. According to Art, the old people said, "It didn't rot. It was just cooking in the pit. You wait for so many days for the dzaxwan to cook in the ground." Once the dzaxwan are "cooking in the pit," it's time to start cooking the first batch of dzaxwan. Prior to this, the dzaxwan are not touched. The seal is broken on the pit once the first shovel load of dzaxwan is moved. The Elders interviewed all agreed that great attention and care needed to take place through the whole process. There were a few things that could affect the taste of the t'łi'na if care wasn't taken—one being the temperature of the fire under the samgat'si. Uncle Art Dick, Sr. said: "… you can't get your fire too hot either because you burn your tin [samgat'si] or you'll have to change it because it affects the taste of the grease."

Art mentioned that old corking in the corners and joints of the samgat'si has an effect on the taste:

> …you have to change the migulam [corking on the samgat'si] so that the damp doesn't change the taste of the t'łi'na. If you don't take out the old corking then the taste will go onto the grease. You can smell it even.

Jack described the process and used the Kwak'wala words for the equipment used during this process "k'alayu, the paddle that's split on the end, you g'ała (shake) it on the samgati'si and the bones come out…then oil will start showing up and you g'ała again. Then the t'łi'na shows up." After the shaking took place the oil began to rise to the top. Harriet shared how her mother used the awayu to skim the oil off the top:

> My mom would grab her pail and her awayu to get the t'łi'na, and all the pails are all ready around the fire, after you transfer the oil from the samgat'si … you use the screen when you first transfer it to the pails. The first batch that comes out, you leave the t'łi'na in the buckets over night.

The Kwakwaka'wakw enjoyed eating dzaxwan a number of ways. A treat for those of us who do not make the annual trip to Dzawadi is frying fresh oolichans. Once the oolichans show up in the river and the 'lap'as (pits) are full, there is usually one or two boats that make a trip out to pick up supplies and bring a load of fresh oolichans to share with the community. Harriet talked about how her dad made little barbeque sticks and her mom would barbeque oolichans:

> I used to love watching my dad make the little barbeque sticks [laughs]…I use to just watch my mom when she barbequed the oolichans. She didn't open up the oolichan, it was still whole when she put it on the sticks. You tied it together with danas [cedar], you wet the cedar to make sure the cedar is really wet, when you tie the oolichans onto the sticks—up to 10 oolichans on a barbeque stick.

Harriet talked about how the old people lived a good life for thousands of years on the natural resources that Creator provided. They harvested and preserved what they needed and the people were much healthier because of the good food we ate "our own food":

> I think there is so much illness now because we eat white man's food, especially these fast foods, that's what I blame. They don't eat the good food we used to eat, our own food…jarred fish and clams, that's what she [her mom] canned so that we could bring it to Dzawadi. It's so different now. I bet the kids don't know how we grew up. I think our bodies aren't strong because we don't eat our oolichan grease.

Diminishing Oolichan Returns

Each person interviewed shared their concern for the future of making t'łi'na in Dzawadi because of depleting oolichan runs. Some of the factors mentioned which have an effect on the small number of returning oolichan were: fish farms in the path of the oolichans travelling to the ocean and returning home, the effect of logging in the valley, the changing river in Dzawadi, and draggers (ocean vessels with long lines and deep nets) by-catch. Art shared an Elder's words about this issue:

> What Glennie Johnston said is there is no more sacredness of the season, they [the fish farms] are here 365 days of the year, yet the sacredness of the season is no longer there, well the different times of the year when we gather different things. To add on to what Grandpa said, that those people better look after that shit [fish farm waste that sits on the ocean floor underneath the pens], and if we don't then our country, all the land and water will go haywire. And gone is the respect of the land, the sacredness of the seasons is gone…The people who are doing the bad things will ruin themselves. Don't stress too much because he's [Creator] going to come and fix our lands for us. Don't let it get to you too much in your day, so you don't go following the people that are fighting it, cause it will fix itself. They are not Creator, because everything they are doing is going to go bad [farm fish and that stuff].

Art went on to talk about the other resources and areas where he used to gather other traditional foods:

> I was just in a place that Gramp called Oya̲nds (a little bay right next to Village Island where you could dig for clams when we lived there) and it smelled [terrible], just like standing in [an outhouse]. Nothing was good where we used to dig clams in our territory…The fish farms are really bad…It will never work because it's not [like] the ways of following the sun and the moon (seasons). There is no more respect, no one cares anymore. There is so much that has been destroyed…what they used to eat the crabs and the clams. You used to see the clamshells and the crab shells in the woods because the otter and mink use to eat it in the forest. They can't eat that anymore because it's not good.

There is an understanding among the Kwakwa̲ka̲'wakw that everything is connected. If you destroy or take away one thing from nature it has a lasting effect on the food chain. Art shared what he had witnessed in his traditional homeland:

> There are no tracks now where the deer use to come down and eat the kelp. There is nothing good for them to eat any more…It's just like murky mud where we use to have our clam beds. There is no more land that is hard any more. It's all just murky mud.

Roy also shared some of his concerns about the effect draggers are having on the dwindling oolichan populations:

> There are stories today about what the draggers are doing even though they were supposed to have behind [the boat] a beam troll that allows the oolichans to escape, and I guess that's still not happening because you still hear stories about those guys dumping oolichans out there.

He also expressed concerns about how fish farms and the logging industry are seriously diminishing oolichan habitats and populations:

> …Now that we've got these… fish farms [in the Broughton Archipelago], who knows how they're affecting the oolichans, and I'm pretty darn sure that somehow they're being affected because they're still using pit lamps at night to feed the farm fish…Well they just attract everything. Those oolichans, they couldn't be very big when they get out this far. They probably just eat them. That's just my suspicion.

Roy talked about changes in the river that he has seen since his first visit to Dzawadi when he was a young man to now:

> …the other thing that's happening up at [Dzawadi], all the logging that's happening up there, I remember the first time I went up there it [the T'łi'na t'łi'na River] used to wind its way down from the bridge, but now it's almost a straight shot from the bridge down to the village now.

The important stories that Elders shared about this one traditional food overwhelmed me. There was so much information, the most important being maya'xa̲la, caring for the land, river and the dzaxwa̲n, as well as the process of rendering the oil, and the many ways of preparing and preserving the dzaxwa̲n. Within the last five years, you would be considered lucky to have a feed of fresh oolichans if your family does not have a boat coming out of Dzawadi. The teachings need to continue as they have since Creator put our ancestors on this land.

Preparing Harvesting Equipment

Boas (1975) described how the Kwakwa̲ka̲'wakw harvested food and created other water receptacles, household utensils, kelp bottles, stinging nettle nets and netting. All these items were used in the collection, storage and serving of the oolichan. "The best kelp (wawadi) or bull kelp for making oil-bottles grows on rocks where there is a swift tide. The kelp is collected by women in the fall, after the berrying-season is over" (Boas, 1974, p. 407). Boas goes into great detail on the cleaning and drying of the kelp before the oil is placed in the bottles. The types of oil saved in these containers were "Olachen-oil (L!e'na) t'l'ina, dogfish-oil (xu'lq!wes) x̲wa̲lgis, and oil made of seal (me'gwat!es) migwat'i̲s, porpoise (Ko'lot!es) k'ulut'is, whale (gwe'gis) and bear (Le'ntses), are also kept in kelp bottles. Catfish oil (dze'k!wis) is kept in small kelp bottles" (p. 419).

The gathering of stinging nettle to create fishing nets and the creation of these nets was a women's job:

> Nettles are cut in October…. Fifty stems of nettles are placed in a heap, and are tied together with split cedar-bark in four places, at about equal distances. These bundles are taken home, the tying is undone, and the stems are split with the nail of the thumb…the nettles on it is placed on a drying-frame, where it is left exposed to sun and wind. In the evening the nettles are covered over with mats so as to keep the dew off. (Boas, 1974, p. 370)

After the nettle fibre is gathered and prepared it is then spun and finally the fishing nets are created. "In making the large oolichan-net, the woman begins with the finest nettle-twine, using the small netting-needle, on which the thread is wound. First the twine is turned twice around the smallest net-measure" (p. 399).

Boas (1916, p. 751), describes feasts where t'łi'na was mixed with fruit: "…feasts of currants, huckleberry feast, Viburnum berry feast, salmon berry feast, crabapple feast and finally feast of salal berries and crabapples." For example, when huckleberries were gathered in the summer, they would be cleaned and then placed in a bentwood box and covered with water and oolichan oil. These boxes of huckleberries would be stored away for use during a huckleberry feast.

The ‘Na̱mg̱is Grease Trail

Oolichan, particularly oolichan oil, was one of the most valuable trade items (Drake & Wilson, 1991). Part of the oral history of the ‘Na̱mg̱is tells of the ancestor U’mała̱me’ walking over the mountains to the west coast of Vancouver Island and trading with the people he encountered (Wasden, 2005). The grease (oolichan) trail that U’mała̱me’ created was a major trade route for the ‘Na̱mg̱is and Nuu-chah-nulth people. Valuable items that were traded were “red ochre, mountain goat wool, herring eggs and songs, but the most important was the precious eulachon oil” (Wasden, 2005, p. 20).

My Big Granny shared stories of my paternal great grandfather G̱wi’mo’las and my paternal grandfather Pa̱l’nakwa̱la Wakas walking this trail. For over 80 years the trail was not used. In 1999, the ‘Na̱mg̱is Grease trail was used to bring t’łina to the Nuu-chah-nulth at a canoe gathering in Ahousaht. ‘Wax̱a̱widi (William Wasden, Jr.) composed a song after completing the journey, called the Grease Trail Song. This song recounts the recent journey of four ‘Na̱mg̱is men who travelled an ancient trade route that extends from the traditional territories of the ‘Na̱mg̱is tribe on the east coast of Vancouver Island, to the territory of the neighbouring Mowachat tribe on the west coast of Vancouver Island (Neel, 2004, p. 5). The words of the Grease Trail song in English are as follows:

> What shall we do my brothers and sisters? Come, let’s wander into the forest and begin our journey.
>
> What shall we do my brothers and sisters? Come, let’s fly around the world as our ancestors did with their spiritual power.
>
> What shall we do my brothers and sisters? Come, let’s go to the other side of our world, the West Coast.
>
> What shall we do my brothers and sisters? Come, let’s hurry now and complete the things we need to do in this life. (Neel, 2004, p. 5)

For several years since 1999, people have hiked the grease trail to see how the old people had to travel to trade grease with the Nuu-chah-nulth. This new generation have not carried dzaxwa̱n, but have learned the importance of the trail.

Following the Path of Our Ancestors

The Kwak’wala phrase Ḵas’ida̱‘asa san’s galga’lis means the path of our ancestors. The Kwakwa̱ka̱‘wakw have survived for thousands of years by continuing to follow the path of our ancestors. Chief Charlie Nowel’s interview took place prior to 1965 when anthropologist Wilson Duff was working at the Royal British Columbia Museum. He concluded his discussion about t’łi’na with, “We still got to have grease––can’t get along without it…good for stomach too. We eat regularly with boilers (potatoes) and dried salmon” (Duff, Prior to 1965). Ławit’sis Elder Stella Beans shares the same view about grease, in the film *T’łi’na: The Rendering of Wealth* (1999). She stated “we still gonna make grease…Stevie [her husband] to Darryl [her son] to Steven [her grandson].” Clearly, it is critical for the welfare and future of our people that this belief and respect continues.

Knowing that much of our own culture and history has been left out of our school curriculum made me want to educate our children about our history and help them to see what they can become. That is why I developed and taught a science curriculum on the dzaxwa̲n and the processing of t’ł̓i’na grease to our Kwakwa̲ka̲‘wakw children. The story of the teachings, the numerous contributions of Elders and community knowledge keepers, and how the students responded during instruction is outlined in chapter 13 of this book.

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Chapter 13 - Gwaya'elas, How We Do Things: The Development and Evaluation of Dzaxwan Curriculum

'Nalaga Donna Cranmer

The 'Na̱mgis First Nation have lived in their traditional homeland since K̲'anik̲i'lakw the transformer was here changing things. The people knew that the balance between humans and nature had to be maintained for the survival of all. With the changing times that we live in today, the balance has shifted. No longer do the fishermen take just what they need, but what big business and companies will pay for. The increasingly efficient resource extraction methods have resulted in (but are not the sole cause of) the decrease in Kwakwa̱ka̱'wakw science knowledge and accompanying value systems and practices concentrating on fisheries such as the dzaxwa̱n.

The dzaxwa̱n (oolichan) and t'łi'na (oolichan oil) were and continue to be staples in our diet and much more. It was used for medicine, trade and there is an important ceremony that is dedicated to the giving away of t'łi'na, called T'łi'nagila-T'łi'na (grease potlatch). Within Kwakwa̱ka̱'wakw culture this particular potlatch (feast) ceremony was the biggest (most prestigious) a chief could host.

A main Kwakwa̱ka̱'wakw teaching is maya'xa̱la which means to treat others or things the way you want to be treated. Today some people use the English word "respect" to define maya'x̱a̱la. Prior to contact a major Kwakwa̱ka̱'wakw teaching was to give words of thanks (words of prayer) before taking a resource from nature because if this did not happen then this resource could be taken away and the people would suffer. We might well ask: "In what way does this lack of respect for the dzaxwa̱n fishery contribute to its catastrophic collapse?"

The historical paper created by the National Native Brotherhood, *Indian Control of Indian Education* (1972); set the stage for many First Nations throughout Canada to take over the education systems and teach their children cultural knowledge and values while teaching life skills for living in contemporary society. During this time the 'Na̱mgis First Nation (formerly the Nimpkish Band) in 'Ya̱lis (Alert Bay) established the T'łisalagilakw School. The 'Na̱mgis Education Board's plan at the beginning was to offer a quality education which that blended traditional 'Na̱mgis and contemporary lifeways. Hence, an underlying theme of the current research was to introduce both traditional Kwakwa̱ka̱'wakw Science Knowledge and Western Science as different but complementary forms of understanding the world in the science classroom.

Purpose

The purpose of this research was to develop and evaluate a science curriculum on the dzaxwa̱n at the Grade 6/7 level that would be located within the Science K-7: Integrated Resource Package, (2005). From the data collected from Elders and other sources prior to the development of the curriculum, I attempted to:

- Identify traditional ways of being in relationship with the land that are integral to a Kwakwa̲ka̲‘wakw worldview (Indigenous Science (IS))
- Identify traditional concepts, skills, and attitudes that are consistent with Western Science (WS) and can be integrated into a science curriculum
- Develop activities and teaching methods that are culturally appropriate.
- Develop culturally appropriate evaluative techniques to determine the effectiveness of instruction (increasing knowledge, skills, and positive attitudes). (Cranmer, 2009)

The Curriculum

It was with the guidance and willingness of t'łi'na makers to pass on their knowledge regarding the preservation and rendering of the t'łi'na that led to the creation of the cross-cultural science unit Gwaya̲‘elas—*How We Do Things Kwakwa̲ka̲‘wakw Dzaxwa̲n*. The curriculum was taught by me with help from the principal and Grade 6/7 teachers at the T'łisalagilakw School. Local Elders, knowledge keepers, and resource people familiar with Kwakwa̲ka̲‘wakw science knowledge and wisdom practices were called upon to visit the class and share their knowledge. The IS and WS lessons were woven together to educate students that both are equally important and can at times complement one another.

Prior to instruction, I developed many instructional activities and had many ideas about how I would evaluate the students' learning. Importantly, while teaching the curriculum, I found that the teaching and evaluative methods seemed to take on a life of their own, that is, culturally appropriate activities, methods of instruction and evaluative procedures evolved during the implementation phase. I kept a researchers' journal to record information such as student engagement and their experiences with specific activities during instruction, and checked to see students' understanding of specific concepts and skills, for example, the accuracy of building models and equipment used in the processing of dzaxwa̲n.

School and Participants

‘Ya̲lis is located on Cormorant Island on the north coast of British Columbia and is the traditional homeland of the ‘Na̲mgis First Nation. The T'łisalagilakw School is run by the ‘Na̲mgis Education Board in ‘Ya̲lis. The student population ranges between 80-100 students. Students begin at age four in nursery school, which is a Kwak'wala immersion program, then to Kindergarten and onto Grade 1 through to Grade 7. The majority of the students are either members of the ‘Na̲mgis First Nation or the Whe-la-la-u Area Council. The Grade 6/7 class was made up of all First Nation students, 10 boys and 7 girls.

The Students' Experiences during Instruction

April is the time of year that the dzaxwa̱n return to Dzawadi (Knight Inlet) and this year it was also the month that I was welcomed into a Grade 6/7 class to teach 8 lessons over nine days. While I was teaching my lessons one of the girls in the class was up at Dzawadi with her parents making t'łi'na.

Lesson one was designed as a way for myself as the teacher and researcher to assess the students' prior knowledge and experience of the dzaxwa̱n. Students were asked to create a word web of their dzaxwa̱n knowledge. It didn't take the majority of students long to complete their word web. I was saddened by the lack of dzaxwa̱n knowledge some students had, even though the majority of the students were born and raised in 'Ya̱lis. I thought everyone enjoys the same experience when the boats come in the spring and we get our feed of dzaxwa̱n. This first lesson showed me that not everyone is lucky to enjoy dzaxwa̱n. One of the students left his web blank, while 3 of the students wrote the question, "What is an oolichan?"

Lesson two was divided into 2 sections. The first examined two Kwakwa̱ka̱'wakw oral history stories regarding dzaxwa̱n; *Eulachon––The Strung Up Fish* told by J.J. Wallas, and *Traditions of the Ligwilda'x̱w* told by Chief Billy Assu. Prior to handing out the stories, I discussed with the students the terms "oral history" and "myth" or "legends." Oral history refers to the stories that have taken place in a First Nations history which have been told since the beginning of time due to having no written language. There was a time in this oral history when our ancestors had supernatural powers. I asked students if they knew the meaning of "supernatural." One student said, "like superman." I gave the example of having the ability to change from human form to being able to fly or have super strength. I went on to ask the students what they thought of when they heard the words "myth" or "legend." One student answered, "A story from long ago." I asked, "Do they think of a myth or legend as being a fact or just a story?" The majority of the class thought of myths and legends as stories and not part of history. I described how these oral histories have been handed down for generations and are a part of Kwakwa̱ka̱'wakw history. Thus, our oral stories are our truth, and are not to be considered myths or legends.

The class was divided into two groups. Each group was instructed to read the stories and be prepared to share their story with the other group when we came back together. When all the students came back together and the students were sharing the story that Chief Billy Assu shared, which told of the woman with the wings on her back who originated from Dzawadi, some students giggled. I asked, "What was funny?" One student replied, "How could a lady have wings on her back?" "Good question" I said, and reminded them of our talk about the supernatural ability of some of our ancestors. "This woman must have had some kind of supernatural ability if she had wings."

I asked the students to think of a time when our people lived in traditional bighouses and used canoes for travel. It was a different time and way of life then how we live now. Our ancestors lived in their traditional areas for hundreds and thousands of years before the Europeans arrived. Their day-to-day life was full of Indigenous Science: catching and preserving food, making medicines, designing canoes, and building bighouses without the tools and machinery that we use today to construct large buildings (Figures 13.1 & 13.2). They also cared for and respected all of creation: the plants, animals, rivers and forest.

Figure 13.1 *Figure 13.2*

Figure 13.1 ▲ Barbeque dzaxwa̲n and salmon. Photo by Barbara Cranmer (1999).
Figure 13.2 ▲ Wayut'an–half smoked dzaxwa̲n after being smoked for 2 to 3 days. Photo by Donna Cranmer (1996).

The students were then asked to create a scientific drawing of an oolichan. Photographs of oolichans (Figure 13.3) were passed around the class then posted on the board. This activity was especially important since some of the students had never seen an oolichan. Each student received the Fact Sheet *Physical Description of the Oolichan*. Students were asked to observe carefully, give the scientific name, exact measurements, draw the oolichan using clean lines, and label four body parts. Some students got right to work while others seemed to have difficulty getting started and completing their drawings.

Figure 13.3 ▲ Stages of an oolichan's life from juvenile to spawning. Photo courtesy of Alaska Fisheries Science Center (n.d.).

In the life cycle lesson students were introduced to many new scientific words. They found it fascinating that when oolichans move from the salt water back into the fresh water they resorb minerals from their teeth and scales to help in the reproduction process. These fish of the smelt family lay eggs in very small gravel. Students were given photographs of oolichan eggs that had been deposited in the gravel, and asked to identify and count the number of eggs. Some of the students found the oolichan eggs among the gravel easily, while others had trouble at first telling the difference between the gravel and eggs. One student questioned "How could an oolichan reabsorb [sic] its teeth?" Students were amazed at the amount of eggs that an oolichan lays. One of the comments was "How could a fish that small hold 25,000 eggs?"

Students recognized the similarities between the life cycle of salmon and oolichans–that they both begin life in fresh water, migrate to salt water and then return to fresh water and to the same stream and location to spawn, and begin the cycle again. Scientists refer to fish that ascend rivers to the sea as anadromous.

The oolichan food web lesson began with a discussion of predator-prey relationships, food chains, and food webs. Photographs were posted on the bulletin board of the different animals that oolichans as predators eat (phytoplankton, zooplankton, krill), and of the animals that eat oolichans (salmon, eagles, seagulls, seals, humans). Two examples of oolichan food relationships were discussed: a food web of oolichans in salt water and a food web of oolichans in both salt and fresh water. The students understood the concepts of food chains and webs by the examples they gave during the discussion. One of the girls gave the following example, "We eat salmon and seals eat salmon…sometimes we eat seals and whales eat salmon."

When the topic of fish farms came up, one of the students pointed out the issue of the extremely large amount of sea lice often found around fish farms and how they affect the small, wild salmon fry that pass by the fish farms. Another student questioned, "How does it affect the salmon fry?" I asked, "Does anyone know the answer to this?" No one responded. I explained that sea lice have been a part of life in the ocean, but because of the large population of fish in the fish farm pens there are also extremely large populations of sea lice in and around these farms (Krkošek, M. et al., 2007) and these sea lice attach themselves to the wild fry that are making their way out to the ocean. If that little fry has too many sea lice attached to it, how can it make its way out to the ocean?

The students were asked if they knew what plankton was. No one knew the answer to this question. A brief discussion took place explaining that plankton are tiny plants and animals that are so tiny that they drift in the ocean and most can't be seen with the naked eye. Most plankton can only be seen with a microscope. One of the students commented, "I'm never going in the water again if I get covered with invisible critters." I explained that plankton have always been in the salt water, they are the foundation of the ocean food chain, and they don't harm us.

The food chain discussion was a good introduction to the *Food Chain Game*. The class was divided into four teams and each team was assigned one of the members of the food chain: oolichan, salmon, seal, and man. Popcorn was sprinkled on the playing area and represented the plankton. All students were given plastic bags marked with masking tape which was their "stomach." The students who represented the oolichans were allowed on the playing area first and had one minute to fill their "stomachs" with plankton (popcorn). When the minute was up the other animals were allowed on the playing area. As players were tagged by a different animal in the chain they had to give up their "stomachs" and leave the playing area. The students played the game twice before we went back to class and discussed what they had learned during the game. It was rewarding to see the students moving around outdoors and having fun playing the *Food Chain Game*.

During the class discussion, the topic of the environment came up. One of the students mentioned that he saw on the internet that, "Out in the middle of the ocean there is an island of garbage." I'd never heard of this before but asked them, "If there is such an island out there, how do you think this affects all the life in the ocean?" One student responded, "That can't be good for the animals that live there." We talked about how we mistreat the rivers and oceans, and this has an effect on the environment around us even if it we think it is small.

Lively discussions followed the game about habitat and how oolichans and salmon have specific habitat requirements, and how pollution or the decline of one organism effects the food chain and of course the oolichans. Other issues that were discussed included oil tankers, oil spills and sea lice around Atlantic salmon fish farms located in our traditional territories. The students had a thoughtful discussion on human's lack of respect for the environment and how they can seriously affect the oolichans and all the other life that live in the ocean.

The next lesson engaged the students to build a model of a 'lap'a̱s (oolichan pit). The lesson started with a discussion about the Kwak'wala word maya'xa̱la. Many of the students nodded their heads when asked if they knew what this word meant. One student stated, "Doesn't it mean respect?" This is one of the most important Kwakwa̱ka̱'wakw teachings—treating others, nature, plants and animals and all things the way you would like to be treated. Non-Kwakwa̱ka̱'wakw use the word respect. I felt it was important to begin this lesson with the giving of thanks and the way in which the ancestors of the Kwakwa̱ka̱'wakw were always giving words of thanks to the resources prior to taking what was needed. I asked students, “When do people usually pray?” “In church,” was the answer. I shared Arthur Dick’s story of how his Grandfather always gave words of thanks or prayed when he shot a deer or was pulling up halibut. It was a part of everyday life, not something that was just done on one special day of the week.

Figure 13.4

Figure 13.5

Figure 13.4 ▲ Model of a tagał (conical net) used with the class. Photo by Donna Cranmer (1996).
Figure 13.5 ▲ Tagał showing anchor posts used in Dzawadi, Knight Inlet, with entrance to the net suspended below. Photo by Arthur Dick, Jr. (2002).

During this unit of study I made arrangements for a t’łi’na maker to visit our class and share his wealth of traditional knowledge. I reminded the students to maya’xala (be respectful of) our visitor, and that their behaviour not only reflected on themselves, but on our school and their families.

O’waxalaga’lis Chief Roy Cranmer visited our class to talk about fishing and the process of making t’łi’na. He explained how the t’łi’na making process worked with the aid of a miniature samgat’si (cooking box), awayu (skimmers), g’ala (shakers) and tagał (conical net) that he loaned to me to use with the class. Figure 13.4 is a photograph of the miniature tagał that was used to show the students the way it worked. The three black arrows indicate the posts, which prior to the 1960’s, would have been pounded into the river bed to hold the net in place. He told the students that the DVD called *T’łi”na: the Rendering of Wealth* (1999) showed the process of making t’łi’na, and asked if we could watch it and if there were any questions he could answer them. When the men were drag seining we stopped the DVD and Owaxalagalis explained that this is how they fished in Dzawadi (Knight Inlet) in 1997, and that today they have gone back to using a special net called a tagał. Figure 13.5 shows the tagał that was used in Dzawadi in 2002 and continues to be the method used today. The method of anchoring the net in place is one of the many differences between the modern tagał and the one used before the introduction of the drag seine method of fishing (Figure 13.6).

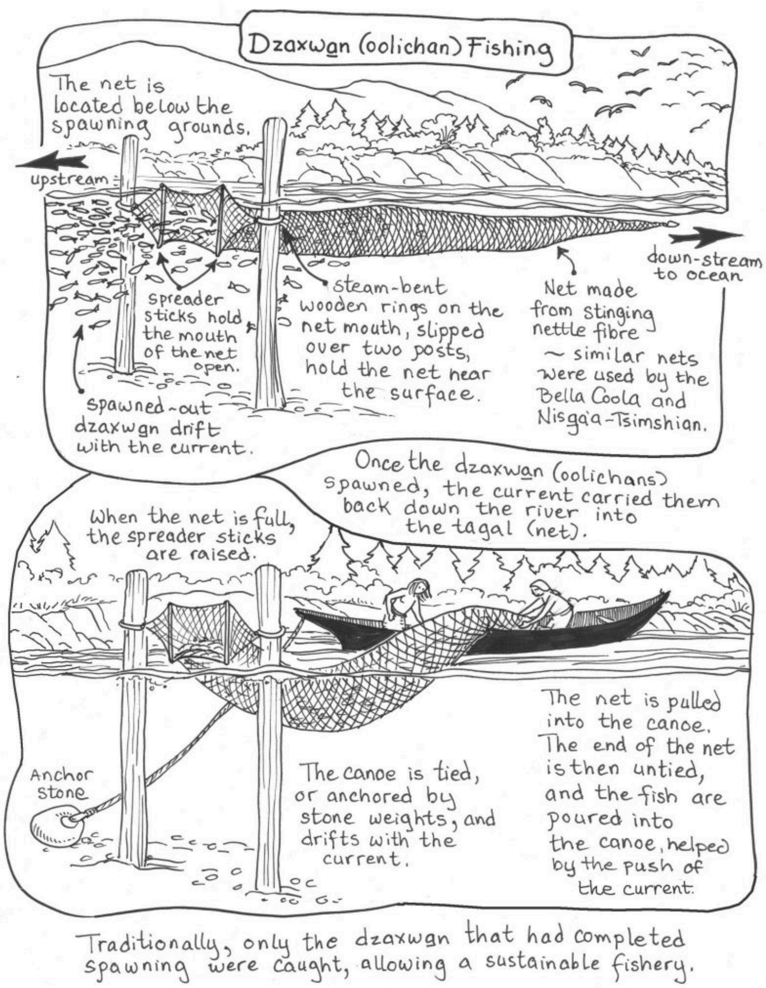

Figure 13.6 ▲ Traditional oolichan net used where falling tide runs swiftly or in swift rivers. Similar nets were used by the Bella Coola, Tsimshian and Nisga'a. Illustration by Karen Gillmore.

Owaxalagalis explained the reason for changing fishing methods was due to the changes in the river. The river has changed since his first visit in 1961, and is now very shallow in some places. One of the students asked, "How is the river changing?" Owaxalagalis explained that when it rains in Knights Inlet, because of all the trees that were taken out of the valley due to logging, the river rises almost immediately. There are a lot of log jams in the river that never used to be there, and the size of the glacier at the top of the river is getting smaller. Owaxalagalis shared many things with the students including; how to make a 'lap'as (pit), fishing methods, putting the dzaxwan in the 'lap'as (Figures 13.8, 13.9 and 13.10), and then moving them to the samgat'si (cooking box), cooking the dzaxwan, and environmental concerns.

Figure 13.7

Figure 13.8

Figure 13.7 ▲ Extremely high pit. Photo in the collection of my mother Gwi'molas Vera Newman, that was from her Ada and Dada (my Grandpa Arthur Dick, Sr.'s parents) (ca. 1950-1969).
Figure 13.8 ▲ Arthur Dick Sr. and Jr. carrying a tub of dzaxwan. Photo by Joanna Recalma, Dzawadi (1997).

The second part of this lesson was a discussion about building a ‘lap'as. Photographs of ‘lap'as in Dzawadi were posted on the board. During his visit, Owaxalagalis informed us that he harvested about 6 tons of dzaxwan to fill his ‘lap'as in the 1990's.

Figure 13.9

Figure 13.10

Figure 13.9 ▲ Richard Smith Sr. dumping a tub of dzaxwan into the pit. Photo by Joanna Recalma, Dzawadi (1997).
Figure 13.10 ▲ Barbara Cranmer sits in front of loaded pit. Photo by Arthur Dick, Jr. (1998).

I said to the students, can you imagine the amount of t'łi'na they rendered from that one ‘lap'as? The photo from the 1998 pit (Figure 13.10) has about 6 tons, how many tons do you think are in the old ‘lap'as? (Figure 13.7). The amount of t'łi'na rendered is determined by several variables, time the dzaxwan lie in the ‘lap'as, the weather and temperature, humidity and the number of dzaxwan.

It was logistically difficult to house students, especially elementary students, at the camps for 2 or 3 nights since the dzaxwan fishing camps are located some distance away from the schools (8 hour seine boat ride). It was necessary to teach about the harvesting and rendering of the dzaxwan through photographs, Elder input and by building a miniature ‘lap'as.

While the boys were creating the miniature ‘lap’as (pit) outside with Anthony, the remaining students were given the fact sheet *Methods of Fishing for Oolichans* and the class discussed the evolution of fishing methods. The students had already heard Owaxalagalis talk about the tagał, kanayu (dipping net) and seine net the day before and had seen examples of the crew drag seining and using the dip net in the DVD. The discussion of fishing methods focused on the two categories: passive and aggressive.

The last two lessons focused on the making of t’łi’na and the ceremony of giving it away as is customary within Kwakwaka‘wakw culture.

Figure 13.11

Figure 13.12

Figure 13.11 ▲ Miniature samgat’si (cooking box). Photo by Donna Cranmer (2009).
Figure 13.12 ▲ Students checking out the tools and miniature cooking box. Photo by Irene Isaac (2009).

A fact sheet, *Making T’łi’na*, illustrated the step-by-step process of rendering the oil from the dzaxwan. Owaxalagalis shared with the students that the water in the samgat’si had to reach just the right temperature before the dzaxwan could be added. He stressed that the water was never to boil. He went on to explain that the two paddle-like tools that are used to pour the dzaxwan over the stick as they are added to the heated water in the samgat’si (Figures 13.11, 13.12). The two long sticks with the slits at the end are shakers. When the dzaxwan begin to float, these two tools are used to scoop the dzaxwan out of the water, tap the side of the samgat’si, and shake the dzaxwan meat from the bones. Finally, the little oval shaped scoops or awayu (skimmers) are used to skim off the oil that floats to the top. Some of these awayu are carved in the shape of a large clam shell and range in size from very small to very large. As the area of oil to skim becomes smaller so does the size of the awayu used to skim.

I explained to the students that during my dzaxwan research one of the Elders I interviewed, Chief Jack Nolie, gave me his awayu because he wanted the knowledge to continue to be passed on. I showed the awayu to the class and explained that it was used to skim the dzaxwan oil from the top of the samgat’si (Figure 13.13). This particular awayu has an eagle wing on the back side (Figure 13.14). I asked the students, “Why do you think the carver of this awayu carved an eagle design on the tool?” No one answered. I asked, “How are these two animals, the eagle and oolichan connected? Think back to the food chain discussions.” Finally, one of the students recalled, “Well the eagles eat the oolichans when they come back to the river.” I added that in Dzawadi when the oolichans are heading up the river to spawn hundreds of eagles can be seen in the branches of the trees. Another student added, “Maybe it was a crest of the owner.”

Figure 13.13

Figure 13.14

Figure 13.13 ▲ Skimming the t’łi’na in Dzawadi. Photo by Donna Cranmer (2009).
Figure 13.14 ▲ Awayu (skimmer) showing an eagle wing and t’łi’na. Photo by Donna Cranmer (2009).

I showed the students a gallon of t’łi’na (Figure 13.14) and shared with them that older members of my family call it “Our gold, it is so valuable.” I asked, “How do we use it?” One of the girls said, “We dip our smoked fish in it.” I told them that it is also used as a medicine. I remember seeing my great grandfather Charlie Dick take a couple of spoonfuls of t’łi’na and swallow it down without any food. We always heard that it kept us healthy—kept the sickness away. It was also heated and rubbed onto the chest of someone suffering from a cold or congested chest.

During the final lesson we discussed two ways in which the Kwakwa̲ka̲‘wakw used the t’łi’na in ceremony and in trade. Before we discussed T’łi’nagila (grease potlatch), the Kwakwa̲ka̲‘wakw ceremony of giving away t’łi’na at a potlatch, I asked the students, “What is a potlatch?” The students responded:

- When a chief will show his family’s dances.
- When Indian names are given.
- When someone dies, their family has a memorial potlatch.
- When dances are given to younger family members.
- It means to give.

I was impressed with the students’ answers, and knew that some of them had participated in their own family potlatches.

Figure 13.15 ▲ *T'łi'na given away at Arthur Dick Sr.'s T'łi'nagila (grease potlatch) memorial for his late aunt Lucy Brown. Photo by Gwi'molas Vera Newman (1974).*

I added that prior to the Europeans coming to our territory our people had many ways of remembering and recording information even though they had no written system. The potlatch was a way for a chief to show his ancestral links to the songs, dances, names and masks that he owned. Host chiefs would invite tribes to witness as he opened his box of treasures, showing dances, songs, handing down names, and privileges. These potlatches took place as memorials for loved ones who had passed on, to mark marriages, pass on names, dances, songs, and even rights to hunting or trapping grounds. The witnesses were paid by the host chief and this is how the history was passed on. The gifts given at these potlatches have changed over the years. Prior to contact a chief's family would save for years animal furs, woven blankets, baskets, and hats to give at a potlatch. Today the majority of items given away at a potlatch are purchased from department stores: towels, laundry baskets, kitchen utensils, and blankets. The one thing that has remained the same over the years is the giving away of t'łi'na. There are some families that continue to host potlatches where this valued gift is given. During a regular potlatch the gifts are given after the host has shown all his family's treasures. During a T'łi'nagila (grease potlatch) the t'łi'na is usually given away after the mourning songs are sung and the copper talk takes place, and before the family dances are shown. Before distributing gifts to the guests whether it is dry goods that is given at the end of a potlatch or t'łi'na, the chief's family lays all the gifts out on the floor of the bighouse. During the T'łi'nagila special feast spoons and dishes are brought out that may be carved with the crests that the chief has a right to use.

In front of the gallons of t'łi'na in Figure 13.15 are a wolf feast dish and two wolf feast spoons which belong to Arthur Dick's family. The tradition remains strong among the families that continue to potlatch. In Figure 13.16, I asked students to notice the same ceremonial objects carried by the matriarchs of Art Dick Jr.'s family in 1999 at his father's memorial. These objects are still being used twenty-five years later.

Figure 13.16 ▲ *Arthur Dick's sister Daisy Joseph, daughter Gwi'molas Vera Newman and aunties, Ethel Alfred, Stella Sumners, and cousin Christine Taylor holding grease spoons and wolf feast dish at a T'łi'nagila (grease feast) he hosted. Photo from Gwi'molas Vera Newman collection (1974).*

In the DVD *T'łi'na: The Rendering of Wealth* (1999) Art Dick Sr. and Jr. refer to this ceremony as the highest (most prestigious) potlatch a chief can give. I asked students who had been to a T'łi'nagila to pair up with a student who had not been to a T'łi'nagila and tell what they remembered. One of the young girls said, "My uncle gave away grease at our family's memorial potlatch for our Grandpa and Ada." I asked, "How many students have seen such a potlatch?" More than half the class said they had attended such a potlatch. The following is a list of memories of T'łi'nagila shared by the students:

- Feast songs were sung.
- Speeches are given by chiefs.
- Sometimes t'łi'na is poured onto the fire.
- Sometimes 20 lb. (9.07 kg) bags of flour are also given out.
- Boxes or baskets of traditional food are also included: homemade jam, canned fish, seaweed, jarred clams, and k'awas (dried fish).

I explained to the class that the potlatch recalls our history and how our family connects to the ancestors form our origin stories that go back to the time of the supernatural beings. I asked the students to think back to the origin stories that talk about the dzaxwa̱n, and imagine how long Kwakwa̱ka̱'wakw people have been hosting T'łi'nagila. "It's been a long time," one of the students responded.

The final discussion in class was about the trade routes called "grease trails" that our people used to travel when trading with neighboring tribes. In his book *Following the Path of our Ancestors* (2005), knowledge keeper 'Wax̱a̱widi William Wasden tells of the 'Na̱mgis First Nation ancestor U'małame' who founded the grease trail connecting the 'Na̱mgis with the tribes on the west coast of Vancouver Island. For almost one hundred years the trail was not in use, but in 1999 four men from our village travelled over the ancient trail carrying t'łi'na to share with west coast relatives at the canoe gathering in Ahousaht. During this journey on the grease trail, a song was composed by ‘Waxawidi William Wasden to commemorate the reopening and use of this ancient trail. Many of the students knew the song but did not know what it was about. I told the students that in Ahousaht when those four men and their crew of pullers (people that paddle in the canoe) landed they carried t’łi’na off their canoe to give to the Ahousaht chiefs. That is the first time that song was sung and danced.

For our final class we hosted a mini feast and invited our parents to come and see what we had learned. I asked for student volunteers to create a drawing that we could use as an invitation to our luncheon. Students helped to prepare food and set up the gym for this luncheon. We were lucky to have our feast when a boat had just come out from Knights Inlet, and they shared some fresh oolichans with us. The parents and students were able to have a feed of fresh fried dzaxwan. Smoked dzaxwan was also on the menu along with yusa (fish soup), ka’aba’wakw (baked fish), lak’astan (fried seaweed) and of course t’łi’na. Students were reminded that they were the hosts and that in keeping with Kwakwaka‘wakw customs, the host always serves his guest first. It was a wonderful way to end the two weeks Gwaya‘elas curriculum unit—feasting with our parents and Elders on traditional food.

Evaluating Students’ Learning

This science unit was a combination of Kwakwaka‘wakw IS and WS concepts. It is a strong held belief that for our First Nations children to be successful they need to know where they come from; they need to know their traditions and history. One of the ways of showing students Kwakwaka‘wakw traditional science was by bringing community members into the classroom to share their knowledge. Traditionally this is how the knowledge was passed on, with older community members sharing their knowledge. The method of evaluation for this unit was both traditional and modern. The students:

- Created a web of their prior dzaxwan knowledge and their post instruction dzaxwan knowledge.
- Read and discussed two origin stories of the dzaxwan.
- Created scientific drawings of dzaxwan: labelling four body parts, giving the scientific name, Kwak’wala name, and measurements.
- Participated in the *Food Chain Game* and identified predator-prey relationships within a food web.
- Brainstormed and ordered into a proper sequence a list of what takes place during a T’łi’nagila (grease potlatch).
- Listed the gifts that were given at a potlatch prior to contact and today.
- Created a chart of the life cycle of the dzaxwan; illustrating the measurement of the fish at each stage of their life, length of time in each stage and name of each stage. Made connections between stages of the life cycle and habitat requirements.
- Answered a mini quiz with review questions from the first four lessons that covered: oral history, different stages of the life cycle, food webs, predator-prey relationships, habitat, environmental concerns, and human effects on the dzaxwan population.
- Studied, compared, and described the many methods of catching dzaxwan: tagał-conical trap, drag seine, and dip-net.
- Studied and described the process of making t’łi’na.

- Listed reasons for the decline of the dzaxwa̲n.
- Participated in a question and answer period during the visit by a local t'łi'na maker to the classroom.
- Examined a map provided by the 'Na̲mgis Treaty researcher and found and traced the ancient grease trail walked by 'Na̲mgis past and present.
- Created a miniature model of a 'lap'a̲s (dzaxwa̲n pit).
- Explored variables that determine the time dzaxwa̲n require to cook in the 'lap'a̲s: weather, temperature, humidity, and the number of dzaxwa̲n.
- Made connections with the concepts: decomposition, heat and temperature, boiling point, and food preservation.
- Demonstrated the Kwakwa̲ka̲'wakw teaching of maya'xa̲la for their parents and Elders at the final celebration by extending a personal invitation, getting chairs, setting tables, preparing plates of food and serving Elders.
- Created a dzaxwa̲n drawing using traditional elements of Kwakwa̲ka̲'wakw art.
- Exhibited maya'xa̲la to the Elders and community members who visited the class during a traditional dzaxwa̲n knowledge lesson.

While gathering research for this curriculum the community members that were interviewed all stated that they were shown firsthand what to do, and when the old people felt they (the learner) were ready, they were left to do the job. From a First Nations perspective this was a very formal process. In earlier years, children experienced the sharing of dzaxwa̲n (oolichan), the distribution of dzaxwa̲n throughout the community, and would have learned how to show respect to the dzaxwa̲n as part of the dzaxwa̲n grease rendering process. The teaching took place as day-to-day living happened. The valuable dzaxwa̲n knowledge continues today with the families that continue to travel to Dzawadi (Knight Inlet). The sad fact today is that less than a dozen children have the opportunity to experience the dzaxwa̲n teachings on the land, where as in the past all Kwakwa̲ka̲'wakw children enjoyed and experienced dzaxwa̲n teachings in Dzawadi.

During this unit, I made many observations myself of what students were accomplishing in class. I found myself falling back into wanting to just evaluate students using methods I learned during teacher training. I created a quiz and asked the students to fill out the questions. I realized later that all this information would have come out in the final knowledge web they created at the end of the unit. It is hard to break methods of teaching and evaluation learned during formal teacher training. The majority of students came away from this unit with a greater understanding of Kwakwa̲ka̲'wakw dzaxwa̲n and the care we need to take of our environment so we can maintain our traditions.

Future Possibilities

It could be possible in the future within this unit or after this unit to focus on more abstract concepts such as heat and temperature and using the dzaxwa̲n as a catalyst for further exploration. Instruction could include science concepts that are included in the upper elementary and high school science programs, but are difficult for students to understand such as aerobic and anaerobic bacteria, hot and cold, heat and temperature, the measurement of heat, and the theory of kinetic energy (molecules in motion).

There are a variety of ways we could more closely replicate the rendering of oolichan oil. For young children we could make papier-mâché figures to represent the oolichans. For older students, we could use frozen oolichans to experiment with different ways of modeling the process of fermentation and rendering of the oil. Traditionally, after the oolichans were allowed to ferment and begin to “break down” in an open wooden pit, the softened fish were placed in a wooden cooking box or even a canoe and heated with hot rocks. Temperature control was important—the mixture must not boil. Heating rocks in an open fire can be dangerous (some types of rocks crack). In the classroom we could use an electric frying pan to simulate the cooker and skim off small quantities of t’łi’na with a spoon. (Note: in an open pit aerobic bacteria break down muscle tissue and help free the oil.) What would happen if the fermentation step involved anaerobic bacteria—if they were kept in a warm sealed jar? (Note: anaerobic bacteria will cause the fish to rot.)

One of my dreams when going through my teacher’s training at Simon Fraser University was to eventually teach our own children our Kwakwa̱ka̱‘wakw history and culture. Due to my own lack of high school science courses I was unable to achieve a minor in biology as part of my B.Ed. degree, which was my original goal. By creating *Gwaya̱‘elas, How We Do Things: Kwakwa̱ka̱‘wakw Use of Dzaxwa̱n*, I gathered and shared the knowledge about this important resource and showed the children the ‘Na̱mgis peoples’ science. This may result in some of our students wanting to explore other traditional science areas.

With very few Kwakwa̱ka̱‘wakw teacher resources readily available to teachers in ‘Ya̱lis and on northern Vancouver Island, it is hoped that an important outcome of this research will be the development and evaluation of usable curriculum resources for the Kwak’wala speaking people, as well as other communities. I believe that it is crucial that First Nation students participate in school science and as a ‘Na̱mgis First Nation educator and parent I see the need for such curricula to be developed. In writing this chapter, I found myself struggling with the challenge of finding where Kwakwa̱ka̱‘wakw IS fits with WS or trying to make it fit. Looking at the BC Ministry of Education documents and attempting to see where this dzaxwa̱n IS fits, I have come to the conclusion that it does not have to fit perfectly in order to be useful. Kwakwa̱ka̱‘wakw science, or IS, is what has sustained our people on this coast since the beginning of time. It can stand alone, and it can stand beside Western Science, but it does not have to fit within it or as an add-on. While coming to this conclusion I know from experience that we First Nations people sometimes give less credit to our own knowledge and ways of viewing the world; I often remind myself that our people would not have successfully lived to see this century if it had not been for our ancestors’ science knowledge and way of life.

While teaching the Grade 6/7 class at T’łisalagi’lakw school it became apparent to me that we need to teach our children as soon as they enter our school the following, “’Na̱mega̱n’s o’a̱m dla̱‘wa̱ns a̱wi’nagwisex̱—We are one with the land.” These are words that were shared that summer by our ‘Na̱mgis Chief Kwaxa̱lanukwa̱‘me’ ‘Na̱mugwis William Cranmer as our people returned to many of our traditional village sites within our territory. I was excited by the knowledge that was shared about what our people did at places like: Anutz Lake, Wa’as Lake and the Gwa’ni River, visiting areas where traditional food was gathered, and learning about the plants that our people used for medicine. I imagined visiting these sites during the school year and ensuring that our children would know the teachings of our ancestors about the land. The passing on of this valuable traditional knowledge would give our children a sense of belonging and knowledge of who they are as Kwakwa̱ka̱‘wakw.

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Chapter 14 - Storytelling is our Textbook and Curriculum Guide

Understanding Kwakwa̱ka̱‘wakw Science Knowledge and Way of Life Through Story

‘Welila’ogwa Irene Isaac

Storytelling is Our Textbook

Storytelling has always been an important aspect of Indigenous cultures throughout the world. Traditional stories were carefully constructed around the observation of natural events and the plant and animal world, their styles of obtaining food and the history of the people. While entertaining and sometimes charged with emotions, the Indigenous stories influence young people to become knowledgeable and responsible citizens.

Central to the cultural and spiritual practices of the Kwakwa̱ka̱‘wakw people is the potlatch or winter ceremonies when stories are retold, dramatized, and shared. Most of these teachings are passed down through storytelling and the practice of the potlatch—the giving of a great feast. Thus, storytelling is the foundation of traditional Kwakwa̱ka̱‘wakw education processes. Stories about the plant and animal world continue to be our textbook and curriculum guide.

According to Yup’ik scholar Oscar Kwagaley (1995), “In legends and myths, there is always the mention of supernatural beings and the living world,” and he describes most Indigenous worldviews as “seeking harmony and integration with all life, including the spiritual, natural, and human domains” (p. 2). Thus, a Kwakwa̱ka̱‘wakw worldview is expressed consciously or unconsciously through family and community stories; and by art, dances, ceremonial masks, totem poles and customs. The stories contain the historical events that transform the earth over time and the guiding principles for good relational living that each generation must learn.

During special feasts and potlatches, the Kwakwa̱ka̱‘wakw continue to use many types of ceremonial instruments—whistles, horns, rattles and drums to bring to life our songs, dances and stories (Figures 14.1 and 14.2). When seeing the dancers and hearing the beat of the Kwakwa̱ka̱‘wakw drum in the bighouse, it is easy to hear the sounds of the Thunderbird, Raven, Dzunuk’wa (the Wild Woman of the Woods) and the Hamat’sa—the dance of the Baxbakwalanuksiwe “the cannibal from the North end of the world” (Figure 14.3).

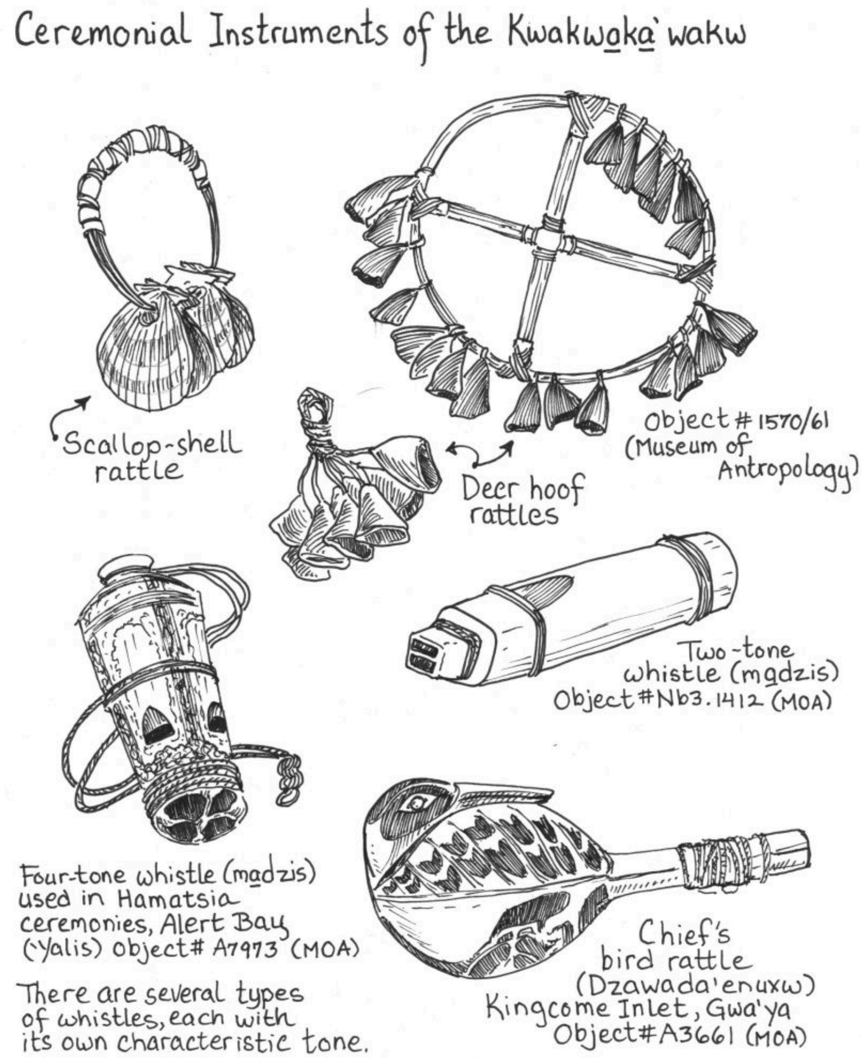


Figure 14.1 ▲ The Aboriginal peoples of the Pacific Northwest continue to use a variety of traditional ceremonial instruments to accompany their songs, dances and stories. Illustration by Karen Gillmore.

Traditionally, it was mainly the elderly men who carried the role of drummers given their wisdom and knowledge base. Today there is a revitalization of singing and drumming traditions that is seeing younger men playing a greater leadership role at the log, much of this inspired by "Wa" (William Wasden), a young chief and cultural leader from our territories.

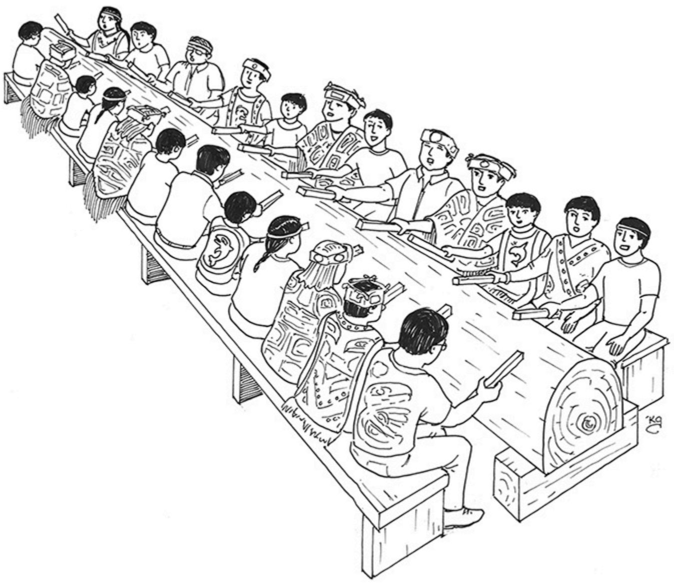


Figure 14.2

Figure 14.3

Figure 14.2 ▲ The Kwakwaka’wakw drum is a hollowed out cedar log, and sits up to 12 drummers on either side. Illustration by Karen Gillmore.
Figure 14.3 ▲ Kwakwaka‘wakw dancer wearing raven mask during the Hamat’sa—the dance of the Baxbakwalanuksiwe. Photo by Gloria Snively (1985).

Traditionally, Kwakwaka‘wakw education involved specific skills that were needed to live and evaluation of learning was determined by the community and simply by an individual’s ability to carry out his or her responsibilities within the group. Life on the land was tough, but it also had a sense of meaningfulness; the lifestyle was healthier as people were more spiritually, emotionally, physically, and mentally connected to the land and each other. People had to co-exist with their environment rather than conquer the land.

During the first decades of the 20th century, many of the teachings that embody songs, dances, ceremonies and potlatches were prohibited by federal and provincial laws, and subsequently the Kwakwaka‘wakw were no longer able to give thanks for the things they were given by Creator. Connections were lost with the spirit world, and the people no longer took only what they needed. It has only been within the last few decades that significant attempts have been made to reconnect with our traditional Kwakwaka‘wakw teachings and the knowledge and values these teachings encapsulate.

Local traditional knowledge and wisdom has meant life and wealth for the Kwakwaka‘wakw, and continues to be accumulated through time spent living on the land with young people working alongside families and communities. Hence, our traditional knowledge is the science of our people, our Indigenous Science (IS), and has always been interconnected with the land. To separate the two would detach one from the true meaning of IS, which is to live in harmony with the land. The goal then is to create science curriculum that connects us to the land, which is more relevant to our Aboriginal learners who may have previously rejected school science because it conflicted with their cultural value system.

Following Snively and Corsiglia, Chapter 6, I use the term IS to refer to the science of Indigenous peoples worldwide. I use the term WS to represent Western Science or Modern Science, the science taught in most classrooms. The inclusion of traditional ways of knowing, our IS with Western Science (WS), brings a glint to the eyes of our grandmothers while it sparks the interest of our children. We seek to inspire and enable our students to access the vast storehouse of our collected and refined observations and understandings while also having access to the language and modes of analysis used by newcomer science and governance.

One of the biggest challenges First Nations communities face is overcoming the negative self-images and self-worth that has stemmed from "failure" in the classroom. What could be more encouraging than to learn about the IS that has proven to sustain the Kwakwa̱ka̱'wakw in their homeland for hundreds and thousands of years? As a First Nations educator, I wanted to find ways to use our stories in the classroom in order to balance IS knowledge and wisdom practices with WS knowledge and practices, thus making school science more relevant, meaningful, and accessible to First Nations children.

I chose the story, *Raven Steals the Light*, as the focus of my science unit and the catalyst for student learning. Raven, the trickster and transformer, is credited with many heroic deeds, as well as being ridiculed for his greed and gluttony. Raven performed many important tasks in making the world a good place for humans, including releasing the sun that was hidden in a bentwood box by a selfish chief, so that at last there was daylight and people no longer had to live in darkness. The story occurs in many versions and is only one of numerous Raven "creation" stories.

In developing a culturally relevant science curriculum, I needed to more fully understand a Kwakwa̱ka̱'wakw worldview in order to develop lessons that accurately portray the values and traditions of our people. I also needed to find methods of assessment that are effective and culturally appropriate.

Background

Specifically, the project had a three-fold purpose: (1) interview Elders and knowledge keepers to describe, at least in part, a Kwakwa̱ka̱'wakw worldview, (2) in collaboration with Elders and knowledge keepers, develop a unit of study that used Kwakwa̱ka̱'wakw stories as a catalyst for exploring IS and WS concepts and processes, and, (3) pilot test sample lessons and obtain evaluative feedback from Elders and students. From a First Nations teaching and learning perspective, the study was designed to investigate the following:

- identify stories that need to be developed to teach IS knowledge and ways of life in the classroom,
- show how particular teachings are embedded in the stories,
- identify IS and WS related examples (knowledge, concepts, processes, and wisdom) embedded in the stories,
- determine how the stories need to be represented in the classroom and/or outdoor setting,
- describe aspects of Kwakwa̱ka̱'wakw worldviews portrayed in the stories,
- describe the students' experiences during instruction, what they learned and how they responded, and
- link the curriculum to the prescribed goals as set out in the BC Ministry of Education. (Isaac, 2010)

From a Kwakwa̱ka̱'wakw perspective, what could be more illuminating than seeing how interactions between Elders, children and the land stimulate and draw forth the most meaningful teaching and learning?

The community of 'Ya̱lis (Alert Bay) is located on Cormorant Island, within the area known as the Broughton Archipelago on the mid-coast of British Columbia. Cormorant Island lies within the traditional territory of the 'Na̱mgis

First Nation, one of 16 remaining Kwak’wala speaking nations. Directly adjacent to Cormorant Island, on Vancouver Island, is the mouth of the Nimpkish River (Gwa’ni). The Nimpkish watershed is the largest on Vancouver Island. According to the legend of the river’s origin, Gwa’ni was placed there by Creator to support “many kinds of salmon…food for your descendants for as long as the days shall dawn on the world.” It was these salmon runs that gave birth to the Kwakwaka‘wakw people (see Chapter 13 for a more complete description of ‘Yalis).

The student participants in the study included Grade 6/7 intermediate school students at the T’lisalagi’lakw Band School in ‘Yalis. There were 18 participants with a balance of both male (10) and female (8). The students ranged in age from ten to twelve years old and most were of Kwakwaka‘wakw ancestry or from other First Nations.

Interviews with Knowledge Keepers

Since my research involved the IS and worldview of a home place, community involvement was essential. The six knowledge keepers I interviewed had dedicated their time to preserving our rich culture through potlatching, speaking our language, researching our history, and being well versed in Kwakwaka‘wakw stories, songs, and dances.

The interviews were designed to explore story and its place in Kwakwaka‘wakw education, and to gain a basic understanding of a Kwakwaka‘wakw worldview. The interviews were digitally recorded in video and audio by the ‘Namgis Treaty Communications officer and myself. Thus, I relied on a form of oral history where people had the opportunity to speak in their own words about their life experiences.

By having similar backgrounds in relation to home, culture, and education and by listening to the interviewee’s comments, and focusing many questions on the interviewee’s previous comments, an informal feel to the interview was achieved, like an open discussion. Following my interviews, I was able to explore relevant applications to teaching science by incorporating knowledge elements that were and are still taught by the Kwakwaka‘wakw.

The research was also based on historical research that relied on archival data stored at the U’mista Cultural Centre Society, located in ‘Yalis. The Franz Boas collection was explored along with the ‘Namgis Treaty collection. Suitable stories were chosen from these two collections, as well as stories shared by the participants. These stories then became the basis for developing my science unit of study.

Towards a Kwakwaka‘wakw Worldview

A worldview is a term to describe how one’s beliefs are used to view the world. According to Kawagley (1995), “The concept of worldview is very closely related to definitions of culture and cognitive map” (p. 7). Each person’s “life understandings” take place over time as he or she engages in new events and experiences, and interacts with others, and derives answers to questions about life and living with fellow human beings. “Young people learn these principles, including values, traditions, and customs from myths, legends, stories, family, community, and examples set by community leaders” (Kawagley, 1995, p. 7). Every child comes to the classroom with a worldview that is closely aligned with his or her cultural experiences. Every system of education is built upon some way of looking at life and the world. Hence understanding the concept of worldview is to education what a foundation is to a building.

By looking for patterns in the Elder interviews, nine main themes emerged. These themes encapsulated, at least in part, a Kwakwaka‘wakw worldview and are the themes I kept in mind while developing my lesson plans.

(1) Rules and Regulations

Kwakwaka‘wakw rules for guiding us in doing things right was communicated through our stories and ceremonial practices. As ‘Namgis Treaty researcher Diana Jacobson reminds us of traditional knowledge embedded in story:

> There's one woman who is a twin and she turns into a dog salmon. She told all about the fish carcasses that they had to be thrown back into the river. This way our old people knew that the carcasses fed the future fry by coming up when they emerged. This knowledge was passed on with the stories so anytime they cut up the fish and heads that they used, it went back into the river and it rotted…and it fed the fish. (personal interview, July 16, 2008)

These rules and regulations are framed as positive duties and obligations and they help ensure that there would always be enough resources for everyone in the community. The Kwakwaka‘wakw way of life and the continuation of life depends on people following these rules that were laid down through story. Alternatively, if these strict laws were broken the stories speak of terrible things that would happen. Significant messages are also found within traditional songs and like so many other oral teachings, they were passed on when it was considered the right time.

(2) Life Lessons

In all Kwakwaka‘wakw stories, our people are educated about how to live well and sustain our way of life. Diane Jacobson shares her explanation:

> Oh, what William said earlier that every one of our Kwak'wala stories up and down the coast talk about a Flood story. We knew about tides. It was told in origin stories…when to go pick clams. We knew about medicinal plants. The stories told you how they did it, how they cooked it, how to prepare it. They talked about the environment, weather and they talked about different fish and plants and how to use it and how to respect it. That's all in origin stories. (personal interview, July 16, 2008)

The children learned right from wrong through the experiences played out in story. Teachings are extrapolated by children from stories and songs; rules of behaviour are not taught in a direct way. Also, the story identifies where things originate and therefore gives one a better understanding of self. Humour and storytelling made abstract ideas meaningful, interesting, and memorable to the child. Cultural teacher, Gwi'mo'las Vera Newman shares one of her memories:

> My grandpa used to add his own little words in Kwak'wala. ‘You have been given to me a gift even though I'm a stinky old man,' and he did that just to be funny and we used to think he was really funny. So humour is a major part of teaching and fun. I think we should not forget to have fun and it should be fun to learn. (personal interview, July 16, 2008)

While we learn from the lessons within a story, we are reminded that the teachings that stick with us the most are often the ones that fill us with communal happiness and laughter.

(3) Spirit and Interconnection

In Kwakwa̲ka̲‘wakw culture there is mention of several supernatural beings who do not have a physical body, but are able to use their magical powers to transform. Spirits such as Raven were given gifts that allowed them to connect with all things in nature. There are many consistencies found within story and song that illustrate our close connections to nature and to the animal world. We are all part of the same circle of life; we are all connected. If there is no reciprocity the things we rely on the most will no longer come back to us.

(4) Respect for all Things

In all of my interviews, maya’xa̲la is mentioned in one form or another. Most speak of maya’xa̲la, which means a respect for all things. Cultural teacher, Andrea Cranmer explains:

> There is a legend about Jack Peters (Elder) who was a teacher of our new school, and he said ‘don’t kill a spider. They’re our friends.’ We used to grow up all our life without hearing this particular part of being educated about spiders and he said that the spiders saved one of our tribes. When there was war, the tribe hid in the cave and then the spiders went back and forth making their webs covering up the cave. So the spiders protected the tribe from being attacked by the enemies. In our belief we are connected to everything, so why would we want to go and kill something… (personal interview, July 21, 2008)

Maya’xa̲la teaches us to have respect for all things, with the most important being self. Messages of maya’xa̲la are seen throughout Kwakwa̲ka̲‘wakw stories, legends, songs, and dances. Today anyone who is a part of the Kwakwa̲ka̲‘wakw culture will speak of maya’xa̲la, it is a term that is used for all things at all times (used in the big house and other teachings, it is spoken to remind children of the need to be respectful).

(5) Community and Working Together

One of the most powerful components of any unit of study involves community, which should be no surprise since the children are the stakeholders. The foundation of Aboriginal worldviews is people’s relationship with each other, across families, communities, generations, as well with their other relatives—plants, animals, fish, trees, birds, killer whales, and all the other elements of creation. By involving community, we add time-tested knowledge and wisdom that is not available in the standard resources we are required to use in schools. More importantly, we bring an enthusiasm and sense of pride that comes from working together towards a common goal.

(6) The Land is the Foundation of our Teachings

All Kwakwaka'wakw stories tell about a specific time or place in local history, and provide a view of life prior to contact. Through story, we begin to have a better understanding of the landscapes within our traditional territories and our impact on these lands. More importantly, our ancestors passed on to future generation's experiences and stories that are rooted within the land. Many people will tell you that it is a different feeling when they are on the Nimpkish Lake or at Woss Lake because they feel they are surrounded by their ancestors. Therefore, it is important to make these connections from our stories to the land and its place in science. As students learn more about their land, they are more likely to have a vested interest in taking care of their land because they have experienced its beauty and rich history.

(7) Behaviour and Morals

Our Kwakwaka'wakw stories give us a sense of what is right and what is wrong. How we conduct ourselves is a reflection of how we are taught. Gwi'mo'las Vera Newman shares her experiences of the Dzunuk'wa story, also known as "The Wild Woman of the Woods":

> (t)he first thing I had to learn and I still have a hard time doing is listening. I grew up in a time in Village Island where I had just about every night with my grandparents, and they talked about how we conduct ourselves. We had tea with our Granny (Ada) and our Grandfather and sometimes he told us legends. Sometimes he danced for us and Ada would sing and it was always teaching…As an example, this 2008 my sister Eva had her two grandsons and they weren't listening to their Ada. They call her Ada too. I said, "Eva, is there anybody misbehaving in here? Look there is a Dzunuk'wa running around…" My sister said, "Wow, thank you for that!", because when we misbehaved when we were young the Dzunuk'wa was going to come…the only time she comes out is when kids are being naughty. (personal interview, July 16, 2008)

Stories and ceremonies reinforce how one should conduct oneself, and when a student is made accountable for their actions, they are more likely to become responsible citizens. So when Elders entrust a student with the knowledge that has been handed down to them, there is a responsibility that falls upon the student. These responsibilities shape the individual, the community, and even the world.

(8) Important Teachings Happen within Family

Stories confirm rights and privileges and explain where families originated. Traditionally, it was the responsibility of the parent and extended family members to come together to teach essential life skills and to find peoples' gifts. It is our family members who shared with us the stories we remember the most. Grandparents, aunties, uncles, and those who were exceptional storytellers, would use as many opportunities as they could to communicate our connections within family and place. The most memorable and teachable experiences often happened within family and the lessons stayed with that individual to carry on to their children and their children's children.

From what the Elders have said, from the historical stories, the vision is simple—to integrate Kwakwaka'wakw knowledge that has been gathered since the beginning of time through story and ceremony, with Western Science. As the Kwakwaka‘wakw engage in joint ventures these two knowledge bases will ensure that the natural resources and traditional practices of the Kwakwaka‘wakw are protected.

The Curriculum Development Process

Through the collaboration of Elders and cultural teachers, this science unit of study was developed using the story *Raven Steals the Light* as a catalyst for exploration. From a teaching and learning perspective, the story was selected for the following reasons:

- the story is told up and down the west coast of Canada and Alaska, and there are several oral and written versions that can be adapted,
- the story links to the mortuary customs of the Kwakwaka‘wakw (relating to how the Kwakwaka‘wakw were placed in bentwood boxes and buried in trees) because Raven stores the light in a bentwood box, hence the story could be elaborated to include the art and science of making bentwood boxes,
- the insightful message relates largely to greed, and in the destruction of our lands and natural resources we are seeing the devastating effects of greed,
- many science concepts and processes could be easily drawn from the story; and the story is relevant to the students' lives.

The goal is to acknowledge and strengthen the First Nations Indigenous Science education experience, while simultaneously engaging students in Western Science education experiences so that our students would find school relevant and be successful in the school science program. Additionally, the story could be linked to many prescribed science learning outcomes outlined in the Grade 5 and Grade 7 BC Ministry of Education Integrated Resource Package (2005).

From my interviews with respected cultural leaders, it was clear that putting the spirit of maya'xala into all aspects of the curriculum was imperative: the goals, lesson plans, materials, and resources used, evaluation and how students behaved. I was certain that the success of any science program must include spirituality because it is what connects us to all things. The land creates the foundation for what we know as science, so it became important to travel to selected locations within the Kwakwaka‘wakw traditional territories to explore aspects of Kwakwaka‘wakw story, and because many ‘Namgis children had not travelled much beyond ‘Yalis community. Family and community working together became a powerful part of the science curriculum, and the involvement of Elders and community resource persons became its foundation.

Story: The Raven Steals the Light

Long ago, the ancestors of our people formulated the Kwakwaka‘wakw version of the *Raven Steals the Light* story. In the story, the infamous Raven can be a spoiled child, a helper for people, and a transformer (Figures 14.4, 14.5, and 14.6). The essence of the story is about the gift of light. The following is a much shortened version of the story:

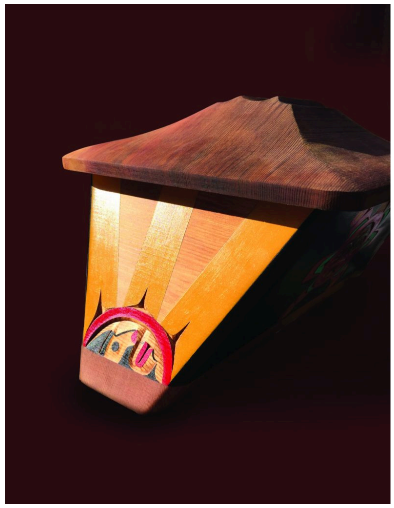
At the creation of the world, there was no light. The sun and the moon were kept in a treasure box by a greedy Chief who owned the treasure box and would not share it with anyone. One day, Raven, whose name was Kwikwaxa'wi (Great Inventor) heard about the Chief and his treasures. He heard how bright and warm the sun was. He wanted to have it. So Raven thought about how he could steal it for himself. Raven transformed himself into a salmonberry so that he would be able to trick the chiefs' daughter into eating him (the salmonberry). Once he is in the daughters' stomach Raven transforms himself into a baby boy and the chief's daughter gives birth within four days of eating the salmonberry. Raven grew fast and could talk as soon as he was born. One day, Raven came home crying loudly. His grandfather asked him, 'What is the matter with you?' Raven replied, 'I want to play with the treasure box that hangs from the roof beams'. His grandfather told him very sternly, 'No one is to touch that treasure box and do not ask again!' So Raven threw the biggest tantrum he had ever thrown and cried and cried and would not stop. Finally, Raven's grandfather took pity on him and told his daughter to lower the treasure box. He told her to open the lid just a little for Raven to see. When Raven saw the beams of the sun shining out he started to cry. He begged to play with the box. So, his grandfather allowed him to play with the box only if he promised not to open it. Raven promised and played with the box all afternoon without opening it. Another day, Raven was allowed to put the box that held the sun in the bow of his canoe. Then he paddled away and went out to the sea. When he was quite a distance away, he opened the box just a little bit. Out from the box flowed some bright rays of light. He was really proud of himself that he had stolen the sun and had it all to himself. He yelled back to his mother and grandfather and said, 'You thought you would have the sun for yourselves and be the only ones to have daylight! Now look who has the sun. It is me, for I am the great Raven!' He opened the lid a little more and at that moment a wave came and rolled the canoe. Raven fell back in the canoe and the lid fell off the box. The sun came rising up and quickly floated into the sky. It was too hot for Raven to grab. There was nothing he could do. He had lost the sun and daylight was released to the world.

-Story adapted from Kwakwaka'wakw First Nation

Figure 14.4

Figure 14.5

Figure 14.4 ▲ Bentwood box depicting Raven releasing Sun by 'Namgis master artist Bruce Alfred. Photo by Sandra Seib (2013).
Figure 14.5 ▲ Bentwood box depicting darkness replaced by sunlight by 'Namgis master artist Bruce Alfred. Photo by Sandra Seib (2013).



amgis master artist Bruce Alfred" class="wp-image-659" height="250" width="193" srcset="https://pressbooks.bccampus.ca/knowinghome/wp-content/uploads/sites/55/2016/07/14.5-Bentwoodbox4-791x1024.jpg 791w, https://pressbooks.bccampus.ca/knowinghome/wp-content/uploads/sites/55/2016/07/14.5-Bentwoodbox4-232x300.jpg 232w, https://pressbooks.bccampus.ca/knowinghome/wp-content/uploads/sites/55/2016/07/14.5-Bentwoodbox4-768x994.jpg 768w, https://pressbooks.bccampus.ca/knowinghome/wp-content/uploads/sites/55/2016/07/14.5-Bentwoodbox4-65x84.jpg 65w, https://pressbooks.bccampus.ca/knowinghome/wp-content/uploads/sites/55/2016/07/14.5-Bentwoodbox4-225x291.jpg 225w, https://pressbooks.bccampus.ca/knowinghome/wp-content/uploads/sites/55/2016/07/14.5-Bentwoodbox4-350x453.jpg 350w" sizes="(max-width: 193px)

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Figure 14.6 ▲ Bentwood box depicting sun taking over the world by 'Namgis master artist Bruce Alfred. Photo by Sandra Seib (2013).

Generally, Raven is a comic figure, but at his best, when he is most evolved, intelligent, and skillful, he rises above all other heroes and actually brings light and life to the entire world. By overcoming the greedy and self-involved chief who kept the entire world in darkness, Raven shows us the obligation that comes with intelligence and clear knowledge of our circumstances. Intelligence is not merely for entertainment; nor is it enough to make ourselves comfortable or even grand at the expense of others. Our obligation is to keep our world in balance and set things right when a wrong is being committed. By engaging our intelligence and acting with perseverance and determination, even the most difficult obstacles and dangerous adversaries can be overcome and harmony can be restored. Thus, Raven shows us how to focus on what is important in matters both very small and very large.

The Students' Experiences during Instruction

At the outset, the students were introduced to definitions of Traditional Ecological Knowledge and WS as they were outlined in the classroom science textbook, *BC Science Probe* 7 (Chapman, 2005). I also introduced students to the term IS, and how Kwakwaka'wakw stories are filled with examples of IS knowledge and practice. It was helpful to assess the students' background knowledge around the terminology that I would be using. I imagine students of all cultures and races struggle with these terms. I informed the students that they would be involved in a science curriculum that would link them to their cultural roots, their traditional Kwakwaka'wakw territories, and the animal and plant world. Students learned that traditional Kwakwaka'wakw stories are more than just myths or legends. These stories represent "Kwakwaka'wakw truths." It was explained that there are thousands of stories that confirm Kwakwaka'wakw presence in our traditional territories and these stories teach what it means to live in community and with each other—this is Kwakwaka'wakw science.

Lesson 1: March—Introduction to Kwakwaka'wakw Spring Science

Before we started our first out-of-school lesson, I reviewed with the students several important Kwakwaka'wakw teachings related to values, respect, and behaviour. 'Waxawidi William Wasden, a high-ranking chief among the 'Namgis First Nation and respected cultural teacher produced a handout with information he had gathered from Elders in the community (Table 14.1). *Kwakwaka'wakw Teachings* were introduced to students as guidelines to follow as they participated in this unit of study and in any experiences in and out of school. Students were reminded that how they behave reflects not only on them but also on their family and the school.

Table 14.1 Kwakwaka'wakw Teachings by 'Waxawidi William Wasden (used with permission)

Honour your family, whatever you do reflects on them and their teachings.
Respect yourself, to respect others you must respect yourself first.
Obey your Elders, to gain wisdom you have to listen.
Watch what you say, once your words come out you can't take them back and they will always come full-circle back to you.
Speak the truth, if you lie you will be labeled a Tłiḵ̓was (liar) and no one will ever believe in you.
Do not take what is not yours, if you steal you will be branded as Galut'łikw (thief) and never trusted.
Share and give of yourself to family and friends, this is what our culture is based on.
Cherish the land, our Ancestors were blessed with it and it has sustained us from the beginning of time.
Have gratitude; remember to give thanks especially to our Creator for everything that we have.
Friendship, the best thing you can be to someone else is a friend.

Digita in Kwakwa̱ka̱'wakw Nations means the washing away of shame. To keep students safe and on their best behaviour, cultural teachers shared stories throughout the unit of study that dealt mainly with shame and how ill behaviour reflects badly on the individual, the family, the school, and the community at large. For instance, the shame that the trickster/Raven holds becomes the responsibility of the family. So, when someone shames their family it is the family's responsibility to wash away the shame by holding a feast and paying people to witness the washing away of shame so that it will no longer be talked about. These lessons found within stories kept our large groups of students (18) on good behaviour and safe as we travelled by boat down the Johnson Straight or hiked throughout the traditional territories of the 'Na̱mgis.

Lesson 2: March—Story Telling at U'mista Cultural Society

The second lesson took place at the U'mista Cultural Society Museum. U'mista in Kwak'wala means the return of something important. The students gathered in the front space of the building that was built for the return of the stolen potlatch collection of masks and regalia. During a potlatch in 'Ya̱lis in 1921, the Kwakwa̱ka̱'wakw people were sent to jail. Government agents from the federal Department of Indian Affairs confiscated their ceremonial masks and they redistributed the masks to museums and private collectors.

The students listened to 'Wa̱xa̱widi William Wasden share stories about the mortuary customs of the Kwakwa̱ka̱'wakw. As discussed previously, the *Raven Steals the Light* story could be linked to the mortuary customs of the Kwakwa̱ka̱'wakw because Raven stores the sun in a bentwood box. Specific kinds of bentwood boxes were used to store food and household items, for transporting goods in canoes, and as burial boxes.

As opportunities arose, William discussed themes around the important concept of respect, and this question and answer period was a natural flow into the actual storytelling. Interestingly, several stories emerged from the discussion. As the students talked about their own family crests (Whale, Double-headed Sea Serpent, Raven, Wolf, and Sun) William shared the origin stories of these crests. He encouraged all of the students to research their family crests further because it gives us our sense of place and origin.

After we said G̱ilakas'la (thank you), the students went to a nearby building to observe the steaming of a bentwood box presentation by 'Na̱mgis master carver Bruce Alfred (Figure 14.7). Bruce described the steps involved in bending cedar planks and the principles behind steam bending of wood. He then gave a demonstration of the technique he had mastered over years of practice.

Figure 14.7 ▲ 'Na̱mgis master carver Bruce Alfred painting a bentwood box. Photo by Irene Isaac (2008).

Lesson 3: April—Hanson Island Cedar Planking

Several weeks later students were fortunate to see a demonstration on the steps involved in splitting cedar planks by David Garrick, a local research scientist (Figure 14.8). He is widely respected because he led the struggle to stop clear-cut logging and saved Hanson Island from environmental and cultural destruction—the Island has the largest number of culturally modified trees in Kwakwa̱ka̱'wakw territory.

Figure 14.8

Figure 14.9

Figure 14.8 ▲ David Garrick demonstrates how to make cedar planks. Photo by Irene Isaac (2008).
Figure 14.9 ▲ Simple machines used to make cedar planks. Photo by Irene Isaac (2008).

 

Figure 14.10 *Figure 14.11*

Figure 14.10 ▲ Student displays a cedar plank. Photo by Irene Isaac (2008).
Figure 14.11 ▲ Students practice. Photo by Irene Isaac (2008).

Students planked their own piece of cedar from a fallen tree (Figures 14.9, 14.10 and 14.11). Though a more modern method was employed, these planks were similar to the ones that were traditionally used (Figure 14.12), as illustrated in the book *Shaped Cedars and Cedar Shaping* (Garrick, 1989). I also taught a lesson discussing the more traditional steps involved in splitting cedar planks by using Stewart's cedar book as a reference (Figure 14.13).

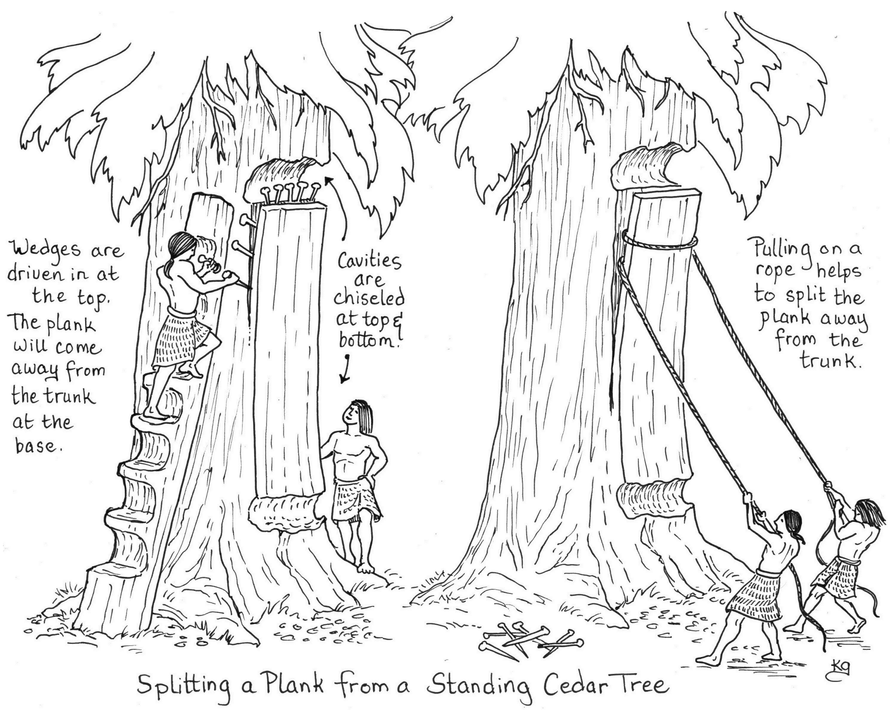

Figure 14.12 ▲ Splitting cedar planks from only one side of the tree ensured a sustainable harvest in the area. Illustration by Karen Gillmore.

To complement this lesson we visited the Ecological Park in Alert Bay (‘Ya̱lis) where there are stands of living culturally modified trees (CMT). It was explained to students that these CMTs have been used to confirm our presence in our traditional territories over hundreds and even thousands of years. Following our discussion students were asked to list the six steps involved in splitting cedar planks and identify the uses of simple machines: wedge, lever, maul, and crossbar.

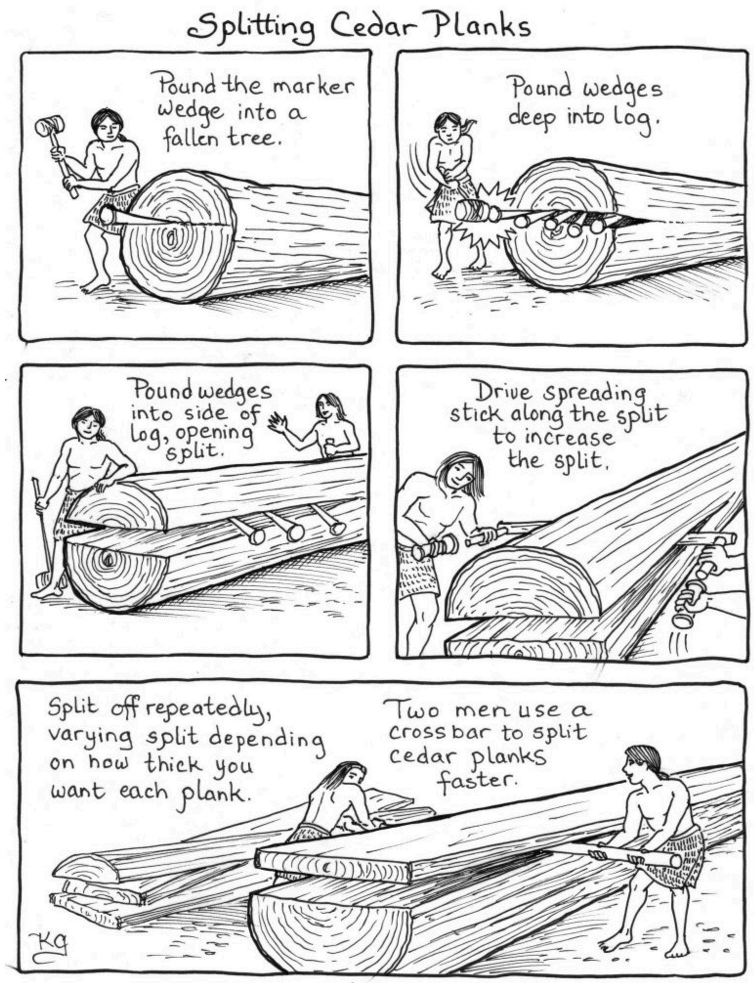

Figure 14.13 ▲ Students’ worksheet on steps involved to splitting cedar planks. Illustration by Karen Gillmore.

Lesson 4: May—The Art and Traditional Knowledge of Steamed Bentwood Boxes

Our next class involved exploring the procedure of forming a steam bentwood box as outlined in Hilary Stewart’s book titled *Cedar: Tree of Life to the Northwest Coast Indians*, (1984). Students observed the properties of wood in relation to heat, temperature, steam, expansion, and polymers. The students began art classes with the goal of painting their family crests on the bentwood boxes they made using the techniques that they learned from Bruce Alfred (Figure 14.14). Students reviewed many of William’s resource books to see how master artists put elements together to form a design, noting that many of the designs were symmetrical and showed balance. The students learned about other elements of design––line, colour, and form. Each class began with a demonstration and a step-by-step approach on how to bring the elements together to form designs such as a hand, bear, wolf or whale. Students copied this procedure and were constantly reminded to take their time and put positive thoughts into their art. After the students practiced flat design for six weeks, they learned painting techniques: how to hold the brush, how much paint to use, and how to put the brush onto paper and wood. The completed boxes were later displayed along the runway at the *Enjoy Being You* fashion show as part of a series of self-esteem activities (Figure 14.15).

Figure 14.14 ▲ Students putting designs on their cedar bentwood boxes. Photo by Irene Isaac (2008).

Figure 14.15 ▲ Completed cedar bentwood boxes with designs. Photo by Irene Isaac (2008).

Lesson 5: June—Traditional Kwakwaka‘wakw Story

I started the next section of my unit by handing each student a copy of the story *Raven Steals the Light*, the version that ‘Waxawidi William Wasden had written down from the oral story that he knows. Up to now the students had listened to several stories relating to the significance and the origin of the sun and the raven, so I challenged the students to think more critically and to think about what the Raven and Sun symbolize to the Kwakwaka‘wakw people. Following the story, we discussed themes that relate to the concept of greed. There was consensus that both Raven and the chief were greedy for trying to keep the sun for themselves. We discussed how the sun was required for life on earth, and that keeping the sun stored in a box symbolized death. Without the sun, there would be no sunlight and the earth would be a dark frozen planet. Though this story required a lot of guiding the students were able to make connections to their previous teachings and identify the importance of the sun as the primary source of life.

Lesson 6: June—Kwakwa̱ka̱ʼwakw Food Relationships

In the next lesson, I introduced the students to the key wildlife species map of Hanson Island and discussed the concepts of predator-prey, food chain, and food energy flow (Figure 14.16).

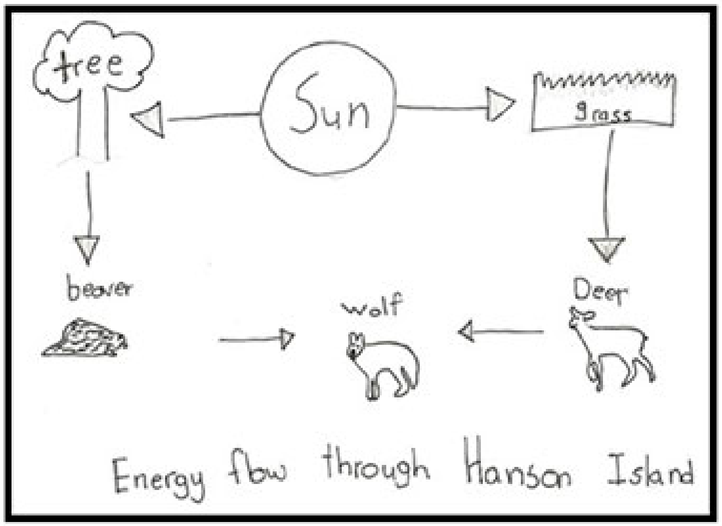

Figure 14.16

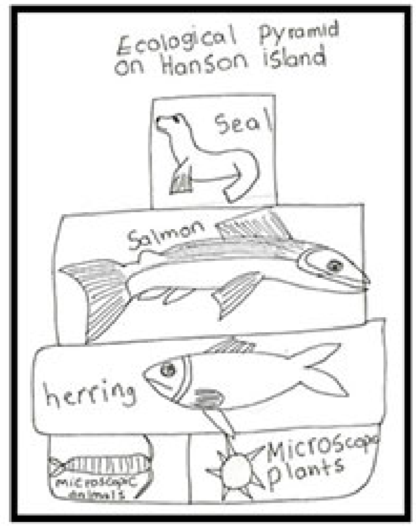

Figure 14.17

Figure 14.16 ▲ Student's example of food energy flow (2008).
Figure 14.17 ▲ Student's example of an ecological pyramid (2008).

I used a drawing of an orca (killer whale) as an example to illustrate that the materials the orca needs to maintain its body is matter and that the orca itself is made up of matter. I asked the students to identify the wildlife species illustrated on the map, and explained that these wild animals spend most of their time searching for food and they use this food to gain energy. I presented an example on the blackboard to explain that plants use carbon dioxide from the air and sunlight, along with water in the soil, to make food for themselves (photosynthesis) and that some of these animals rely on these plants for food. I used a handout to explain how food energy flows and asked the students to make a food energy flow chart and a simplified ecological pyramid representative of Hanson Island (Figure 14.17).

So, in exploring what would happen if Raven were to steal the sun, the students gained a basic understanding of the ecology of ecosystems. This activity linked nicely to chapter 2 of the textbook, *BC Science Probe* 7 (Chapman, 2005) where students learned about the role of the sun and green plants as energy producers in ecosystems.

Lesson 7: May—Culturally Modified Trees

One of the most important and memorable components of the unit involved our Hanson Island trip, a one-hour seine boat ride down Johnstone Strait. This trip takes place annually in May, as this is when the beach and forest are teeming with life and many stories can be told. As we travelled, Elder and Chief Steve Beans, the skipper of the boat, shared stories in his own quiet way about the land and his lifelong experiences of being on the water. When we arrived on Hanson Island, we held hands and formed a big circle while our cultural teacher Andrea Cranmer gave a prayer of thanks. As we walked up the steep trail to Earth Embassy (the living classrooms of Hanson Island) David Garrick and Don Svanvik (both local experts), identified the culturally modified trees (CMTs), explained their physical characteristics, and how cedar trees were harvested and used for traditional purposes. Students counted growth rings on a CMT and inferred the exact date that the Kwakwa̱ka̱‘wakw occupied specific areas. David provided detailed descriptions of a wide variety of shrubs and plants and asked the students to identify the names by looking at the labels he had created on small pieces of cedar located in each plant box. These labels listed the WS names of the plants as well as the English names, and some listed the Kwak’wala names. The tour ended with the students engaging in a presentation with Dawn Cranmer about the medicinal uses of plants. Several days later, she also came to the school to show us how to make some of the traditional medicines.

Lesson 8: June—Salmon Release and Traditional Kwakwa̱ka̱‘wakw uses of Plants

In mid-June, the class was invited by the Gwa’ni Hatchery to witness 10,000 sockeye salmon being released at Woss Lake. The main goal of this day was to witness the release of the salmon and to take part in a spiritual ceremony where cultural teacher, ‘Wax̱a̱widi William Wasden led us in a traditional song that gave thanks to the salmon. The area in which we released the salmon was an ideal location for harvesting cedar and medicinal plants, which allowed the students to learn the proper techniques and prayers for gathering cedar bark and medicines.

Enrichment Lessons

One enrichment activity involved identifying animals that live in our traditional territories and the students identified the animal’s English name, Western Science name, Kwak’wala name, and their traditional uses. The second activity was an introduction to plant pressing–where the students learned how to use a plant press. They collected plants and later glued the plants to paper and identified the plants’ Kwak’wala, English, and WS name, for example, nak’wał (salal, English), *Gaultheria shallon* (WS). It was important for the students to note that the medicines that Kwakwa̱ka̱‘wakw have been using for thousands of years are similar to the medicines that are used in Western medicine and that many of these remedies came from Indigenous Knowledge.

Once the student projects were finished, the students invited their parents to a celebration for the completion of the lessons and to show the displays, including the hand-made bentwood boxes. It was a great way to bring the community into the school and witness what the students were learning from our local knowledge. It was extremely evident that on this day the students were proud to be Kwakwa̱ka̱‘wakw.

Combining Traditional Kwakwa̱ka̱‘wakw and Modern Evaluation Techniques

Several traditional methods of evaluation were used and several school-based modern methods of evaluation were developed to assess student learning. A major focus of this unit dealt with observation: the ability to listen, observe, and experience the traditional knowledge and wisdom of the Kwakwa̱ka̱‘wakw. Following many activities students were expected to communicate orally the processes and understandings involved. They learned about the classification of the different types of stories, songs, art, and dances that are used for specific Kwakwa̱ka̱‘wakw traditions. Students had to keep specific observations and measurements in mind when they made medicines and medicinal teas to boost their energy (using devil’s club, alder, and stinging nettle), harvested cedar bark and made steam bentwood boxes. In the past, these teachings were mastered over years of practice and listening to the wisdom of the knowledge keepers who held these skills. In the past, these teachings were mastered over years of practice and listening to the wisdom of the knowledge keepers who held these skills.

As discussed previously, students developed knowledge and skills associated with WS. To name a few: they developed their skills in observing and comparing when they identified and classified plants and animals using their scientific names; counted growth rings on a tree; identified simple machines; observed properties of wood in relation to heat and temperature; created food webs and food chains using pictures and arrows to show the direction of food energy flow; described the process of photosynthesis; and expressed opinions on clear cut logging and resource extraction on Hanson Island.

This science unit of study was built on what was already in the community—knowledge, skills, and cultural practices. Lessons focused on Kwakwa̱ka̱‘wakw identity and gaining self-confidence that comes along with knowing who you are and where you originate. It was imperative for students to work with the community to reach their goals and to celebrate accomplishments. In the past, this is how evaluation took place, and this is why the success rate in this unit was much higher than it tends to be in the standard school science program.

Today, in the more recently developed BC science curriculum there is some mention of First Nations and Indigenous Knowledge, but the evaluation standards remain the same. In my unit of study, I did my best to follow the teachings of the Elders and what I felt was a more traditional method of assessment. In most situations I was not the expert so I left it up to the experts (the Elders and cultural teachers) to guide the students and set the standards. The teachers modelled what was expected from the students and they either “got it” or they didn’t, and it reflected in their finished products. Those who had difficulty grasping concepts and skills were given more guidance and those who “got it” were given more responsibility. For example, some students walked away with one bundle of cedar bark while others walked away with four bundles.

Observation and respectful interaction seemed to be the most powerful evaluation tools used in this unit of study. I spent most of my time watching students’ complete tasks or getting help to complete tasks. Some of the students may have needed more guidance and support, but all of the students finished several tasks and took part in what was asked of them. So the completed bentwood boxes; the split cedar planks; the completed drawings and charts; the jars of medicine and bundles of cedar; the respect they showed the Elders, plants, animals and the land; the way they resolved disputes; all combined to show me that the students understood the IS knowledge and ways of life of the people. The students also understood and practiced maya’xa̱la, and they understood what it means to be Kwakwa̱ka̱‘wakw.

The Gift of Kwakwaka‘wakw Stories to the Science Classroom

In this unit of study the lessons explored how the Kwakwaka‘wakw made their living in the natural world. Students experienced and explored the exact territories that their ancestors walked. They were exposed to the beauty of the territories and the stories that were imbedded in nature. There were stories about the trees, mountains, lakes, rivers, rocks, birds, and fish. Stories appeared everywhere, and the students became involved in a process of creating their own stories. As one example, students culturally modified trees by harvesting cedar, and in hundreds of years from now, these trees would tell the story of their presence. Though all of the students heard the same stories their perception of the stories were different, so the students took from the stories the teachings that were meant for them at that time.

It was story that educated us about conservation and it was conservation that guided the story. There was little impact on the natural environment because the stories passed down from generation to generation teach us to "take only what you need." For the lessons, the students took care not to collect too many plants and displayed gratitude to the plants and animals for providing them with food. Kwakwaka‘wakw and many other Indigenous stories speak of something terrible happening when a gift that has been given to us is abused or used in the wrong way. Origin stories tell us that Mother Earth is a gift as well and today we see the terrible things that are happening to the earth as the gift is abused. First Nations education relies heavily on story and as a result the natural world benefits. Something terrible is reflected in loss of the Kwakwaka‘wakw teachings, and is reflected in the continued abuse of land within the traditional territories of many Indigenous peoples worldwide.

Kwakwaka‘wakw ways of knowing respected the gifts that were given to us by Creator. Giving prayers of thanks before harvesting cedar or returning fish carcasses back to riverbeds was based on a relationship our people had with the natural world. So as long as there was a display of gratitude there would continue to be an abundance of natural resources. Stories remind us of the valuable relationships and understandings we have with the natural world. I have only touched on the themes that were generously shared with me by our Elders and knowledge keepers. My goal is to be mindful of what has worked for the Kwakwaka‘wakw since the beginning of time and that my lessons are a respectful reflection of the Kwakwaka‘wakw.

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Chapter 15 - Gitga'at Plant Project: Bridging the Gap between Generations

Edōsdi Judith C. Thompson

The impetus for the Gitga'at Plant Project was for students to make connections with their Elders, through school science curriculum, in order to learn about their culture, land, and language, which are all inextricably linked. Indigenous Knowledge (IK) is recognized as an important type of locally based knowledge held by Indigenous and other long-resident peoples (Berkes, 2012; Snively & Corsiglia, 2001; Turner, Ignace & Ignace, 2000). First Nations peoples have had, and continue to have, an intimate relationship with their homelands, based on knowledge that is highly localized, cumulative through many generations and socially oriented (Kawagley et al., 1998). Yet, Elders and educators in First Nations communities have expressed deep concerns that youth are no longer learning the cultural and local environmental knowledge that sustained them and their ancestors for generations (R. Quock, Tahltan Elder, personal communication, 1997; R. Dennis, Tahltan Elder, personal communication, 1992; H. Clifton, Gitga'at Elder, personal communication to N.J. Turner, 2002). Sadly, the opportunities for communicating IK and for incorporating this type of knowledge into public school science curricula are scarce.

Cameron Hill and Eva-Ann Hill, First Nations educators and members of the Gitga'at Nation of Northern Coastal British Columbia, recognize that their children and youth have not had the same opportunities as past generations to acquire knowledge about their home territory and traditional resources. They see the need for themselves and other teachers to take the lead in remedying this situation:

> You would think that growing up in such an isolated First Nations community, such as Hartley Bay, where the Gitga'at people reside, that our youth would be more in-tune with their natural surroundings. This is, however, not the case, in certain areas such as botany. The knowledge of plants within Hartley Bay lies with our Elderly people. It is up to us, as teachers, to bridge the gap between generations. (C. Hill & E.-A. Hill to J. C. Thompson, personal communication, 25 September, 2003)

As First Nations educators, we need to find ways to bring IK into the school science curriculum in order to make science more accessible and relevant to First Nations children. Children spend more hours in a classroom removed from the land than with their extended families learning on the land. Helping to fill this need was the main motivation for developing the Gitga'at Plant Project at the Hartley Bay School (Thompson, 2004).

Background to the Study

This research began when Dr. Nancy Turner, (Professor, University of Victoria) an internationally distinguished ethnobotanist, presented a proposal to the school in Hartley Bay in which individual students would research and learn about a specific indigenous plant that is culturally important to the Gitga'at people. In conversations with Gitga'at Elders Chief Johnny Clifton and Helen Clifton, as well as Ernie Hill Jr., principal of the school and a hereditary chief of the Eagle clan, Turner was told that the children and youth were not learning as much cultural or local environmental knowledge as previous generations had learned. This erosion of IK was a concern for the Elders. Around the same time, I was approached by Dr. Charles Menzies, (Professor, University of British Columbia), who is Gitxaała Ts’msyen, to develop a science curriculum for his research project, “Forests for the Future,” a two-year research project with the goal of conducting community-based research into local ecological knowledge in the Ts’msyen community of Gitxaała. The curriculum would be based on the local ecological knowledge of the Gitxaała people, another coastal Ts’msyen group located northwest of Hartley Bay. Menzies saw the development of culturally relevant education resources as a way to give something tangible and useful back to the people of Gitxaała. As part of this project, I developed a curriculum unit entitled, “Traditional Plant Knowledge of the Tsimshian” (Thompson, 2003). (“Tsimshian” was changed to “Ts’msyen” in 1998 by fluent Sm’algya̱x teachers to reflect the correct spelling of the term).

This project was designed to provide the Gitga’at youth of Hartley Bay with the opportunity to learn about the plants that have been, and continue to be important to their people. More significantly, it was designed to re-establish the connections between Aboriginal youth and their Elders in order to facilitate the transmission of Indigenous Knowledge. My research, in collaboration with the students, teachers, parents and guardians, Elders and community members of the Gitga’at community of Hartley Bay, was to help implement the Gitga’at Plant Project and to study its effectiveness for the students and community of Hartley Bay as a means of supporting the intergenerational transmission of cultural and environmental knowledge.

My central research question was: How does the involvement in a school research project designed to promote the intergenerational transmission of IK impact Aboriginal youth and their community?

Given the importance of retaining local environmental knowledge within a community, the following specific points were addressed: what the students learned and/or experienced as a result of the plant project; whether the Gitga’at Plant Project was an effective way for students to learn about plants and other IK from their Elders; and other methods that could be used to enhance the transmission of knowledge between generations.

This study took place in the Gitga’at community of Hartley Bay, British Columbia, which has a population of approximately 200. Hartley Bay is located 140 kilometres (90 miles) southeast of Prince Rupert, BC, at the confluence of Grenville Channel and Douglas Channel. The Hartley Bay School is located in the heart of the community. At the time of the study, the Hartley Bay School had 68 students, with four classes ranging from Nursery School to Grade 12. All of the students were of Ts’msyen descent. The staff was made up of a principal, five teachers, a learning assistance teacher/librarian, a Sm’algya̱x language teacher, an administrative assistant, and a custodian. With the exception of two teachers, the rest of the staff were members of the Gitga’at Nation.

The Gitga’at people are members of the Ts’msyen Nation. The Ts’msyen inhabit the lower portion of the Skeena River, the islands found at the mouth of the Skeena, and along Douglas Channel (Tsimshian Chiefs, 1992). Gitga’at territory includes a large portion of the mainland south of the Skeena River, as well as several offshore islands. Ts’msyen territory is characterized by a mild, marine climate with heavy precipitation, which in turn supports dense, wet conifer forests. Biologists recognize the Coastal Western Hemlock Zone as the major biogeoclimatic zone within Ts’msyen territory. The Ts’msyen speak the Sm’algya̱x language.

Methodology is important in that it sets the context for the questions being asked; it establishes the tools and methods to be used and shapes the analyses. In regards to Indigenous methodologies, Māori scholar Linda Tuhiwai Smith (2012) stated that they are “often a mix of existing methodological approaches and indigenous practices (p. 144). It was important to me as a First Nations educator and researcher to ensure that this project was framed within an Indigenous context. I chose to use community action research within an Indigenous context as the overarching methodology, with a case study approach as the more specific design.

Smith (2012) maintains that a community action approach makes a positive difference in the lives of people in the community, and also provides a way for First Nations researchers to actually do research in their own communities.

While many research methodologies have assumed that the researcher is an outsider able to observe somewhat objectively, Smith (2012) states that, “Indigenous research approaches problematize the insider model in different ways because there are multiple ways of both being an insider and outsider in indigenous contexts” (p. 138).

The Gitga’at Plant Project

The Gitga’at Plant Project was developed and implemented by two Hartley Bay teachers, Cameron Hill and Eva-Ann Hill, and myself, thereby creating the case by our actions. Essentially, the Gitga’at Plant Project, the case was a community action research project that was participatory and collaborative in nature, which involved the community in an attempt to make a positive difference in the education of the children in Hartley Bay.

The project was conducted from September 2003 to June 2004. Working in pairs, Grades 9-12 Gitga’at students each researched a particular plant known to have cultural importance to their people. They consulted with Elders and community members and carried out literature and web-based botanical research, as well as made observations of their plants during field study sessions (Figure 15.1).

Figure 15.1 ▲ Student measuring Skunk Cabbage with a ruler in the field notebook. Photo by Edōsdi Judith C. Thompson (2003).

The student researchers gave oral presentations of their findings at community gatherings, and picture posters of the students with their plants and a summary of what they learned were presented to the community. A book entitled *‘Nwana’a lax yuup: Plants of the Gitga’at* (2006), edited by Nancy Turner and Edōsdi (Judith Thompson), which included almost 100 plants, was presented to the community as a way to honour the knowledge of the plant informants and to thank the community for their assistance and input. The 12 plants that the students researched were given prominence in the book, which included their detailed findings, who they learned from, and pictures of themselves and their plants.

The Gitga’at Plant Project was made up of three stages: (1) Development, (2) Implementation, and (3) Evaluation.

Development. It is important to state that there were two stages of development for this project. The first stage involved myself developing a relationship with the community of Hartley Bay. The second stage involved the actual development of the Gitga'at Plant Project. From February 2002 to April 2003, I developed a unit plan entitled "Traditional Plant Knowledge of the Tsimshian" (Thompson, 2003) which was made up of six lessons:

- Learning about Traditional Plant Knowledge
- Plant Observation, Collection, and Identification
- Plant Use of the Tsimshian
- Plant Harvesting, Preservation, and Storage
- Plant Nutrition
- Relationships with other First Nations and their Plants

While the curriculum was specific to the Ts'msyen, I tried to make it flexible enough to be adapted to other First Nations groups.

Indigenous Knowledge is holistic in nature and therefore not confined to the artificial boundaries of disciplines or subject areas. Therefore, while these lessons were developed with science courses in mind, they also covered the prescribed learning outcomes in courses listed under Social Studies and Applied Skills, as well as Sciences. I felt unsure about matching IK to the then prescribed learning outcomes listed in the *Science Integrated Resource Packages* (Science: K-7, 8-12 IRP, 2002a, 2002b) which came from a Western perspective. I wanted to be guided by First Nations' ways of knowing, First Nations peoples, and First Nations communities. I also wanted to encourage all teachers to use the curriculum. As many community schools have mixed grade classes, the lessons were prepared for Grades 5 through 12 so that students and teachers could utilize the materials and bring Indigenous Knowledge into their classrooms.

Implementation. Consistent with community action research, the development process continued while the Gitga'at Plant Project was being implemented. The teachers and I were constantly responding to student feedback, taking notice of what worked and what did not, in order to make their teaching more productive, informative, and relevant to the students. As the project progressed, changes were made along the way and lessons or assignments were developed as needed. For example, Cameron, Eva-Ann, and I planned a lesson together involving a role-play about the protocols of interviewing an Elder or other resource person.

During the times when I was in Hartley Bay, I routinely met with the students both formally and informally. I was often present for class discussions, either as an observer or as participant, and occasionally contributed to lessons that were being taught. Cameron and Eva-Ann did most of the implementation of the project with the students. With the production of a plant booklet, posters, and by speaking at community gatherings, students were actively involved in the dissemination of their newly learned skills, knowledge and wisdom.

Evaluation. The evaluation of the project began as it was implemented. I received feedback from the students on an ongoing basis in the form of feedback cards and from their field notebooks. I met with Cameron and Eva-Ann every day while I was in Hartley Bay and also kept in contact via telephone and electronic mail. All of the teachers provided me with written feedback. The interviews of the plant informants, parents/guardians, and the rest of the school staff began after the students had completed their interviews.

Discussion of the Findings

I have organized the results in terms of the four research questions, with the findings being discussed within the context of relevant discourse.

Experiences of the Participants

Overall, the students reported very positive experiences. In particular, students wrote and spoke about how much they enjoyed learning from their Elders and learning about the Gitga'at uses of plants (Figure 15.2). For example, a Grade 9 student commented:

> Well, I think it's pretty cool if you ask me and I hope we can do this again.... And well, I think this book will be cool and maybe our kids can look at this or these books and maybe they'll get to do this experience too and they'll have fun, lots of fun.

Figure 15.2 ▲ Harvesting Ksiiw with Gitga'at Elder Archie Dundas. Photo by Edōsdi Judith C. Thompson (2003).

Many students shared this knowledge with family, with parents seeing positive changes in their children. The teachers had varying degrees of involvement in the project and all of them spoke or wrote about the cultural significance of the project. A First Nations teacher raised in Hartley Bay wrote:

> A whole project done by First Nations for First Nations, what more could you want? A community like Hartley Bay where all of the plants are from and used by the people here, with input from the people that know and use the plants. The Gitga'at voice shines through our kids in the project.

Many adults saw changes in the children's self-esteem, their pride in themselves and their people, and confidence in their new knowledge and wisdom. Most of the Elders were impressed with the way that the students behaved and with the respect that they showed to them, with many expressing a desire to spend more time with students teaching them about their traditional knowledge. Cameron Hill and Eva-Ann Hill stated how it was the responsibility of teachers to "bridge the gap between generations" and it is apparent that the Gitga'at Plant Project provided a wonderful opportunity for children to connect with their Elders. One of the goals of the project was to facilitate and strengthen the connection of First Nations youth to their land and culture through their Elders as a means of improving their self-identity, cultural pride, self-esteem, and ultimately their health and well-being. As Smith (2012) states, “Connecting is related to issues of identity and place, to spiritual relationships and community wellbeing” (p. 150).

The project also gave youth the opportunity to communicate with their parents about schoolwork, as several either shared their knowledge with the parents or asked for assistance. One mother said that her child never got into anything at school, but now seemed really interested in the plant project. Another parent noticed that her children were “into plants now.” Yet another parent wrote, “My son definitely tackles homework assignments in a different way; more methodical.” This same parent stated that, “I didn’t realize that so many of them have a love of the outdoors.” Another parent said that she told her son that she wished that she had been able to work on such a project when she was going to school and that he was lucky.

Torres (1998) noted that parents often think that their children may not need them as much as they enter high school, and it is at this very time in their development that youth start to feel less connected to their school, their family, and their community. Parents may also feel disconnected from their children and the school at the very time when these students need their family involved in their education, and when they need to see themselves and their community reflected in the curriculum. As Torres stated (1998), “It is an age at which young people’s connections to families, communities, and schools need to be strengthened rather than strained” (p. 60), and the present findings underscore this importance.

What the Students Learned

Students were able to articulate clearly what they learned in terms of knowledge and skills. They learned the Sm’algya̱x names, characteristics, medicinal, material and food uses, as well as the cultural significance of the plants, and were able to explain these to their classmates and community members. A Grade 9 student wrote, “I learned stuff on salal berries. Like making jam and how they used the leaves for when they were drying seaweed. They would put the leaves in the middle so it wouldn’t stick together.” Another student reported what she and her partner learned:

> We learned that you could make string with yellow cedar but you can’t use it for warp (or something like that) but you can’t rub your eyes after touching it. You have to wash your hands after touching it. And you could make a rectangular shelter you just take a piece of yellow cedar in a rectangular shape lay it on the ground and get more pieces and sticks and if it’s raining you can put the yellow cedar the slippery way. So it will just drain off.

In regards to a food plant, a student wrote, “Some things we found out about blueberries were so amazing. I never ever knew they could be used as a medicine.” Many students wrote about the plant knowledge and wisdom that was specific to their people and tied to their land. From one Grade 9 student:

> I learned that a lot of people like to eat salmonberries with oolichan grease and sugar or milk and sugar. Salmonberries grow last at Old Town up in the valleys. I also learned that you can eat the oł (sprouts). People really enjoy salmonberry jam at feasts. They never used to use freezers to preserve salmonberries, they would make jam. Salmonberries can stay in the valleys of Old Town until middle of November. Bears and birds really enjoy eating salmonberries.

Another student described the importance of the plant she researched to her people:

> I learned that yew wood is just not a plant, it is very important to us First Nations, it is used for cancer, and some people in Hartley Bay have to drink it, it's used for any kind of cancer.

A Grade 9 student wrote about the importance of taking part in the Gitga'at Plant Project in Hartley Bay: "…doing this experience is really fun, getting to know what is important to our relatives and what relatives have to use it, it's very interesting."

Language was an important aspect of the Gitga'at Plant Project as the students learned the Sm'algya̱x names for the plants they researched, many acknowledging: "We learned the Sm'algya̱x name '*smmaay*' which means oval-leaf blueberry, if I can remember correctly." Another student wrote, "I learned the Sm'algya̱x name for devil's club." Two sets of partners identified several Sm'algya̱x names for their plant at various stages of growth and development. For example, one set of partners identified the Sm'algya̱x names for the actual salmonberry plant, as well as the names for the berries when they are both yellow and red. A Gitga'at teacher wrote, "Even though I don't think many of us feel we know much about our language, I feel we do and this project brought it out. We know our language more than we think."

With regard to skills, students learned about field research, text research, information integration, and interviewing skills. One teacher stated:

> The students' experience with the plant project has been positive on so many levels, from the standpoint of doing research, of sharing knowledge, of marrying the practical experience of fieldwork, to the 'book learning'. They learned to meet deadlines, to write reports, and to express what they were learning in a variety of ways of reporting. Students also learned about the protocols of their community as well as the protocols of interviewing individuals.

A First Nations teacher stated, "The protocols were all followed to a tee. I think all of our Elders were well informed and all protocols done, done well." The adults were able to identify additional gains, such as pride and respect, and self-confidence. When the students were showing their teacher the work they had done, the teacher could see the pride they had in their work. Another teacher wrote, "I saw growth in the students. They were shy at first to go out and do the interviews, but they did it, and they seemed to have pride in the results that began to appear." One of the Elders said that many of the students were showing interest in their people's knowledge as well as pride in who they are.

The Gitga'at Plant Project included learning experiences that validated the students' culture, their community, and their people as sources of knowledge. It demystified knowledge by giving students the opportunity to be researchers and thereby making knowledge accessible, it emphasized the importance of their Sm'algya̱x language, and helped to redefine the relationships between students, teachers, parents, and community members, as well as the school and the community in general. Besides learning about plants, one student wrote how one Elder talked to him about his family: "I learned about my family. She told me who I was related to."

In their role as researchers, the students gave presentations of their findings at community gatherings. Posters that included pictures of all of the students with their plants and a summary of what they learned were presented to the community Elders and others with whom the students consulted. This project had a lot in common with the "Sharing" project outlined by Smith (2012), which is about First Nations researchers sharing information and knowledge that they were discovering with the community. "For indigenous researchers sharing is about demystifying knowledge and information and speaking in plain terms to the community" (Smith, 2012, p. 162). This happened several times during the Gitga'at Plant Project when the teachers, students, and I shared with the community what the project was about, why it was important, and the knowledge that the students were learning. As Smith (2012) has stated, "Oral presentations conform to cultural protocols and expectations" (p. 162).

The Effectiveness of Intergenerational Transmission of Knowledge

In this study, the "effectiveness" of instruction was gauged by: the overall positive responses from all involved, the tangibles that were produced by the students, such as information included in the booklet, or the students' work that was included in the creation of the posters, and the relationships between generations that were strengthened. The comments from both students and adults alike were a good indication of their interest and accomplishments. Recognition by adults and Elders of significant learning and of their pride and respect was also very important (Figure 15.3).

Besides the Elders involved with this project, Elders from other First Nations communities talked about the need to use the school system as well as modern technologies and contemporary approaches in order for Aboriginal youth to learn from their people about their ways of knowing (Robert Quock, Tahltan Elder, personal communication, 2000; Annie Ned as cited in Cruikshank, 1990). As Medicine (2001) stated, educators can work with Elders in order to, in the words of Cameron and Eva-Ann Hill, "bridge the gap between generations," so that First Nations children can learn about their people's traditional ways of knowing within a contemporary setting.

Figure 15.3 ▲ Harvested devil's club by student. Photo by Edōsdi Judith C. Thompson (2003).

Enhancing Intergenerational Transmission of Knowledge

All involved with the project generated ideas about how the Gitga'at Plant Project could be expanded upon or changed. Ideas such as including the whole school in such a project and the concept of role modelling, whether by Elders, adult community members, or older students, would be an important step toward community commitment and involvement. One student wrote, "I think the younger students would enjoy doing the plant project. I would help them. I would help them with their interviews." Another stated, "I think that it would be cool for the younger classes to do what we are doing and it would be good experience for when they get older." As well, expanding the classroom to the outdoors was raised as a way to enhance the intergenerational transmission of knowledge. What was evident was the importance of ongoing and regular opportunities for learning and sharing, and the need to tie learning to everyday activities. Language was raised as a way to bring about both the learning of IK and as a way to re-connect youth to their Elders.

Implications

The study's major findings inform the discussion on Indigenous Science, educational theory and practice in this area, and cultural identity and transmission of knowledge. Several implications can be construed from the study results and these implications are outlined and substantiated by illustrative examples.

Indigenization of Science Curriculum

There is a continuing need for the development of a curriculum that is relevant to the lives of First Nations students and that involves them as active learners. Indigenous Knowledge needs to be incorporated into the mainstream curriculum, providing locally relevant ways and examples of learning about the environment, plants, animals, geography, and language that will give students self-confidence and a stronger sense of identity and community.

In regards to the Gitga'at Plant Project, the focus of the project was to bring IK into the science curriculum. A teacher wrote that the most important thing that the students learned was "that traditional values and knowledge can exist side by side with 'modern' science, and that the values and knowledge of the past has a dominant place still today." First Nations students can become more successful at school with the development of such a curriculum.

Smith (2012) noted, "Indigenous students across many contexts have struggled with Western Science as it has been taught to them in schools. Science has been traditionally hostile to Indigenous ways of knowing. Science teaching in schools has also been fraught with hostile attitudes towards Indigenous cultures, and the way Indigenous students learn" (p. 161).

While it is important to educate students about different nature-knowledge systems besides Western Science, the world of science academia should also be open to other worldviews.

Community-based Learning The application of this learning must be brought into children's everyday lives, not only in their lives at school. Elders and adult participants were adamant that the learning had to go beyond the gathering of information to the "hands on" learning experiences with Elders teaching children about their traditional knowledge systems on the land. This type of learning happens when the Gitga'at people travel to Ki'el, their traditional seaweed camp, and children learn how to harvest seaweed and to catch, prepare, and dry halibut from Elders and family members. These types of learning experiences need to become how the students both live and learn. This can only come about if the experiences are relevant to the students' lives and if the students can be active participants in their learning. In the Gitga'at Plant Project, students learned from their Elders about the Gitga'at uses of plants, along with other culturally relevant knowledge and wisdom. By using the school system and curriculum, a contemporary method was utilized to bring back and/or continue the intergenerational transmission of Indigenous Knowledge. Turner (2014) stated that "a rich legacy of ethnobotanical and ethnoecological knowledge has persisted, thanks to the determination of many elders and others to keep it alive" (p. 259). With such projects directly involving children learning *about* their land *on* the land from Elders, IK will be strengthened and revitalized.

Youth Participation in Life-career Planning Another implication deals with the active participation of youth in planning for their future. Marshall, Shepard and Batten (2002) list concerns that face youths living in rural communities, such as, "isolation, health risks, lack of occupational role models, limited access to training or education, and cultural or identity differences" (p. 2). This project provided students with many of the skills needed for life-career planning, such as the research skills they acquired, presentation skills, computer and internet skills, working with others, to name a few. However, like the youth in Marshall, Shepard, and Batten's (2002) study, they may "need help to picture how they might actually implement these transferable skills to real work and life roles" (p. 7). The results indicate that students feel more confident in regards to their schoolwork and have more pride about who they are from taking part in this plant project; this may increase their hopes and aspirations about future possibilities (Marshall et al., 2002).

Importance of Language The effects of colonialism have had devastating repercussions on the transmission of knowledge. While many Aboriginal people were not allowed to speak their language in the residential schools, others were not taught their language because of the misconception that they would do better in school and in everyday life if they learned to speak English and forget their language (Julia Callbreath, Tahltan Elder, personal communication, 2001; Battiste, 1998; Smith, 2012). Culture is tied to language (Battiste, 1998) so if children are not learning their language, they are probably not learning other cultural ways of their people. Turner writes, "Language and plant names are tied to places, to narratives, to technologies, and to seasons. They are key to communicating local ecological knowledge and therefore key to people's survival and to the continuity of their knowledge, practice, and belief" (Turner, 2014, p. 188). From this research, adult community members talked about the importance of children learning about IK from their Elders. This could have an impact on students learning their Sm'algya̲x language outside of school, which could complement their language classes in school.

In my doctoral research, which focused on the revitalization of my Tahltan language, the importance of children learning their Ancestral language was made clear to me by Tahltan fluent speakers, Elders, and language teachers. "From what I learned, our land is intrinsically tied to our language, and from that stems our culture and worldviews, and the relationships that we have with all the things that we share the land with" (Edōsdi, 2012, p. 119).

Intergenerational Transmission of Knowledge The transmission of knowledge is important to Aboriginal communities. Retention and promotion of IK can be enhanced by providing opportunities and situations that encourage and facilitate the learning of IK; factors that contribute to the maintenance of IK in a community. Because of changing times and colonialism, amongst other things, many of the circumstances supporting and facilitating interactions between children and Elders are disappearing quickly or are already gone. It is urgent to address this gap and to help re-connect children to Elders. While many reasons can be given for why such interactions might not work, there is a need to work together to explore solutions. The community and families have to want this to happen, and it can begin at the school with projects such as the Gitga'at Plant Project.

Research *with* and *by* Aboriginal Communities Aboriginal control over research in their community is another important implication of this research. While I am not from Hartley Bay, as a First Nations person, I wanted this project to involve the community as much as possible, and especially the students. The people interviewed did not have a negative thing to say about the project, only suggestions for ways to improve upon it. With the students taking on the role of "researchers," they were learning research skills as well as learning about cultural protocol and about their peoples' IK. As Menzies (2004) stated, it is vital that First Nations communities take control and play an active role in research that takes place in their communities and with their people. As a member of the Ts'msyen Nation, Lewis (2004) pronounced, "As Gitxaała we are no longer interested in sitting back and watching our country being exploited by outsiders" (p. 8). From these data, it appears that the people of Hartley Bay felt like they were actively involved in and benefitted from this research project.

Conclusion: Directions for Future Research

The majority of the Hartley Bay School administrators, teachers, and support staff are members of the Gitga'at Nation. Future research could determine how such a school project would work in a First Nations community that does not have their own people in such pivotal educational roles. Another possibility would be to implement the project in an urban community where there are many Aboriginal children from many different First Nations, as well as non-Aboriginal students in the schools. What is also needed is a better understanding of effective ways in which Aboriginal learning and teaching can be facilitated, particularly in relationship to IK. Working with First Nations communities to identify elements of IK, as well as ways of transferring this knowledge and wisdom, is an area that needs to be looked at more closely (Thompson, 2004).

As a First Nations educator, learner, and researcher, I know how important it is for First Nations children to see their own culture, their ways of knowing, their language, their people and themselves reflected in the curriculum in a way that is meaningful and relevant. The need for curriculum that integrates First Nations knowledge and wisdom is critical. It is vital that we represent all peoples in the school curriculum, not just that of the dominant culture. As well, First Nations students need to see that learning about their people's ways of knowing belongs not only in social studies, art, First Nations Studies, or language courses, but also in science courses and that it is viewed as legitimate science knowledge.

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Appendix A: Curriculum Connections

Flow Chart of Indigenous Science Curriculum Connections

The following charts provide a brief overview of science concepts and processes that can be explored at suggested grade levels. Although the BC science curriculum was taken into consideration, the concepts and ideas reflect many examples from this book that go beyond the prescribed curriculum, as well as topics for students to research in libraries, by internet searches and by involving Elders and knowledge holders. The ideas are starting points for engaging teachers and students about Indigenous Science knowledge in their local areas. Teachers are encouraged to use their own creative imagination and flexible thinking to weave IS concepts and cases into the science curriculum.

Sample Processes and Skills of Science: observe, compare, describe, question, predict, communicate, infer (give reasons), measure and record, classify, build models, theorize, experiment, and interpret.

GRADES K, 1 AND 2: DAILY AND SEASONAL CHANGES

Concept: The activities of Aboriginal peoples in BC change with each season.

- Give several examples that show how local Aboriginal activities differ according to seasonal cycles and regions (differences between the interior of BC and the coast, north, south, etc.)
- Prepare a detailed list of local Aboriginal activities for each season:
    - spring – prepare fishnets, clean creeks and springs, planting, dry seaweeds, oolichan runs (usually first fish of the year), spring salmon
    - spring, summer, and fall – gathering abalone, octopuses, shrimp, sea cucumbers, mussels, oysters, red sea urchins, Dungeness crabs, king crabs, red rock crabs, and chitons (sea prunes)
    - summer – salmon runs, gather medicinal plants
    - fall – berry picking, drying berries, clams lightly smoked and preserved in grease, hunting goose, duck, moose, and deer
    - winter – important potlatch/feasts, oolichan grease feast, bring in firewood, sports activities, work indoors carving utensils, sewing clothes, weaving baskets, making moccasins, leggings and boots
    - year round activities – making bannock, medicinal plant gathering.
- Develop a class seasonal wheel illustrating how local Aboriginal peoples harvest plants and animals through the seasons
- Give three ways that modern technology has changed daily and seasonal activities (e.g., electricity, freezer, canning, motorboat, chainsaw, skidoo).

GRADES K, 1 AND 2: ANIMALS GROW AND CHANGE

Concept: Animals are important in the lives of Aboriginal peoples in BC.

- Identify from books, Elders, and historical sources on how animals help to meet the needs of Aboriginal peoples (e.g., bear fur for warmth during the winter, oolichan grease for cooking and preserving berry cakes, bones for tools, seal oil and meat on the west coast, ducks, geese, salmon, herring, beaver, mountain goat, deer, elk, moose, marmot, seals, whales, clams, eagle feather ceremony)
- Identify and illustrate different methods of hunting and fishing (e.g., spear, bow and arrow, dip net, stinging nettle fish net, halibut hook, conical fish trap, weir, reef net, and Dentalium shell broom).

Concept: Knowledge of animal life cycles and migration patterns help Aboriginal peoples to survive.

- Give several examples of Aboriginal knowledge of animal life cycles (e.g., life cycle of oolichan, life cycle and migration routes of salmon, migration routes of caribou and moose, ducks and geese, Dungeness crab)
- Invite an Elder or knowledge holder into the classroom to describe traditional knowledge of migrations and life cycles in relation to hunting and fishing practices
- Describe expectations for respecting Elders, knowledge holders and other guest speakers (e.g., active listening, asking questions, presenting a gift).

RADES K, 1 AND 2: PLANTS GROW AND CHANGE

G
Concept: Plants are important in the lives of Aboriginal peoples.

- Identify and illustrate different Aboriginal methods of harvesting plants for food in BC (e.g., root vegetables, crab apples, huckleberries, blueberries, salmonberries, cranberries, thimbleberries, soapberries, salal berries, currents, seaweed, camas bulbs)
- Research how Aboriginal peoples of BC gathered the available plant materials (e.g., cedar bark, birch bark, cottonwood, spruce roots, wild cherry bark, stinging nettle) to make berry-picking baskets, cooking baskets, large storage baskets, ropes, twine, clothing, mats, blankets, diapers, paint brushes
- Identify different plants used by Aboriginal peoples for medicines in BC (e.g., willow bark tea for colds)
- Identify and illustrate different harvesting tools (e.g., yew digging stick)
- Identify ways that Aboriginal peoples maintain the health and well-being of plants (e.g., not over-picking, stripping bark from only one side of the cedar tree, taking only one cedar plank from a tree, leaving the tree alive and healthy)
- Research and illustrate different fruits and vegetables in Meso-America that Indigenous peoples harvest

(e.g., corn, pumpkins, yams, potatoes, beans, tomatoes, avocados, sunflowers, papayas, pineapples, cocoa/chocolate, coffee).

GRADES 3 AND 4: CLASSIFICATION OF LIVING AND NON-LIVING THINGS

Concept: Different peoples around the world sort living and non-living things in their own way and use different classification systems.

- Share personal perspectives on "living" and "non-living"
- Compare Aboriginal and Western Science perspectives on "living" and "non-living"
- Share perspectives on the Western Science concept of hierarchical classification of plants and animals
- Press five (5) wild native plants. Label each plant with its Aboriginal name and its scientific name. What do the names tell you about the plant?
- Describe a Kwawaka'wakw perspective of classification
- The Nuu-chah-nulth people classify coho salmon depending on whether it lives in the sea or in fresh water. Explore the usefulness of this classification system
- Explore how the way people classify organisms reflects the way they see the world—their worldview.

GRADES 3 AND 4: LIGHT AND SOUNDS

Concept: Aboriginal peoples in British Columbia make a variety of ceremonial instruments for singing and dancing, and producing dramatic sound effects.

- Identify and illustrate ceremonial instruments that Aboriginal peoples in BC make (e.g., rawhide drum, hollow cedar tree drum, wooden whistles, flute, deer or mountain goat hoof rattle, bear claw rattle, puffin beak rattle)
- Using whistles of various lengths, explore pitch and volume
- Using traditional one, two, or three tone whistles, explore pitch and volume
- Explore drumming, chanting, and singing for telling stories
- If possible, invite an Elder into the classroom to demonstrate the sounds and songs of ceremonial instruments
- Make a whistle, drum, or rattle from traditional materials. Explore pitch and volume

- Research how some Aboriginal peoples use light and sound for dramatic effect during ceremonies (e.g., the Nisga'a and Kwakwa̱ka̱'waka achieve a bright flash of light by throwing oolichan oil on the longhouse fire at the climax of a dramatic performance of a legend or family crest story).

Concept: Research how some Aboriginal peoples have traditions regarding the respectful use of ceremonial instruments. Some groups allow only designated Elders to handle and use ceremonial instruments.

- Interview an Elder to learn about the traditions of the local Aboriginal community
- Identify proper etiquette for using (or not using) local ceremonial instruments.

Concept: Indigenous peoples of the Americas make ceremonial instruments for singing and dancing

- Research how Indigenous peoples of the Americas make ceremonial instruments for singing and dancing, such as mouth bows (ancient stringed instrument), Apache violins, Aztec drums, flutes, whistles, and ocarinas.

GRADES 4 AND 5: STARS AND PLANETS

Concept: Knowledge of celestial events influenced Aboriginal culture.

- The Aboriginal concept of time draws heavily upon natural cycles and does not include precise measurements (month, week, hour, second). Explain how the Aboriginal concept of time differs from the western one
- Research how Meso-American astronomers and mathematicians calculated calendars more accurately than calendars used by Europeans at the time of conquest
- Research Yup'ik terminology of constellations and understanding of seasonal positioning of constellations
- Research traditional stories about the sun, moon, and stars (e.g., *How Raven Stole the Light*)
- Generate specific questions in response to traditional stories focusing on celestial objects
- Write stories, complete with illustrations, on a celestial object (e.g., how the moon came to be, how stars came to be)
- Infer how the Nisga'a predicted the arrival of important migrating fish by observing changes in the location of the sun rising over mountainsides
- Research and describe Nuu-cha-nulth moon phases
- Research and describe Kwawa̱ka̱'wakw moon phases
- Identify three ways that knowledge of stars and planets influenced Indigenous culture in the Americas (e.g., community location, migration, ceremony, agricultural cycles)
- Research Navajo and Pawnee star maps and their knowledge of equinox, summer solstice, and sky constellations.

GRADE 4 AND 5: HABITATS AND HOME-PLACE COMMUNITIES

Concept: Aboriginal peoples developed a deep connection and knowledge of their home-place.

- On a map of the local region, identify Aboriginal place names
- Research place names and their meanings in relation to a local Aboriginal group
- Students as researchers – use audio and visual technologies to interview and document traditional knowledge of home-place
- Discuss the quote "ownership is a marriage between the chief and the land"
- Interview an Elder or knowledge holder to find out how the harvest of fish, clams, seaweeds, etc., was shared with all members of the community
- Read stories that demonstrate the relationship Aboriginal peoples have with the land, water, animals, plants, and the sky
- Select a relationship with any three—land, water, animal, plant, and sky—then write and/or tell how they personally show respect for each of their choices
- Indicate how their behaviour is similar to or different from the Aboriginal stories they read and wrote about.

Concept: Aboriginal technologies have contributed to the settlement of communities in home-places.

- Build a model of a cedar dugout canoe for long distance ocean journeying; whaling canoe or interior birch bark canoe for streams and lakes; or Inuit kayak for icy waters. Explain how their choice of canoe is designed for a specific purpose and environment
- Build a model of a west coast big house made of cedar planks, an interior tepee made of rawhide, or an igloo made from blocks of ice. Explain how their choice of shelter is designed for a specific environment
- Research the traditional lifestyle of the local Aboriginal community. How did they get their needs met for food, transportation, shelter and housing? How has their lifestyle changed?

Concept: Aboriginal peoples developed deep respect for the home-place environment.

- Give several examples that illustrate how traditional Aboriginal peoples respected plants and animals (e.g., prayer to the salmon, prayer to the cedar tree, prayer to halibut, thanks to deer, clan names)
- Describe how traditional Aboriginal peoples did not waste edible parts of fish, including the head, bones, cheeks, eyes, edible internal organs, and eggs
- Describe traditional ways of being responsible for the care and preservation of the environment
- Illustrate traditional stories that demonstrate the relationship Aboriginal peoples have with the land, water, animals, plants, and sky
- Engage in an action project that demonstrates respect for home-place environment (recycle, clean up stream bed, engage in a salmon restoration project). Reflect on the outcomes
- Plan a feast that celebrates the foods harvested by local or regional Aboriginal peoples.

GRADES 5 AND 6: FORCES, TOOLS AND SIMPLE MACHINES

Concept: Simple and compound machines were used in daily life by Aboriginal peoples in BC and by Indigenous engineers in the Americas.

- Describe the various ways in which Aboriginal peoples in BC have used tools and simple machines to meet basic and artistic needs in their lives (wedge, lever, maul and cross-bar for splitting timber; inclined plane, lever and fulcrum for raising cedar logs for big houses; fish wheel for catching and storing live salmon, raising totem poles)
- Explore effects of pushes and pulls on movements of objects (building blocks, pulleys, rocks, ropes)
- Observe, predict, and explain the effect of size, shape, and material on movement of objects
- Role play how to move large objects (canoes, cedar beams, totem poles)
- Create a diorama or build a model and explain how massive cedar beams were traditionally lifted onto big houses
- Create a diorama or build a model and explain how totem poles are raised using wedges, blocks, ropes and manpower. Explain how force and energy is transferred
- With the help of a knowledge holder, try splitting cedar planks (take safety into account—e.g., eye goggles)
- Research Inca engineering of roads and bridges (culverts, road tunnels, rope suspension bridges, pulley-operated gondola bridges)

GRADES 6 AND 7: RENEWABLE RESOURCES AND SUSTAINABILITY

Concept: Aboriginal peoples in British Columbia have increased the production of food by developing renewable and sustainable resources.

- Research how Aboriginal peoples have designed tools and technologies to ensure sustainability of resources
- Describe in detail how Aboriginal peoples (past and present) practiced fish enhancement (re-stocking rivers and lakes with salmon, trout, and herring)
- Describe and illustrate how traditional Aboriginal forestry practices show respect for trees, shrubs and plants (stripping cedar bark from one side of the tree, leaving the tree alive and healthy)
- Research how to (or with a knowledge holder) weave a cedar bark bracelet, headband, or basket
- Describe, using examples, how traditional Aboriginal fishing practices show understanding of sustainability practices (seine nets with big holes could catch very big fish while letting juveniles pass through, weirs trapped a designated number of fish while letting large number of fish pass upstream)
- Build a model of a weir or reef net, allowing an escape route for fish to continue the population

- Research how Aboriginal peoples in BC used controlled burning to add nutrients to the soil, control insects and enhance wild food crops (e.g., harvesting blue camas bulbs)
- Research and create a diorama and/or mural demonstrating how coastal Aboriginal peoples built sustainable clam gardens
- Research and create a diorama or mural demonstrating how coastal Aboriginal peoples engineered tidal flats and developed root vegetable gardens
- Research how Aboriginal gardeners tending tidal flats gathered larger root vegetables for eating and put smaller plants back into the ground to ensure future harvests
- Invite an Aboriginal scientist to speak to the class (e.g., biologist, geologist, fisheries biologist, environmentalist, engineer).

Concept: Aboriginal peoples understood the concept of the interconnectedness and interdependence of the environment.

- In groups, explain the traditional Aboriginal concepts of "circle of life," "everything is one," and "everything is one and becomes another"
- Explain, citing examples, how and why traditional Aboriginal peoples' relationship with the environment demonstrates responsibility for the land and resources (never take more fish than you can eat, use every part of the fish, seal, moose or deer, wasting nothing)
- Infer how the practice of sharing the fish or clams or berries with all members of the family and/or community contributes to an understanding of interconnections and interdependence
- Discuss why the Nisga'a often refer to the bear as "a teacher"
- Discuss the common belief among traditional Aboriginal peoples that one should observe nature closely because the plants, animals, forests, and all entities are our teachers
- The Seven Generations principle implies that the actions we take should honour the ancestors seven generations into the past, and have repercussions for the present, as well as seven generations into the future. Explain the Seven Generations Principle in relation to Aboriginal values (worldview).

Concept: Aboriginal peoples past and present engage in monitoring and restoring renewable resources.

- Research how Tsartlip First Nations students helped to monitor eelgrass meadows and restore eelgrass beds (restoring fish habitat) at SNITȻEŁ (place of the blue grouse)
- Research how the T'Sou-ke First Nation uses solar panels and wind for energy, decreasing fossil fuel demand
- Research how the Nuu-chah-nulth First Nations are working with Oceans Network Canada and the University of Victoria to monitor changes in ocean temperature and water quality
- Identify a local resource issue and explore ways Indigenous Science and Western Science can be used to resolve the problem.

GRADES 6 AND 7: WEATHER AND CLIMATIC ZONES

Concept: Aboriginal peoples use a variety of ways to forecast the weather.

- Research how Inuit women and girls forecast the weather using traditional knowledge (i.e. animal behaviours)
- Research how Inuit peoples observe changes in land and weather, and how changes are having an impact on their lifestyles
- Interview an Elder to explore how to forecast the weather
- Observe and record the weather over a five-day period, paying attention to traditional knowledge
- Predict tomorrow's weather.

Concept: Aboriginal peoples developed specific technologies to meet their needs in different climatic zones.

- Explain how Aboriginal peoples made use of the different climatic zones in each season (mountain, valley, river/lake, coastal, muskeg, and tundra)
- Illustrate with accurate, detailed drawings a range of Aboriginal technologies for use in cold snow and icy weather conditions (Haida ocean canoe, Cree snowshoes, Inuit eye goggles, igloo, kayak, sled, and Algonquin toboggan)
- Research how Aboriginal peoples living in a rainforest developed technologies for life in extremely rainy weather conditions: e.g., wove warm waterproof clothing from shredded cedar bark. Explore, using different materials, how multiple layers of fibre give good insulation
- Illustrate with accurate drawings how rain coast peoples shaped roof planks to allow runoff of rain.

GRADES 6 AND 7: HEAT AND TEMPERATURE

Concept: Aboriginal peoples (past and present) use heat and temperature in a variety of ways to meet their needs.

- Describe and illustrate how Aboriginal peoples preserve food using heat and temperature (sun-dried seaweeds, wind-dried and sun-dried fish, smoked fish and clams, salted fish, preserving using oolichan oil)
- In collaboration with knowledge holders, use heat to dry seaweeds or fish
- Research how Aboriginal and Inuit peoples deal with issues of heating in traditional housing (igloo, tepee, and big house)
- Explain how heat is used in a variety of ways for meeting the needs of Aboriginal peoples and for artistic purposes (steaming bent cedar box and rendering oolichan oil)
- North American Indigenous peoples make pemmican from bison, deer, or elk by pounding the lean meat with hot fat and dried berries. Make some pemmican using beef, deer, or elk
- Aboriginal peoples preserve different runs of salmon in different ways depending on the fat content of the fish (high fat content is not as good for drying as low fat content fish): early runs of sockeye salmon are not as good for drying as later runs of sockeye salmon. Chum salmon are less oily. Predict, observe, infer

and compare drying early sockeye salmon with later sockeye salmon

- With a partner, research a traditional Aboriginal method of using heat for the preparation of food or clothing or making dyes. Does the process involve a physical change, chemical change or both?
- Infer how Indigenous peoples might have experimented to develop a process for tanning hides by boiling a broth using deer or elk brains. Does the process involve a physical change, chemical change or both?
- Research how the Aztecs made rubber balls, water-proofing, and gumboots prior to the arrival of the first Europeans
- Research how Indigenous peoples from Meso-America processed freeze-dried potatoes. Does the process involve a physical change, chemical change or both?
- Give examples of Indigenous theorizing and experimenting.

GRADES 7 TO 9: SUSTAINABLE ECOSYSTEMS

Concept: An ecosystem is made up of all the interacting organisms (plants and animals), rocks, water, soil, sun, as well as the interactions between organisms and their environment.

- Identify examples of ecosystems: e.g., forest, wetlands, Garry oak meadow.

Concept: Humans impact ecosystems.

- Research examples of how human activity during the 20th century has impacted ecosystems in BC (clear-cut logging, logging over stream beds, damming rivers, filling in and polluting wetlands and estuaries, and oil and gas pipelines)
- Research examples of how human activity has impacted Aboriginal resources in BC over the past century (decline of oolichans, salmon, halibut, herring, cranberry bogs, and crab apple orchards)
- Research how a huge hydro electric dam in BC created Williston Lake—flooding the traditional lands of the Tsay keh Dene peoples and affecting the ecosystem and way of life
- Interview an Elder or knowledge holder to explore how loss of lands and resources have affected the local Aboriginal culture.

Concept: Aboriginal peoples showed respect and understanding of the inter-connectedness of ecosystems.

- Describe, using examples, how traditional Aboriginal fishing practices (past and present) show an understanding of the preservation of fish habitat (walking stream beds in spring to remove debris from spawning channels allowing salmon to return to spawning grounds)
- Describe, using examples, how traditional Aboriginal forestry practices affect forest ecosystems (controlled burning adds nutrients to the soil, reduces understory and decreases wildfire intensity and insect infestation)
- Research how Haida Elders and knowledge holders (with their knowledge of land and sea), work with scientists on conservation and cultural projects in the National Parks Reserve on Gwaii Haanas

- Research how Nisga'a fish wheel technology and modern satellite technology is being used to monitor salmon migrations and maintain the population.

GRADES 7 TO 9: CLIMATE CHANGE

Concept: The earth and its climate has changed over geological time.

- Research and describe, using examples, how Aboriginal and Inuit Elders and knowledge holders are often first identifiers of climate change (changes to seasons, changes to snow, ice, glaciers, permafrost, and available clean water)
- Research and describe, using examples, how Aboriginal and Inuit Elders and knowledge holders are often first identifiers of changes in animal, bird and plant migration (e.g., killer whales arrive in Arctic region for the first time, first sighting of killer whales hunting narwhales, unusual polar bear migrations)
- Research ways that Aboriginal/Inuit knowledge holders and scientists are working together to study climate change issues.

GRADES 5 TO 12: GEOLOGY, ROCKS AND MINERALS

Concept: Aboriginal peoples (past and present) use rocks and minerals in a variety of ways.

- Illustrate how Aboriginal peoples in BC shaped stones to meet their needs (e.g., arrow heads, knives, spears, hand mauls, wedges, beads and pendants, stone bowls, scrapers for tanning hides, stone anchors for fish nets and dugout canoes)
- Research how traditional peoples were keenly aware of the different properties of rocks and minerals: sandstone for grinding; slate for splitting into slabs; basalt for scrapers, arrow points, knives and spears; glass-like obsidian for fine arrow heads, knives, and pendants)
- Research or invite a knowledge holder into the classroom to explain how Aboriginal peoples in BC worked copper to make knives and to show the wealth of the family
- With the guidance of the teacher and an Aboriginal knowledge holder, explore the properties of rocks and minerals. Try making an arrow head (use face goggles)
- Visit an Aboriginal artist to observe how he or she works with silver, gold, argillite, jade and/or other precious stones to make jewellery, decorate masks and other products

- Research how Mayan, Aztec and Incan artists worked with gold and silver to make jewellery, face masks and animal figures
- Research Aboriginal artists from BC who are famous for their beautiful works with gold, silver, jade, or argillite (e.g., Charles Edenshaw, Bill Reid, Robert Davidson, Roy Vickers).

GRADE 9: FORMS OF REPRODUCTION

Concept: Indigenous peoples developed in-depth knowledge of plant propagation (asexual reproduction) and care for harvesting food sources.

- Research how Aboriginal peoples in BC developed knowledge of plant propagation and genetic variability (pruning, budding, grafting, coning, weeding, selective harvesting, and transplanting roots)
- Research Indigenous peoples of Meso-America's knowledge of plant propagation and genetic variability (varieties of potatoes, beans)
- Research how ancient Indigenous peoples of southern Mexico developed corn from grass plants using a process we now call "selective breeding."

GRADE 9: MEDICINE AND MEDICINAL HERBS

Concept: Aboriginal peoples (past and present) harvest plants and animals for medicinal purposes.

- Infer why Aboriginal peoples often use the phrase "the forest is our drugstore"
- Invite a knowledge holder into the classroom to discuss medicinal uses of plants
- Go on a plant walk with a knowledge holder to identify medicinal plants
- Identify and illustrate Aboriginal medicines in BC (e.g., willow bark for headaches, yarrow tea for colds, devil's club for diabetes, seaweed/sea wrack for burns)
- Infer how Indigenous peoples might have discovered that tea made from willow bark cures headaches
- Research the Aboriginal and scientific uses of yew wood for medicinal purposes (taxol for curing cancer)
- Research Indigenous medicines from the Americas (quinine, Ipecac, Aloe vera, Echinacea)
- Research the uses of neem oil in India and North Africa (medicinal, biodegradable insecticide)
- Research how pharmaceutical companies develop and patent medicines from Indigenous peoples' knowledge worldwide

- Research how companies gain access to Indigenous knowledge
- Research and discuss the ethics of obtaining knowledge and not returning a direct benefit back to the community
- Research the terms epidemic and pandemic, and how measles and the smallpox pandemic affected Aboriginal peoples and culture after the arrival of the first Europeans
- Invite an Aboriginal health practitioner into the classroom to discuss health issues in Aboriginal communities.

Appendix B: Selected Curriculum Websites

See chapter 5 for a more descriptive overview of projects and curriculum resources.

Canadian Web Sites

Aikenhead, G.S. (2000). *Rekindling traditions: Grades 6 to 10 cross-cultural science and technology units*. University of Saskatchewan. Free downloadable. Retrieved from http://www.usask.ca/education/ccstu/

Arntzen, H. *Artist response team*. Teacher Handbooks and Videos. Specializes in eco-music and education activities that promote understanding ecology, Aboriginal knowledge of nature, and sustainability. To order: http://www.artistresponseteam.com/music-2/

Gaxsoo Canoes: A Cross-curriculum unit for grade 5. First Nations Education Services, SD 52, Prince Rupert, BC. To order: http://sd52.bc.ca/abed/wp-content/uploads/2009/04/orderlist1.pdf

Menzies, C. R. (2003). *Forests and oceans for the future. Curriculum units on traditional plant knowledge, geography, ecology, and resource management*. Free downloadable. Vancouver, Canada: Department of Anthropology, University of British Columbia. Retrieved from http://www.ecoknow.ca

Native access to engineering. Award winning site for kids, parents and teachers supporting Aboriginal youth to become engineers. Concordia University, ON. Free downloadable. Retrieved from http://www.aboriginalaccess.ca/

Oceans Network Canada. Embraces diversity of ocean sciences, place-based knowledge, and cross-cultural learning. University of Victoria. Free downloadable. Retrieved from http://www.oceannetworks.ca/learning/get-involved/educators

Saint Marie, Buffy. The Cradleboard Project. *Science: Through Native eyes*. Nihewan Foundation, CD Rom Series. To order: http://www.cradleboard.org/cd.html

Sila Alangotok: *Inuit observations of climate change*. (2000). Teacher's guide and 60 minute DVD, University of Manitoba, IISD Productions. Chronicles observations by the Inuvialuit that support the Western Science prediction that climate change would be first felt in the Polar Regions.

Summary DVD: http://www.iisd.org/library/inuit-observations-climate-change-full-length-version-dvd

Teachers Guide for the Video: Free downloadable. Retrieved from http://www.edu.gov.mb.ca/k12/docs/support/sila_video/

Strong Nations Publishing. One of the largest selections of Indigenous books on-line, including recent K-1, 2 curriculum resources. Nanaimo, BC. To order: http://www.strongnations.com

Alaska Web Sites

The Alaska materials are highly recommended for BC teachers as much of the content is relevant to west coast and Northern Canadian climatic conditions, wildlife, hunting and fishing, and food gathering technologies.

Alaska Native Knowledge Network: ANKN. A rich database of science lessons searchable by content, cultural region, and grade level. Free downloadable. Retrieved from http://www.ankn.uaf.edu/curriculum/units/

Alaska Science Fairs, Camps and Equipment. Promotes local and culturally relevant curriculum in science and mathematics. Retrieved from http://www.ankn.uaf.edu/publications/alaska_science/Fairs.html

Stephens, S. (2000). *Handbook for culturally responsive science curriculum*. Alaska Science Consortium and the Alaska Rural Systemic Initiative. Alaska Native Knowledge Network. Free downloadable cross-cultural science units. Retrieved from http://www.ankn.uaf.edu/publications/handbook/handbook.pdf

Appendix C: Selected Indigenous Science Books

Indigenous Science Education Books

Aikenhead, G., & Michell, H. (2011). *Bridging cultures: Indigenous and scientific ways of knowing nature.* Toronto, ON: Pearson Canada.

Cajete, G. (1994). *Look to the Mountain: An ecology of Indigenous education.* Skyland, NC: Kivaki Press.

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

Indigenous Science, Worldview and Philosophy

Berkes, F. (2012). *Sacred ecology (3rd edition).* New York, NY: Routledge Taylor and Francis Group.

Cajete, G. (2000). *Native science: Natural laws of interdependence.* Santa Fe, NM: Clear Light Publishers.

Kirk, R. (1986). *Wisdom of the elders: Native traditions on the Northwest Coast.* Vancouver, BC: Douglas & McIntyre.

Knudtson, P., & Suzuki, D. (1992). Wisdom of the elders. Toronto, ON: Stoddart Publishing Company.

Peat, F. D. (1994). *Lighting the seventh fire: The spiritual ways, healing, and science of the Native American.* New York, NY: Birch Lane Press.

Indigenous Science of Northwestern North America

Arima, E., & Hoover, A. (2011). *The whaling people of the West Coast of Vancouver Island and Cape Flattery.* Victoria, BC: Royal BC Museum.

Deur, D. E., & Turner, N. J. (Eds.) (2005). *Keeping it living: Traditions of plant use and cultivation on the Northwest Coast of North America.* Seattle, WA: University of Washington Press.

Stewart, H. (1973). *Artifacts of the Northwest Coast Indian.* Saanichton, Hancock House Publishers.

Stewart, H. (1977). *Indian Fishing: Early methods on the Northwest coast.* Vancouver, BC: J.J. Douglas Ltd.

Stewart, H. (1984). *Cedar: Tree of life to the Northwest coast Indians.* Vancouver, BC: Douglas & McIntyre.

Turner, N. J. (1995). *Food plants of coastal First Peoples.* Royal British Columbia Museum Handbook. Vancouver, BC: UBC Press.

Turner, N. J. (1998). *Plant technology of First Peoples in British Columbia.* Royal British Columbia Museum Handbook. Vancouver, BC: UBC Press.

Turner, N. J. (2005). *The earth's blanket: Traditional teachings for sustainable living.* Vancouver, BC: Douglas & McIntyre.

Turner, N. J. (1997). *Food plants of interior first peoples.* Royal British Columbia Museum Handbook series. Vancouver, BC: UBC Press.

Turner, N. J. (2010). *Plants of Haida Gwaii.* Winlaw.BC: Sono Nis Press.

Turner, N. J., & R. J. Hebda. (2012). *Saanich ethnobotany: Culturally important plants of the WSANEC people.* Victoria, BC: Royal BC Museum Publishing. Check spelling of WSANEC

Turner, N. J. (2014). *Ancient pathways, ancestral knowledge: Ethnobotany and ecological wisdom of Indigenous peoples of northwestern North America, Volume 1: The history and practice of Indigenous plant knowledge.* Montreal, QC: McGill-Queen's University Press.

Turner, N. J. (2014). *Ancient pathways, ancestral knowledge: Ethnobotany and ecological wisdom of Indigenous peoples of northwestern North America, Volume 2: The place and meaning of plants in Indigenous cultures and worldviews.* Montreal, QC: McGill-Queens University Press.

Pasco, J., & Compton, B. (1998). *The Living World: Plants and animals of the Kwakwaka'wakw.* U'mista Cultural Society. Alert Bay, BC: U'mista Cultural Society.

Williams, J. (2006). *Clam gardens: Aboriginal mariculture on Canada's West Coast.* Vancouver, BC: New Star Books.

Indigenous Science of the Americas

Anderson, R., & Bone, R. (2003). *Natural resources and Aboriginal people in Canada: Readings, Cases and Commentary.* Concord, ON: Captus Press Inc.

Inglis, J. Ed. (1993). *Traditional ecological knowledge: Concepts and cases.* Ottawa, ON: International Development Research Centre (IRDC) Books.

Johnson, M. (1992). *Lore: Capturing traditional environmental knowledge.* Ottawa, ON: Dene Cultural Institute and the International Development Research Centre.

Menzies, C. (2006). *Traditional ecological knowledge and natural resource management.* Lincoln, NE: University of Nebraska Press.

Warren, D. M., Slikkerveer, L. J., & Brokensha, D. (Eds.) (1995). *The cultural dimension of development: Indigenous knowledge systems.* London, UK: Intermediate Technology Publications.

Weatherford, J. (1988). *Indian givers: How the Indians of the Americas transformed the world.* Toronto, ON: Random House.

Weatherford, J. (1991). *Native roots: How the Indians enriched America.* Toronto, ON: Random House.

Wright, R. (1992). *Stolen continents: The new world through Indian eyes since 1492.* Toronto, ON: Viking Press.

Appendix D: Research Project and Graduate Program

The Research Team

The project was initiated by Dr. Wanosts'a7 Lorna Williams in September 2003 when she was Director of the Aboriginal Education Enhancements Branch of the Ministry of Education in British Columbia. Dr. Gloria Snively, science and environmental educator and Director of the Graduate Program in Environmental Education at the University of Victoria accepted an invitation to serve as principal investigator for the project. In July 2004, Dr. Williams began a tenure track position at the University of Victoria and became Director of Aboriginal Teacher Education.

The Vision

In January 2003, a group of invited University of Victoria faculty, graduate students, Ministry officials, non-Aboriginal resource persons, and Aboriginal leaders and Elders from around the province met at Dunsmuir Lodge, Victoria to generate a vision statement and to identify possible research directions. The following vision statement reflects the ideas, concerns, and vision of those in attendance.

Programs and curricula need to be developed that:

- Teach Aboriginal children that their culture has contributed to scientific knowledge and will continue to do so.
- Links science instruction to local Indigenous Science and Traditional Ecological Knowledge and Wisdom.
- Recognizes and engages the expertise of local Aboriginal people and links their current observations and understandings to a vast historical and cultural database gained from observation and experience.
- Enables Aboriginal students to understand the importance of science in their daily lives and its relationship to themselves, their community, and the world in which they live.
- Celebrates equity and diversity and recognizes equity and diversity as essential.
- Instills concepts such as giving back to the earth, prayer, offerings, and stream restoration.
- Where possible locating science concepts and practices in First Nations languages to provide a better understanding from a First Nations perspective.
- Enables Aboriginal students to be successful in school and not lose their cultural identify. (Snively & Williams, 2006, p. 232)

These essential points are reflected throughout the context, framework, research methods and expressions of Aboriginal education presented in this project. The research project drew upon the wisdom, knowledge and experience of Elders and community leaders in order to identify both science content elements of Indigenous Knowledge and TEK, as well as identify culturally appropriate and effective ways of teaching and learning science. The intent was to strengthen the connection of Aboriginal children to the land through their Elders, and to develop a new expression of science education for Indigenous children in the 21st century.

Building a Community of Researchers

By working with Aboriginal graduate students, rather than with practiced researchers, this project was unique in that it was designed to promote capacity building amongst Aboriginal peoples. Although this was an important key element of the research project, it had the difficulties of attempting to work with a cadre of inexperienced graduate students, many of whom were at the beginning stages of taking graduate level research courses.

The Graduate Program in Environmental and First Nations Education

During the summer of 2004, an off-campus Graduate Program in Environmental and First Nations Education was offered to both Aboriginal and non-Aboriginal students in ʻYalis (Alert Bay), British Columbia, home of the Kwakwa̲ka̲ʻwakw people. The aim of this graduate program was "to bring together Aboriginal and non-Aboriginal persons to work together in learning about the forest and ocean environments, respecting the cultures of Aboriginal people, and educating future citizens to make wise decisions regarding long-term sustainable communities and environments" (Snively, 2006). Because the majority of graduate students were full-time teachers, the program was developed to take place in three summer sessions.

The graduate program explored a range of research methods deemed culturally appropriate for the research phase of the project: participant observation, informal interviews with Elders and resource persons, participatory action research (PAR), metaphorical interviews, student drawings, students as researchers creating videos of their choice and archival research. In these studies, cultural validity was assured by having Aboriginal teachers as researchers, Aboriginal Elders and groups participating in identifying the content and teaching strategies of the local science curriculum, participating in the teachings, and identifying culturally appropriate assessment practices.

The first summer session combined a variety of experiences with the natural environment with primary historical documents on BC First Nations' history and culture, including input from First Nations' Elders and other resource persons. Courses focused largely on topics dealing with the TEK of several First Nations of BC; current educational issues relevant to Aboriginal peoples; the knowledge and skills of WS; community-environment relationships; and the contributions of both WS and TEK to environmental knowledge, and the resolution of environmental and resource problems.

Although much of the program was team taught, the combined program of courses included Community, Culture and Environment taught by historical researcher John Corsiglia; Ethnobiology of British Columbia First Nations taught by ethnobiologist Dr. Brian Compton; Mythology, Stories and Science, taught by Yup'ik science educator Dr. Oscar Kwagley; and Environmental Education taught by Dr. Gloria Snively. "A key tenant was that environment and culture could not be considered separately, there could be no course on Kwaguʼł culture that was not also about the Kwaguʼł environment. Culture and environment are inextricably linked and must be treated holistically" (Snively, 2006, p. 203).

Common experiences included direct experience with the Elders, and conducting archival and museum research associated with historical events related to colonization and decolonization.

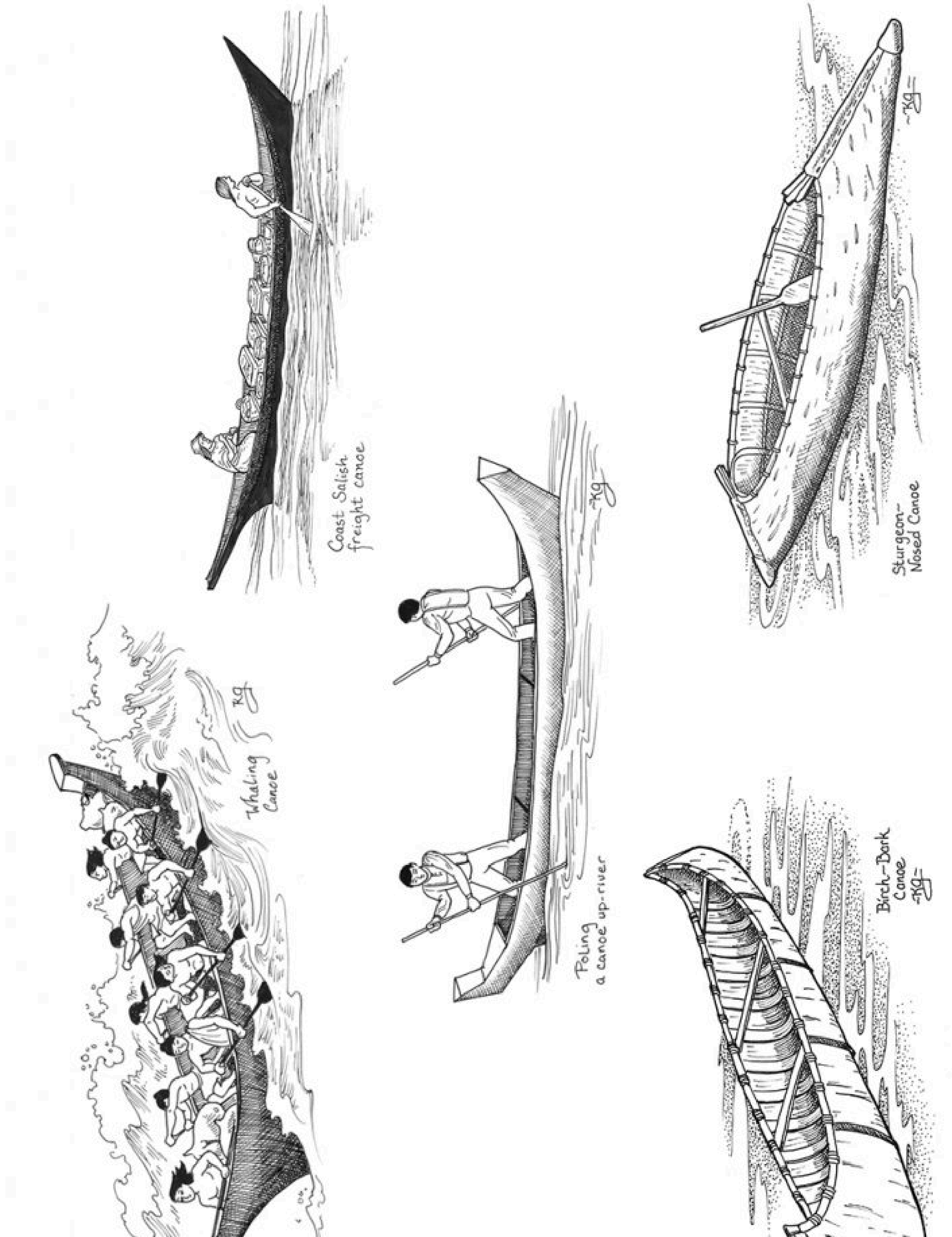
Experiences with Elders and community leaders were coordinated by Gloria Snively and Gwi'molas Vera Newman, a Kwakwa̱ka̱'wakw language and culture teacher; and included informative and inspiring presentations by Chief Kwaxalanukwa'me' 'Namugwis Bill Cranmer, Chief Nulis Edwin Newman, 93 year old 'Mam'xu'yugwa Auntie Ethel Alfred, Ga'axstalas Flora Cook and 'Waxawidi William Wasden, Jr.; and day hikes and extended boat trips led by Wadzidalaga Wata Christine Joseph, Gwi'molas Vera Newman and Tłalilawikw Pauline Alfred. Topics included the use of Kwakwa̱ka̱'wakw traditional herbs, traditional medicines, the ethnobiology of marine forest resources, principles associated with language and culture, and historical cultural events. Western Science specialists gave presentations, including whale researcher Dr. Paul Spong, marine biologist Michael Berry, ethnobiologist Brian Compton, and anthropologist Dr. David Garrick.

By bringing together Elders and acknowledged specialists in the key inter-related disciplines, and by providing both Aboriginal and non-Aboriginal students with a total emersion experience in a dynamic Aboriginal community, the program provided a unique interdisciplinary starting point for designing research projects and developing educational programs and curriculum materials.

During the winter of 2004/5, the students took Field Based Research Methods taught by Gloria Snively that was designed to help the students begin to think about their research proposals. During the summer of 2005, they took two courses that were designed to provide additional research skills and focus on concepts associated with the current project: Aboriginal Ways of Knowing taught by Dr. Wanosts'a7 Lorna Williams and Interpretive Inquiry taught by Dr. Ted Riecken. Finally, during the summer of 2006 the students took Marine Biology for Teachers from Dr. Rick Kool at the Bamfield Marine Science Centre, a world-class teaching and research facility located on the outer west coast of Vancouver Island.

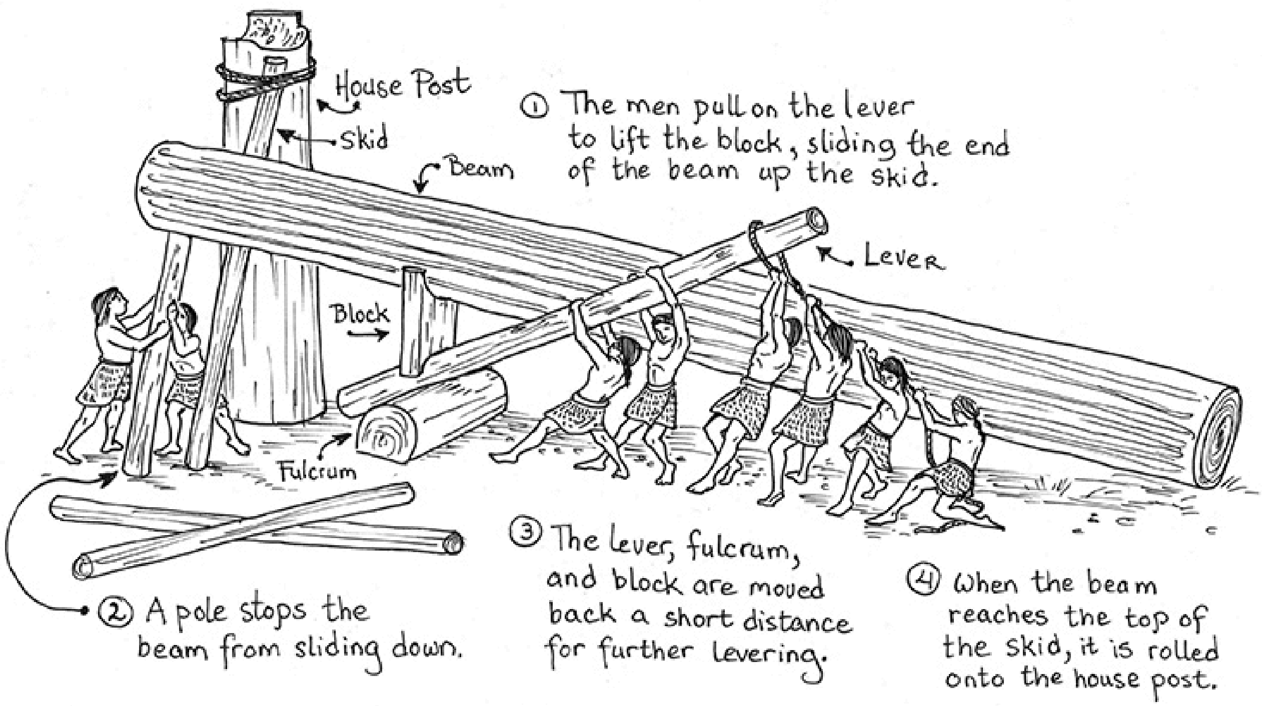
Although we consciously avoided teaching science and environmental courses in an assimilative way, the students were expected nevertheless to understand the world through the eyes of the Western scientist, just as they were expected to understand the world through the eyes of Aboriginal peoples.

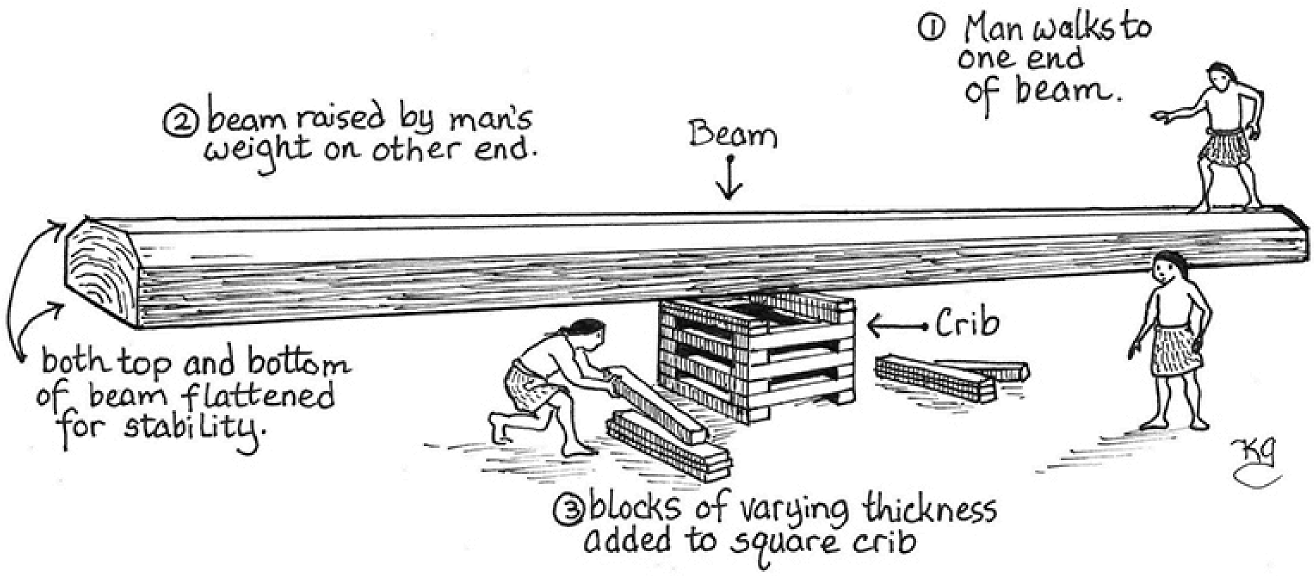
Appendix E: Full-Sized Images



Figures 7.2 – 7.6 ▲ *Different canoe types.*

Figures 7.8 & 7.9 ▲ *House with fluted beams. Photos courtesy of the Royal BC Museum.*





Figures 7.10 & 7.11 ▲ *Lifting house beams.*

Figure 7.13 ▲ Berry picking basket.

Figures 7.17 & 7.18 ▲ Garry Oak meadow and Blue Camas.

Figures 7.19 & 7.20 ▲ Tracey Island clam garden.

Figures 7.21 – 7.23 ▲ *Digging and cooking clams.*

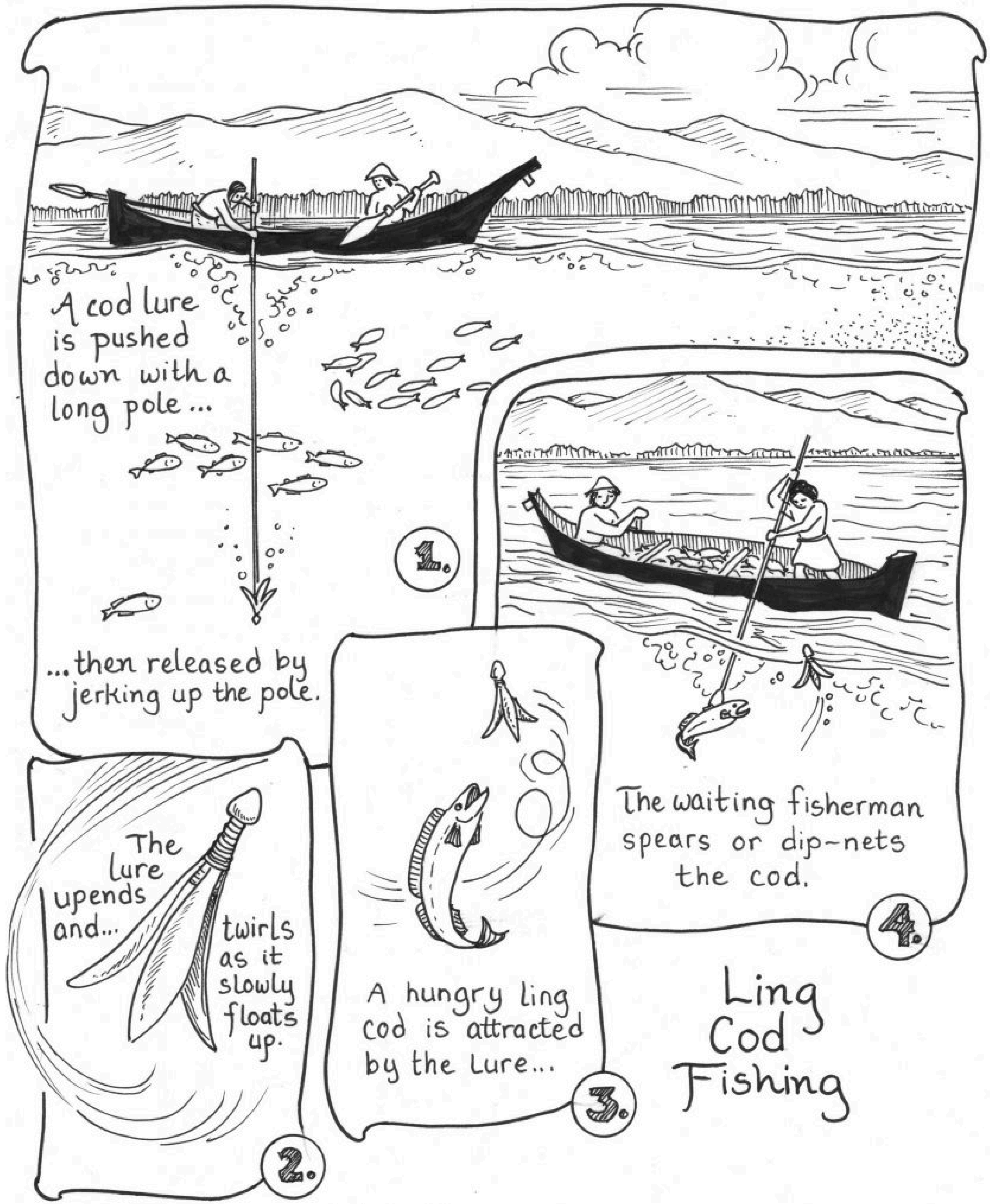
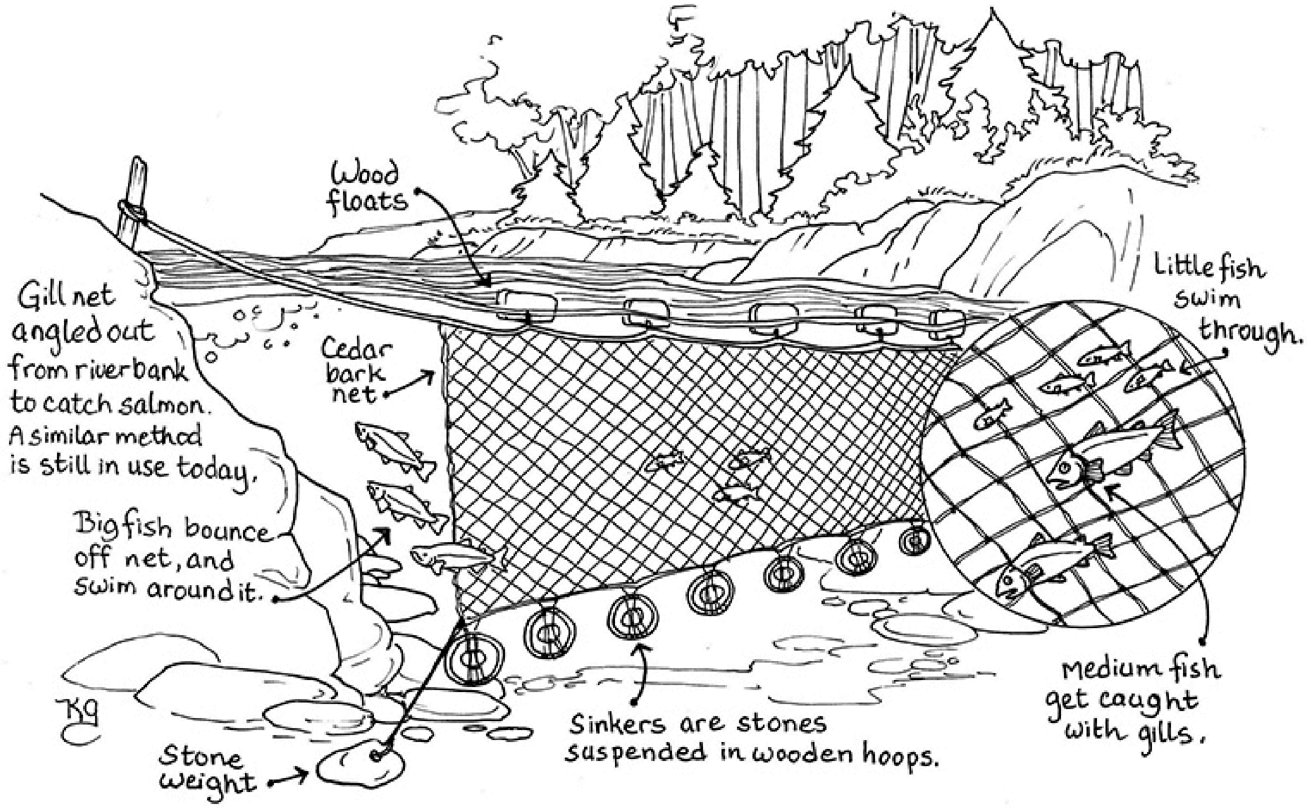
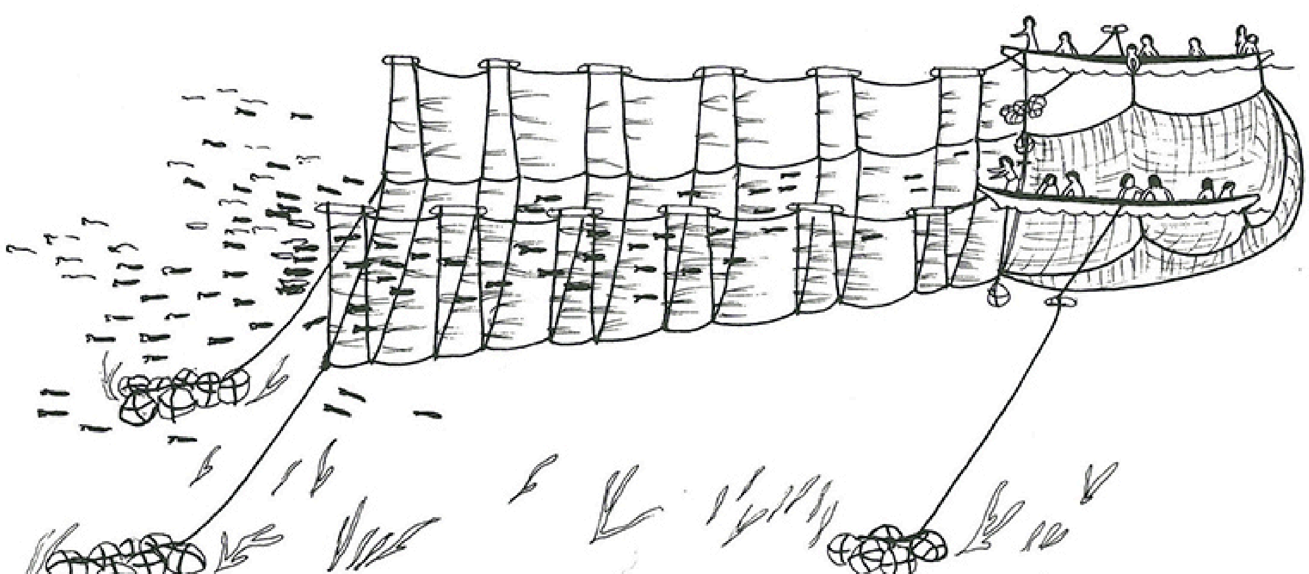


Figure 7.24 ▲ *Ling Cod fishing.*





Figures 7.25 & 7.26 ▲ Traditional gillnet and reef net of the WSÁNEĆ (Saanich) Saltwater people.

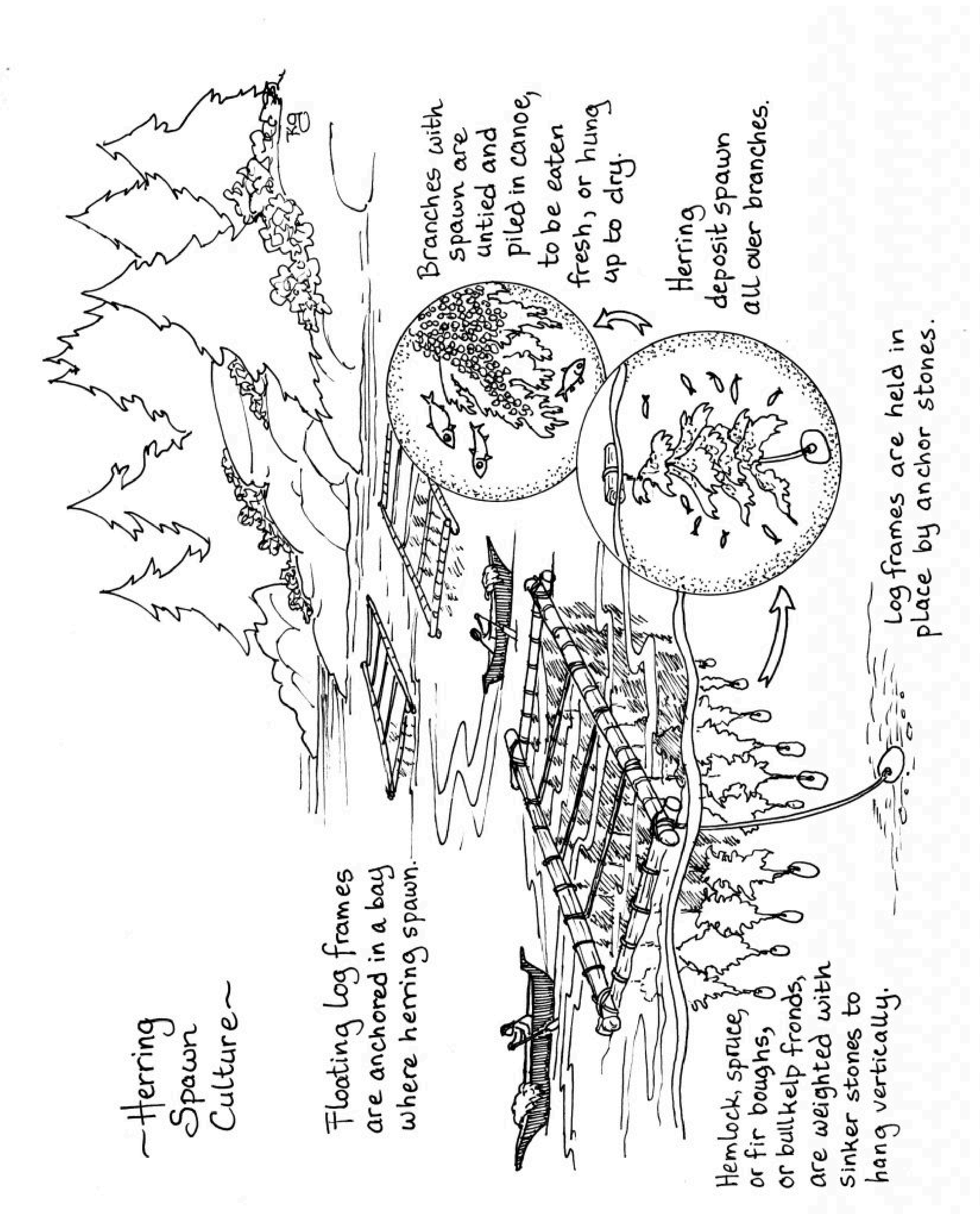


Figure 7.27 ▲ Herring spawn culture.

Figures 7.28 – 7.30 ▲ Top Left: Northern Rice Root Lily; Bottom Left: Springbank Clover; Right: Pacific Silverweed.

Figures 7.31 – 7.33 ▲ Top: Northern Rice roots and seed pod; Middle: Pacific Silverweed roots; Bottom: Sprinbank Clover roots.

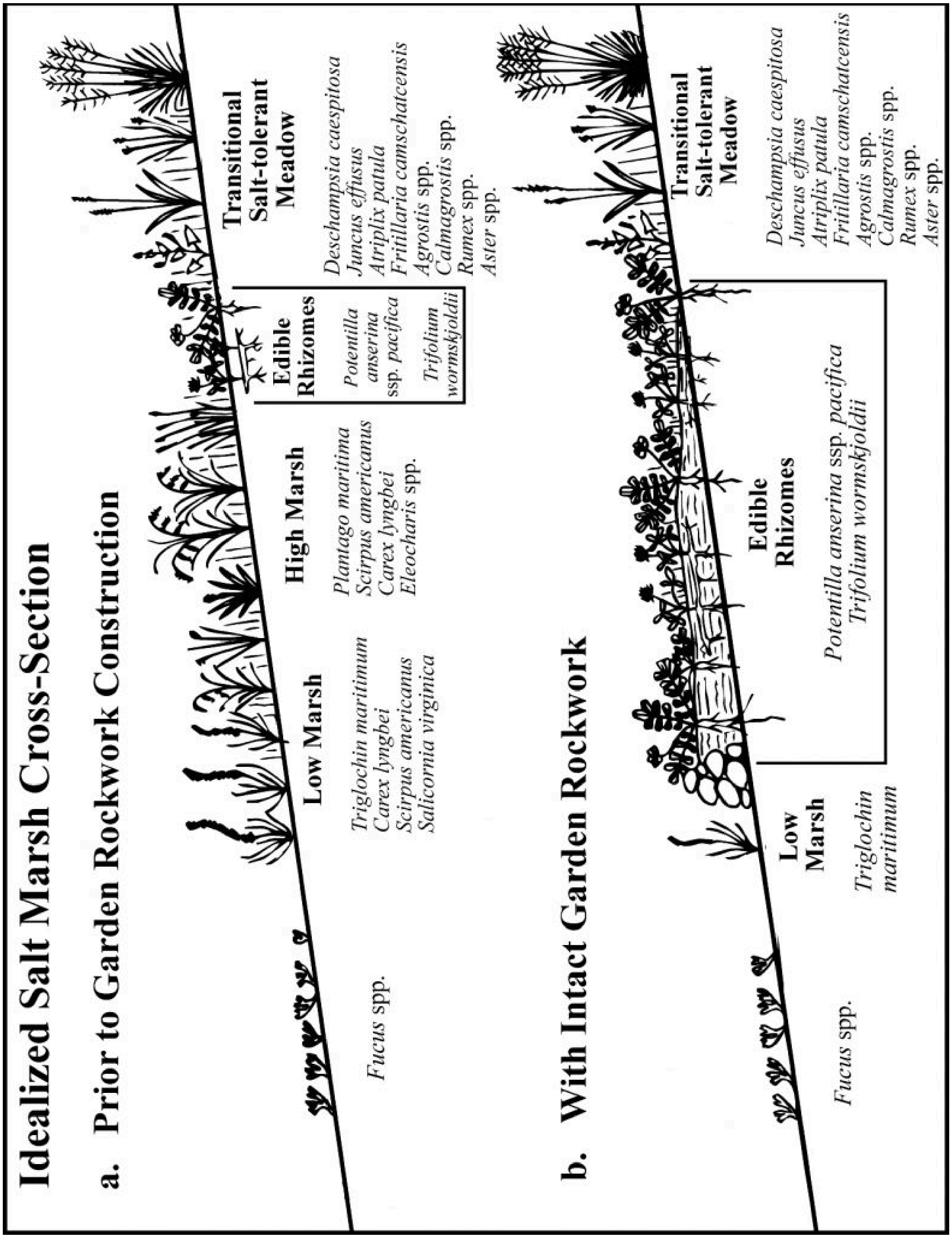


Figure 7.34 ▲ Idealized salt marsh cross-section.

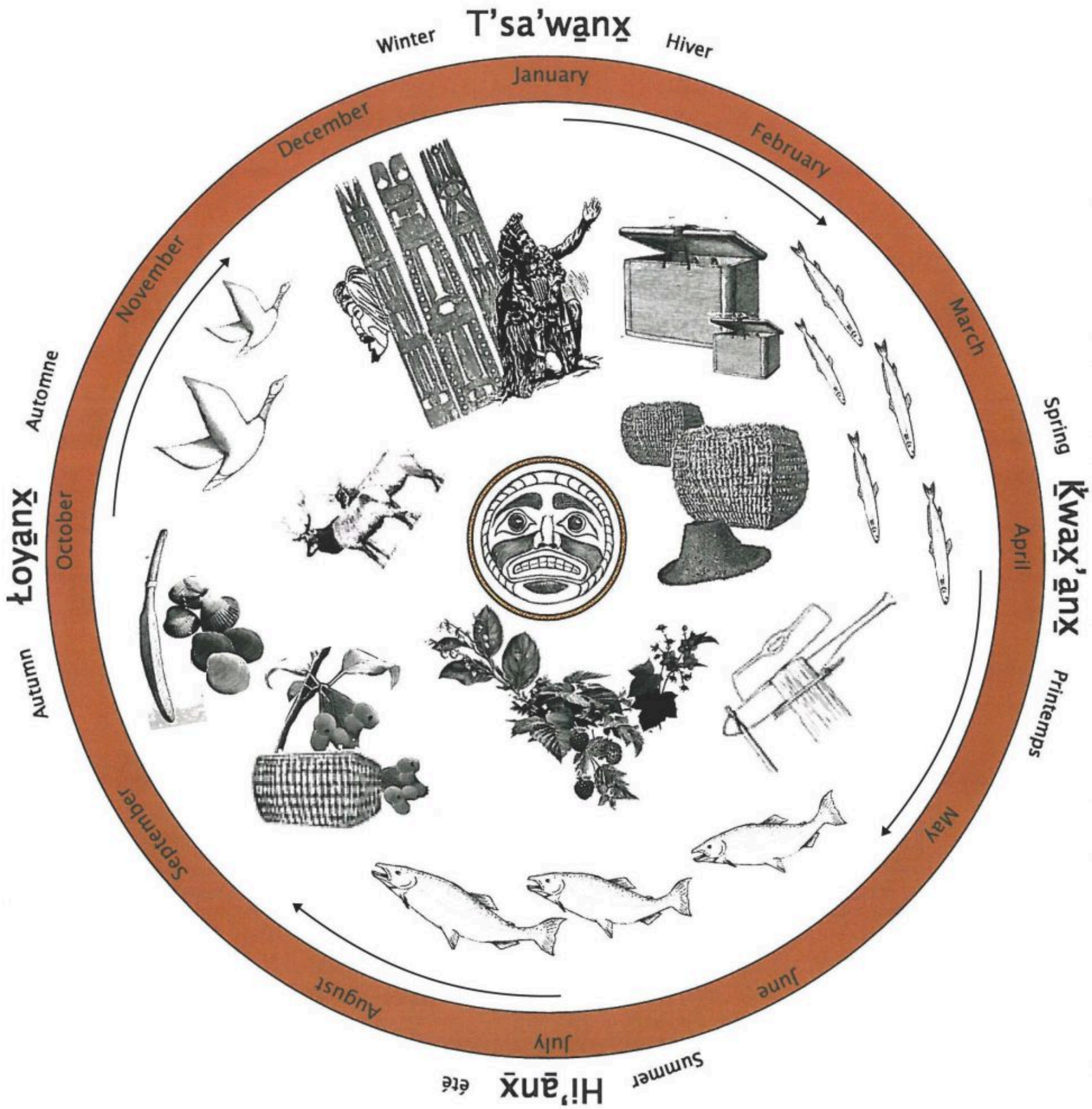


Figure 10.1 ▲ Seasonal wheel chart.

Figures 13.1 – 13.3 ▲ *Dzaxwa̲n (oolichan).*

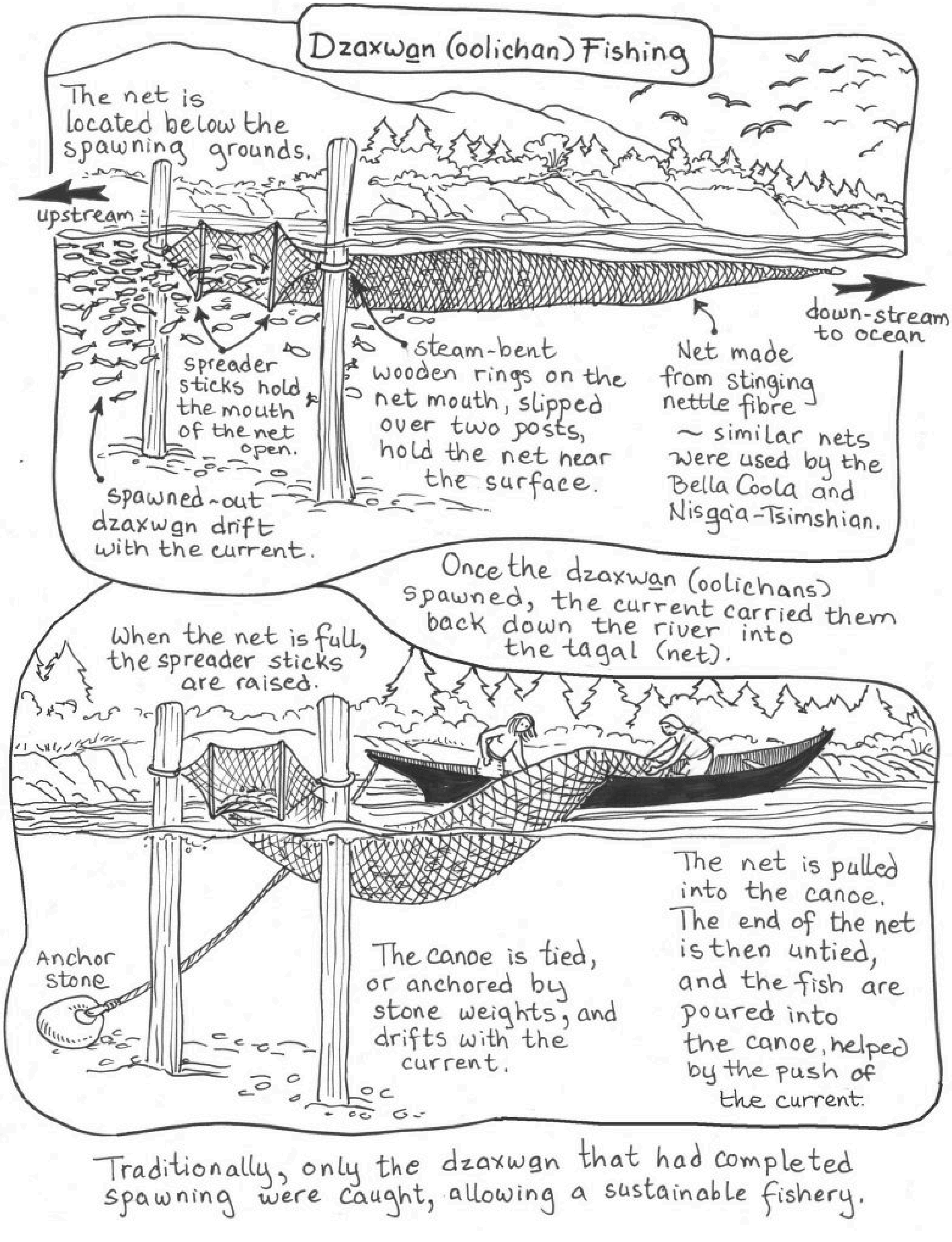


Figure 13.6 ▲ Dzaxwa̲n (oolichan) fishing.

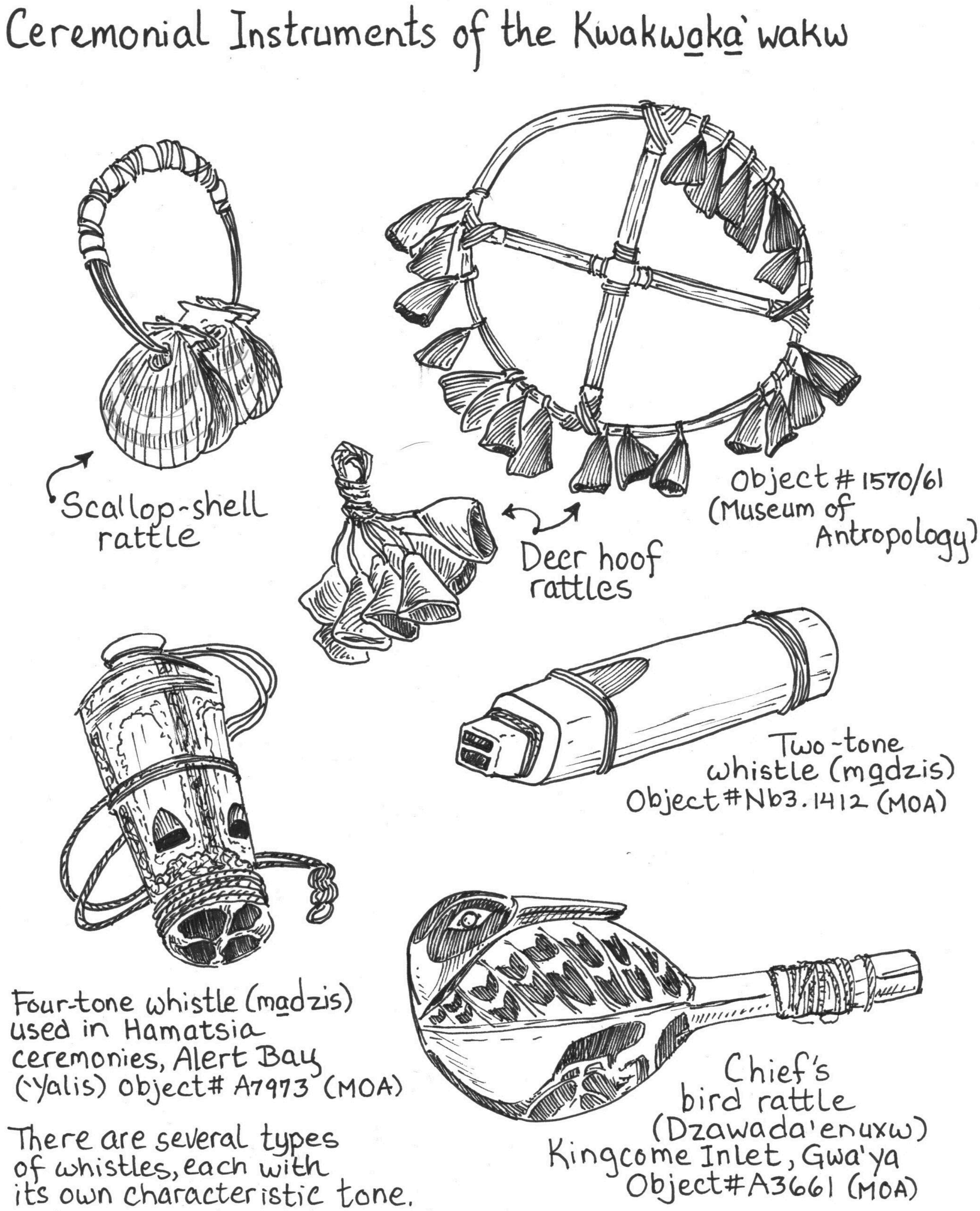


Figure 14.1 ▲ Ceremonial instruments of the Kwakwa̲ka̲'wakw.

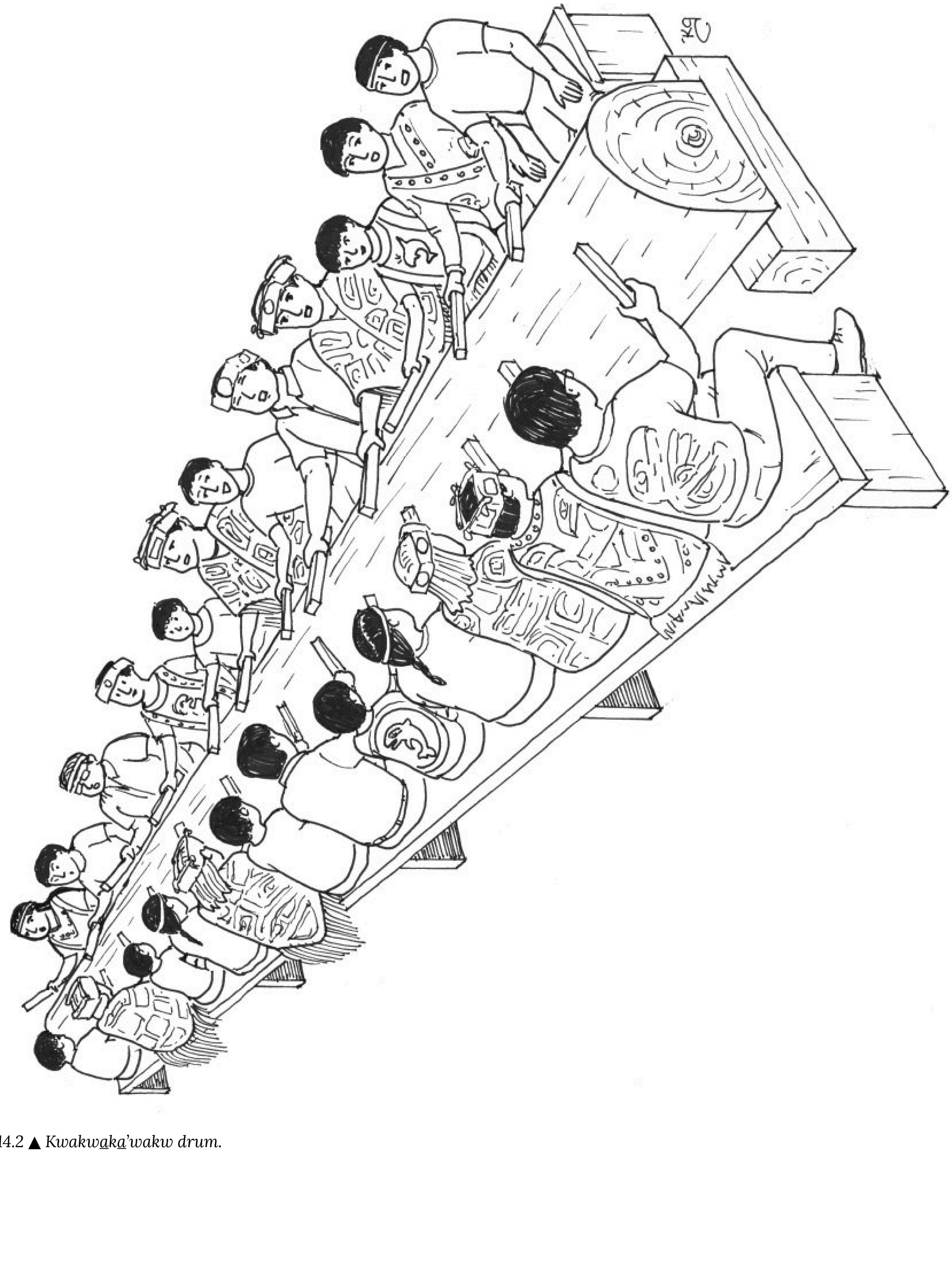


Figure 14.2 ▲ *Kwakwa̱ka̱'wakw drum.*

Figure 14.3 ▲ Kwakwaka'wakw dancer with raven mask.

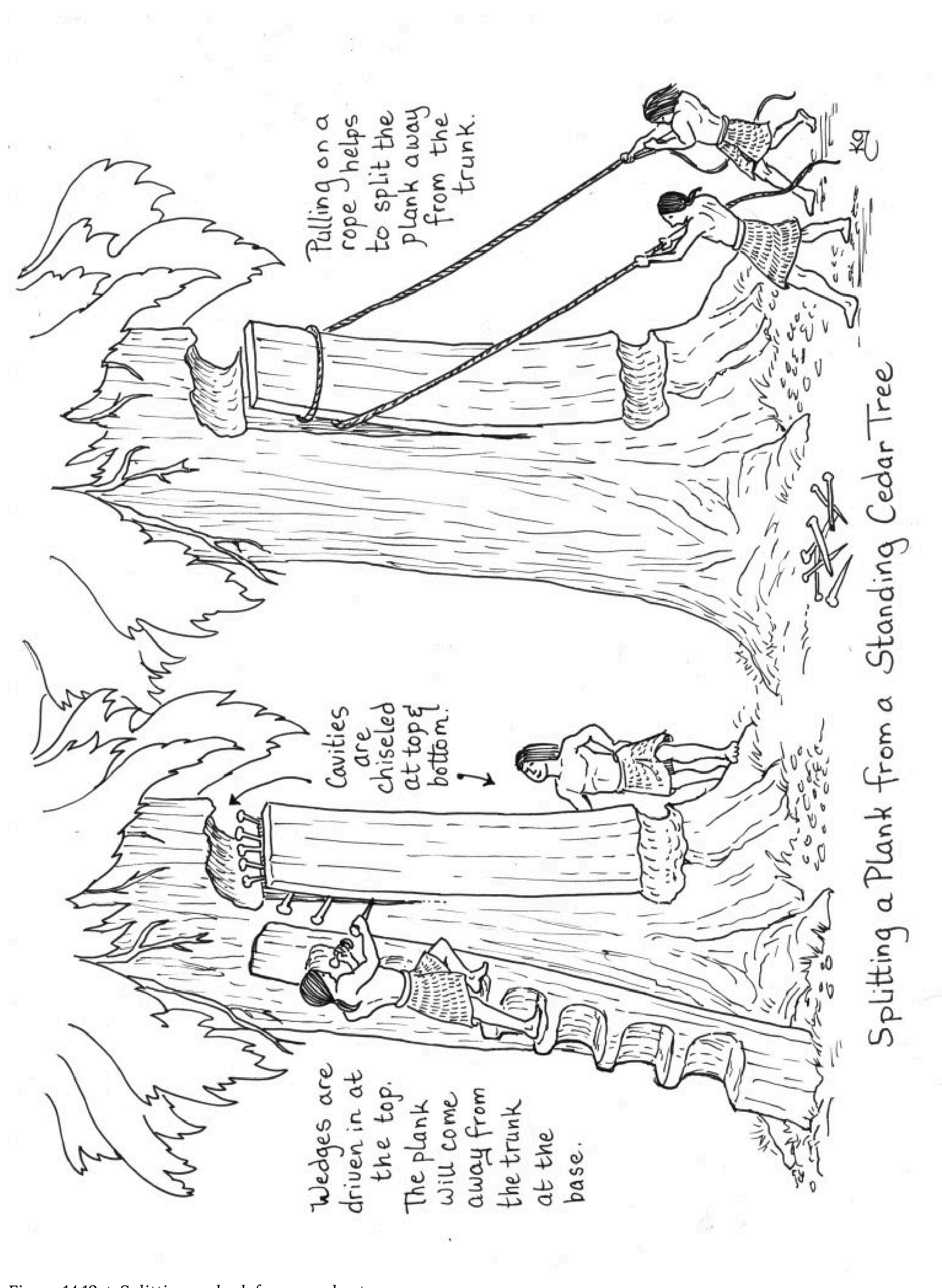


Figure 14.12 ▲ Splitting a plank from a cedar tree.

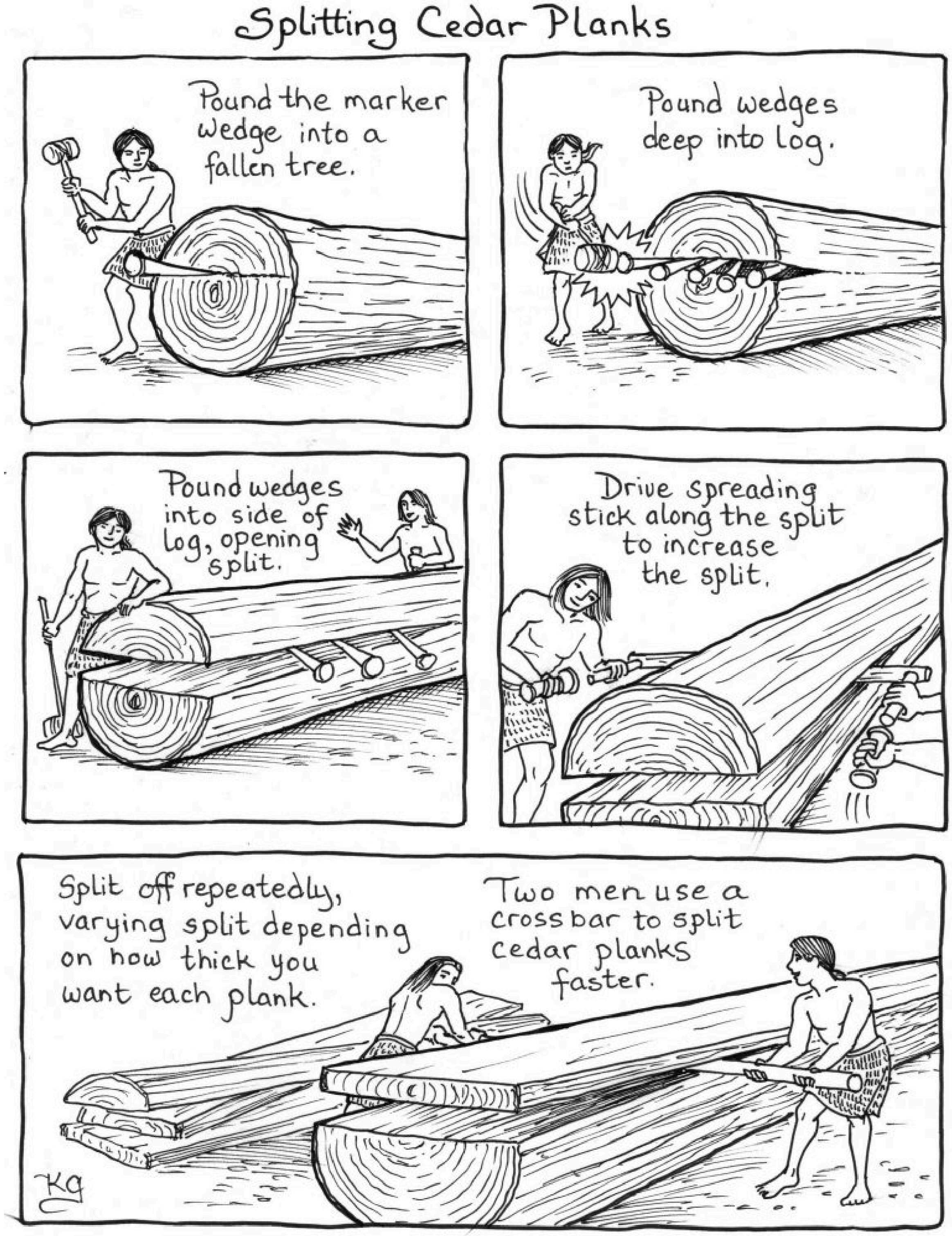


Figure 14.13 ▲ Splitting Cedar planks.

Endorsements

“This book is both timely and critical, coming during the era of Canada’s Truth and Reconciliation Commission’s Calls to Action, and during British Columbia’s implementation of its New Curriculum, where educators have the opportunity to weave Indigenous perspectives into all parts of the curriculum in a meaningful and authentic manner. *Knowing Home* acknowledges and validates Indigenous Knowledges and brings it together with Western Science in a way that will be invaluable for educators.”

Nick X̲EMŦOLTW̲ Claxton, WSÁNEĆ (Saanich), PhD, Indigenous Education, University of Victoria.

“*Knowing Home*: *Braiding Indigenous Science with Western Science* is an inspiring collection of knowledge, expertise and cultural intelligence that will help all educators in transforming the foundations of learning for all students. As we strive to change the narratives in BC and beyond through authentic voices, new curricular directions and Aboriginal worldviews and perspectives, this book defines a way forward for our relationships and understandings grounded in the sacred territories of our people. This rich and reflective resource of traditional and contemporary ways of knowing and being will truly engage each of us in a personal and professional journey of truth and reconciliation.”

Musgam’dzi, Kaleb Child, Kwakwa̲ka̲’wakw, Director of Instruction, First Nations – School District #85, Vancouver Island North

“The attainment of the UN Sustainable Development Goals by 2030 will require transformative new approaches to the creation and use of knowledge. This book Knowing Home provides a brilliant example of how new ways of knowing can be combined with Western knowledge for the betterment of our communities and indeed our planet. Knowing Home places Indigenous Science on an equal footing with Western Science and in the process illustrates how innovative research with Indigenous Elders and students can dramatically enhance our understanding of home/earth/land. And while the focus of this work in on the Indigenous Science of NorthWestern North America, the research methods involved in the creation of this project, the focus on how to use Indigenous Science in classrooms, and the support of emerging Indigenous scholars can and should be carried out in many other parts of the world. Knowing Home is a defiant, provocative and hopeful intellectual contribution to the world we want.”

Dr. Budd Hall, Co-Chair, UNESCO Chair in Community Based Research and Social Responsibility in Higher Education

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Version	Date	Change	Details
1.0	January 18, 2017	Added to the B.C. Open Textbook Collection	
1.1	June 4, 2019	Updated the book's theme.	The styles of this book have been updated, which may affect the page numbers of the PDF and print copy.