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Western Science Coming-to-know Traditional knowledge

by

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ABSTRACT

This thesis explores connections between western science and traditional knowledge, and some educational implications of these connections for the science classroom. The examination of science as a description, explanation and predictor of natural events is viewed from the researcher's location as an *asokan* (bridge, Cree) between two worldviews. The use of Indigenous research methodology has allowed for the researcher's process of coming-to-know traditional knowledge to be used as research results. Interpretation of selected participant interviews and the experiences of the researcher during the research process highlight the importance of including metaphoric meaning, language, elders, oral tradition, narratives, community and relationship as critical elements of science education for Aboriginal students. Additionally, the inclusion of these elements would result in a more expanded meaning of science than that held by most western scientific practitioners, philosophers and teachers. A new paradigm is suggested which would bridge both worldviews for the benefit of both Aboriginal and non-Aboriginal science students.

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1. Introduction

1.1 Problem Statement

As presented to students in school today, western science has a history of conceptual development (Bronowski, 1973). Traditional knowledge embedded within Native culture also has well-developed concepts that describe, explain and predict natural events (Peat, 2002). This research examines links between these two ways of knowing the world, locates some places where these two worldviews connect, and explores implications of the ways in which selected aspects of this area of intersection might be used within science classrooms.

1.2 The Research Purpose

There are many different ways of knowing the world. Various cultural worldviews represent these differences. In western culture, the scientific (hereafter referred to as western scientific)[1] worldview is one way of knowing that has its own epistemological definition, structure and historical account; in some ways it is quite different from Aboriginal worldviews (elements of which are hereafter called traditional knowledge). The western scientific worldview has been compared to and contrasted with traditional Aboriginal worldviews (Peat, 2002; Suzuki, 1997; Ross, 1996). An examination of areas of intersection between these worldviews might reveal pedagogic implications for Aboriginal and non-

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[1] See definitions p. 6.

Aboriginal students in the science classroom. This research addresses epistemological connections that lie at the intersection of the western scientific worldview and traditional knowledge. By highlighting areas of common perspective my intent is to examine the inclusion of elements of traditional knowledge in mainstream science courses. In trying to navigate between these two worldviews, Kawagley (1995) expressed his yearning in this way: "I have . . . been searching for a synthesis between the two ways of understanding the world" (pp. 38–39). The word *synthesis* here may be used metaphorically to describe the confluence of two streams that together create a powerful river. Synthesizing traditional knowledge with post-modern concepts such as constructivism[2] may, for example, give insight into the way meaning is derived for students with different worldviews when they take a course called "science" in school. A synthesis of (traditional and western scientific) knowledge bases may give students a greater understanding of natural events, and at the very least provide a broader perspective of the meaning of science.

1.3 Research Questions

This thesis began many years ago emerging from my lived-in experience of doing scientific research (Igarashi & Elliott, 1975), teaching science, and studying science education (BSc., BEd., MEd.). I worked with Aboriginal youth in both home and school settings. I taught and counselled out-of-school students

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[2] See the bricolage concept of logic, dialectic and rhetoric in D.Geelan's (2003) Constructivism and the nature of science (p. 49), in *Weaving narrative nets to capture classrooms*. London: Kluwer Academic.

in their homes through Edmonton Public School Institutional Services. Later I taught science and math at Amiskwaciy High School– an urban Aboriginal school– and then taught inpatients, including Aboriginal students, at the University of Alberta Hospital. Recently I have been teaching Education students, some of whom are Aboriginal, and as a University Facilitator I worked with student teachers in their education practicums which included two Aboriginal schools in Edmonton. During this time I have talked and worked with many Aboriginal students, teachers and educators.

Two research questions emerged for me from this background of experience and discussion:

1. What connections exist between western science and traditional knowledge?
2. What are the implications of these connections for teaching science?

Marie Battiste, 2007 Aboriginal Awards (in scholarship) recipient, asked the following questions in 2000: "What goals and outcomes are important?, Should we teach and evaluate in traditional Aboriginal ways or adopt contemporary Eurocentric models of education to achieve a diversity of goals?" (Battiste and Henderson, 2000, p.xiv). She then proposed two questions through a Canadian Council on Learning (CCL) Background Paper (2005) after this study was initiated which are similar in nature to those found in this study:

1. How can research methodologies structured toward reductionist analyses offer insight into (w)holistic learning? (p. 13); and

2. How can Indigenous knowledge be effectively translated into educational developmental theory and practice? (p. 13).

Finally, the two questions proposed by her at a Canadian Council on Learning (C.C.L.) Conference (March 8-9, 2007) provide extensions of this thesis for further study: How do you provide learning from within our own culture; and What is evidence of success? Resulting responses from my thesis questions focused mainly on the relationship between Aboriginal students and education. This may be because many respondents discussed more inclusively what it meant being Aboriginal in a non-Aboriginal school system, and not specifically about science education. Extensive literature exists on science education for non-Aboriginal students, for whom the western scientific knowledge paradigm is tacitly understood. It is for this reason that I focused only on Aboriginal participants.

One initial directive in locating my thesis questions is to locate this discourse under the general category of multicultural science. Some proponents of this viewpoint (Hodson, 1992, Pickering, 1992; Aikenhead, 2000a) advocate that this structuring will move science as it is taught in school from 'science for elite' to 'science for all'. Pragmatically this categorization may have allowed for the inclusivity of traditional knowledge in mainstream school science classrooms, however, I am not committed to this categorization for two reasons. None of the Aboriginal participants interviewed for this thesis suggested this structuring; non-native educators suggest it. Battiste and Henderson (2000) continue to ask questions (above) about this Eurocentric approach where the western scientific necessity to locate traditional knowledge as an adjunct form of knowledge is engendered by this categorization. The answer to the question of 'Whose culture is dominant?' allows for the placement of the nondominant culture's knowledge system as a subset of the dominant culture's way of knowing (Smith, 2004; Stewart-Harawira, 2005) rather than as a codominant sharing. Turner (2006) gives dimensions to this argument by suggesting the removal of the association of the English word minority with the word multicultural. Further, a multicultural approach may only be an intermediate step between social constructivism (Solomon, 1987) and a new approach, elements of which are articulated in chapters 5 and 6. Aikenhead (2000a) describes the shortcomings of a social constructivist approach with "the social constructivist view is limited by its preoccupation to enculturate all students into western science (p. 250)."

In summary, to locate traditional knowledge into the context of multicultural science may not address the question of why traditional knowledge has not been, until recently, regarded as science. Table 6.1 summarizes some reasons for this discrepancy. This thesis suggests some elements of traditional knowledge, which were described by participants as an expansion of the meaning of science rather than an inclusion of information under a subcategory of multiculturalism.

At present, biologists and ecologists have established a well-documented branch of science called traditional ecological knowledge (Snively & Corsiglia, 2001; Andrews, 1988; Berkes, 1988; Berkes & Mackenzie, 1978; Inglish, 1993; Warren, 1997; Williams & Baines, 1993). Snively and Corsiglia describe traditional ecological knowledge (TEK) as "time proven, ecologically relevant, and cost effective indigenous science" (p. 6). At the beginning of this study this knowledge had not made its way into mainstream science courses in Alberta (Alberta Learning, 2002; Alberta Learning, 2003). As such, my research questions seek to explore the issue that there exists a scholarly accepted body of knowledge (i.e., traditional knowledge) that has seen little discussion in our science classrooms.

1.4 Definitions

The term science is used here generally in keeping with Alberta Education's (2007) political definition where "the goal of science is knowledge about the natural world". In using just the term science I tacitly mean western science, a term examined below. The term mono-science is used from Aikenhead (2006) in conjunction with pipeline ideology. By applying a western scientific approach to defining and evaluating traditional knowledge concepts, the meaning and essence of those concepts may be lost as the two have quite different philosophical foundations (Levi-Strauss, 1968). When knowledge means a Platonic justified true belief as in, "He has a knowledge of nature", then the term *wisdom* might be more appropriate because it includes a fuller (subjective and affective) human meaning including the processes of researching, absorbing, doing, interacting and reflecting. However, the term traditional knowledge is prevalent in the literature (Bastien & Mistaken, 2004; Peat, 2002; Cajete, 1999; Snively & Corsiglia, 2000; Lightning, 1992) and is used here.[3] A full

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[3] Others, such as Battiste and Henderson (2000), Peat (2002), and Sefa Dei, Hall, and Rosenberg (2002) also use the term Indigenous Knowledge.

understanding of traditional knowledge and how it connects to western science goes beyond a logical, linear, reductionist approach and includes elements of intuition, emotion, spirit and a wholistic view of human's relationship with and position in nature (Peat, 2002). The term wholistic is spelled here to imply whole inclusivity rather than the term holism which subjectively may imply an association with religious beliefs. The term acculturate is used in keeping with Aikenhead's (2006) definition as " [s]tudents borrow some canonical content from school science because of its current utilitarian value, and this content either replaces old ideas or is added to the students' repertoires of ideas" (p.19). Likewise, the term enculturate is used as Aikenhead defines it where "[s]tudents learn the canonical content of science, which harmonizes with their own worldviews, by incorporating that content into their personal way of viewing the world" (p. 18). The term Aboriginal and native education is presented in this thesis as it was used by participants who often interchangeably included meanings of both the content of traditional knowledge and its application to an Aboriginal student population.

1.4.1 Western science

Science itself is a way of predicting, explaining and describing natural events (Chalmers, 1999). The consistent use of a methodology, pedagogically presented as a scientific method, has produced knowledge that is reliable and valid. Western science is often defined as representative of objectivity, empiricism, rationality and predictability (Nadeau & Desautels, 1984; Ogawa, 1998; Ziman, 1984). Western science here is described as being viewed differently amongst the perspectives of the scientist doing science, the science philosopher thinking about the meaning of science, and the science teacher who performs the act of teaching science. Scientists themselves experience doing science, while philosophers of science have particular abilities in describing science: "[S]cientists are typically good at making scientific progress but not particularly good at articulating what that progress consists of" (Chalmers, 1999, p. 252).[4] Both approaches to science are critical to meaning. My use of the terms "western science", "reason to believe", "coming-to-know", "ultimate proof of nature", and "different ways of knowing" correspond to their use by Smith and Siegel (2003) in *Knowing, believing and understanding: The goals of science education.* My examination of selected elements of western science does not imply a rejection of its power and influence or of its use to improve the quality of human life. A distinction between science and scientism is made here. While the activity of science often uses a well-defined methodology to obtain predictable results comprising a scientific study, scientism is the belief that only science can provide true knowledge. Issues of power and privilege which emerge from the application of this belief have been directly addressed elsewhere (Battiste & Henderson, 2000; Dei et. al., 2002; Stewart-Harawira, 2005; Nandy, 1988; D. Smith, 2002; L.T. Smith, 2004) and are only addressed here as they apply

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[4] Teaching science, including using laboratory studies, often differs from doing research primarily because the laboratory activities in school are often designed to give specific predetermined results; whereas the results of basic research are not yet predetermined.

tangentially to my two research questions (Aikenhead, 1997). Concepts of science which pedagogically incorporate scientism into the curriculum are examined in Chapters 4, 5, and 6. Science is viewed in terms of its relationship to pedagogy and to traditional knowledge.[5] Specifically, teaching science is examined to see where it contains residual elements of scientism and how these elements might relate to the present exclusion of traditional knowledge from the realm of western science and of science curricula.

1.4.2 Traditional knowledge

A definition of traditional knowledge from a western scientific perspective is of little value when attempting to address the two research questions.

Levi-Strauss (1968) identified conceptual difficulties when he explored one worldview from the perspective of another. Worldview as defined by Cajete (2000) is "a set of assumptions and beliefs that form the basis of a people's comprehension of the world" (p. 62). Where the researcher situates him/herself and how this influences the researcher's definition of words is an emerging question here. An essential difficulty arose when I explored one worldview using the perspective of another, by using my own experiences and understandings of meanings in one culture to describe or examine those of another worldview. For this research, I located myself at the intersection of two worldviews: I am "coming from" a western cultural perspective. During this research process I came to understand areas of common knowledge and I "come-to-know" areas of

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[5] See Figure 2.1, p. 36.

traditional knowledge. Although I am grounded in the western scientific perspective, this research required that I disengage from and redefine that framework. Similarly those coming from an Aboriginal perspective do not easily enter into the culture of western science (Aikenhead, 2006). However, by experiencing this research process, including reflecting on Aboriginal ways of knowing, I encountered insights into answers to my research questions. From a pedagogical perspective, Kewetin (2003) describes this stance in the following passage:

> One day, as I stood within the community and looked at the school, I saw two different worlds existing in the same physical space, but having no communication between them. I saw a seven year old boy who was full of laughter with his family. His aunts and uncles would tease him, and his grandmother would ask him about school and he would say that he was doing well, and she would smile proudly. He was the same boy I saw in grade one who was always quiet and never smiled. He would cry when he couldn't read. (p. 7)

Ross (1992) also addresses this problem: "Until you understand that your own culture dictates how you translate everything you see and hear, you will never be able to see or hear things in any other way" (p. 4). Levi-Strauss (1968) gives a description of his perspective on approaching nature from two directions. He sees western science's approach to the physical world as "supremely concrete" and using the process of "formal properties," while traditional knowledge approaches to nature are "supremely abstract" and use "sensible qualities" (p. 351).[6]

To demonstrate these differences the following table presents characteristics of both traditional knowledge and western science using a western scientific approach. I present this table as a starting point, an initial way of conceptually representing differences. It will later be discussed in terms of implied meanings that may be conceptually limiting. The separation of descriptive words into categorical boxes does not allow for the diffusion of meaning across a division. This idealized separation does not easily translate into a useful model for teaching science (see question 2, p. 3). A broader context that moves beyond the dialectical extremes of either/or and good/bad is examined in Chapters 5 and 6.

[6]"... the physical world is approached from opposite ends in the two cases: one is supremely concrete, the other supremely abstract; one proceeds from the angle of sensible qualities, the other from that of formal properties."

Table 1.1: Characteristics of Scientific and Traditional Knowledge [7]

Characteristic	Western Science	Traditional Knowledge
Worldview	Linear (e.g. Time) Fragmentation Hierarchical Mechanistic	Circular Wholistic All Equal Spiritual
Understanding of Knowledge	Objective—external to knower Analytical	Subjective—carried witl knower Intuitive
Sources of Knowledge	Scientists Through School and Experimental Methods	Elders Through Experience
Types of Knowledge	Synchronic Quantitative Theoretical Basis Knowledge is Product	Diachronic Qualitative Interpretive Knowledge is Process
Transmission of Knowledge	Written Texts	Orally through Knowledge Carriers
Decision Making	Managerial Hierarchy	Communal

Although this represents an important ideation, immediate questions arise from viewing this table: Why were these characteristics used and who chose them? From what perspective is this comparison being presented? This dichotomy is too simplistic; more opportunities for synthesis/dialogue need to be explored. The distinct border and 'border crossing' between two knowledge systems needs to be further examined. Historically, the western scientific European perspective has been the dominant descriptive written-view of Native thought (Chamberlin, 1975; Fisher, 1977; Berger, 1991, Wright, 1992; Howard & Widdowson, 1996,

[7] Adapted from Ferguson & Dunnigan, 1998. The interface in defining traditional knowledge from two cultural perspectives is also represented in Figure 2.1.

Battiste & Henderson, 2000). Combined European and native thinking include a detailed description of the indigenous worldview translated from Lacota to English by John G. Neihardt in *Black Elk Speaks* (Black Elk, 2000) and a more interpretive account in *Lame Deer, Seeker of Visions* (Lame Deer & Erdoes, 1973).[8] In another instance of critical perspectives, a widely publicized speech was originally attributed to Chief Seattle, but now to European creation and interpretation (Knudtson & Suzuki, 1992, pp. xv–xviii). Table 1.1 may more importantly be considered here as an example of presenting a single (western scientific) perspective than of conveying other information.

The statement, "my perspective influences what I see" is given biochemical credence by Pert (1997). Briefly, she outlines how, as biological organisms, human beings first receive selected information through their five senses, and then go through further processes of reselection and interpretation based on past neural network development and biochemically activated responses precipitated by previous experiences. van Manen (1991) uses a similar concept to present a phenomenological perspective on educational research. Using this phenomenological approach, as a non-Aboriginal scholar, the importance of the meanings that I subjectively ascribe to such words as *intent*, *respect*, *kindness*, *honesty*, *strength* and *sharing* become an integral part of the process of research. In order to gain an understanding of traditional knowledge, I, as the researcher,

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[8] Lightning (1992) notes that it is often incorrectly inferred from these types of writings that ceremony is equated with epistemology.

have to enter into a dialogic relationship with others, many of whom have a different cultural understanding of the world than mine. I enact my understanding of such words as these in this dialogic relationship through dialogue and interview (see Chapter 4: Methods). Kewetin (2003) reflects this approach in her description of defining herself within such a research perspective:

> ...the day I stood in the community with my friends and looked back into the school, is the day I began my life on the picket fence. For the first time I felt my responsibility. Taking the risk to wear another worldview and have some of it permeate your being implies that you will take the responsibility for wearing that view and sometimes feel the burden of its presence. (pp. 7–8)

Viewing how nature works from another perspective means coming-to-know what words mean within that context; what words mean from another worldview. Because defining epistemologies demands the use of words, gaining an understanding of the culturally specific meanings and uses of those words must occur before arriving at more general associated concepts. Elders use words, often in Cree, that are not easily understood from a western context (Wilson, S., 2001). One example cited by Wilson can be found in the use of the English noun *couch.* In Cree, its meaning includes an interconnected relationship between the object (i.e., English noun couch) and the person using the couch. Definitional understanding in traditional knowledge often includes aspects of relationship and reciprocity (Ross, 1996; Weber-Pillwax, 2003). This level of understanding may not be obvious when implied meanings include more than the use of a noun referring to an object "out there".

Rather than attempt a conflation of multiple meanings for the term *traditional knowledge*, I try to interpret meanings as they arise, initially referenced from my western scientific perspective. I reference meanings from my (grounding) *schema* which changed as I come-to-know traditional knowledge. Applying an approach that defines static detailed things-in-the-world to traditional knowledge concepts results in empty or misinformed data analysis, adding to mis-understanding between two perspectives. The reason I call attention to the importance of the meanings of the words I use in this context is not to confuse and obfuscate dialogue, but to clarify it (Weber-Pillwax, 1999). By paying attention to my evolving meanings, I began to see my implicit process of defining terms; I began to come-to-know my definition of these words in association with the process of how I got to know their meaning initially.

Given this perspective, a significant amount of this research represents an interpretation of my own understanding of traditional knowledge as it relates to western science. From a pedagogical stance, van Manen (1991) describes this in phenomenological terms as "pedagogical thoughtfulness." By thinking about and reflecting on the meaning of terms from two different worldviews[9], I, as a

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[9] Although the concepts themselves within a worldview may be similar, the way people relate to the concepts may seem irreconcilable: Caribou is an animal that migrates. Knowing its behaviour as an experienced hunter living with

teacher/researcher, am able to use these meanings pedagogically to bring both perspectives to science classrooms. When I choose and use the term *traditional knowledge* herein, it becomes a term that demands continual "pedagogical thoughtfulness" from me.

While the term *western science* has an implication of modernity or of something newly arrived at, it also accurately reflects a spatial cultural root by giving a direction or location (i.e., western). The term *traditional knowledge* likewise implies a location—in time. I initially use it here in the sense it is found in Suzuki (1997) and Snively and Corsiglia (2000) when they discuss traditional knowledge and western science as knowledge about nature. Initially they describe traditional knowledge as usually being transferred, often orally, and as being about how nature works. Traditional knowledge was painstakingly acquired over thousands of years and passed on from generation to generation within communities to aid in their survival. It is time proven and ecologically relevant knowledge. The use of the term traditional knowledge will be discussed and further expanded on below.

Some other relevant terms elicit implied meanings, such as the use of *cultural indigenous knowledge* (Battiste & Henderson, 2000), *restrictive traditional ecological knowledge* (Snively & Corsiglia, 2000) or simply *native science* (Cajete, 2000). Battiste and Henderson (2000), for example, use the term

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the herd is distinct from knowing it abstractly from books or videos, or by performing an autopsy on a carcass.

indigenous knowledge and begin to give it definition within a cautionary political context: "[P]recise universal definition, while of philosophical interest, would be nearly impossible to attain in the current state of global realities, and would in any event not contribute perceptibly to the practical aspects of defending groups from abuse" (p. 35). Although the term traditional wisdom was often used by participants in this study, in the literature I reviewed, the term *traditional knowledge* was frequently associated with the term western science, especially in relation to ecological concepts (Snively & Corsiglia, 2001); consequently it is the term I use here (Andrews, 1988; Howard & Widdowson, 1996; Snively & Corsiglia, 2001; Williams & Baines, 1993). Precisely defining knowledge bases may parallel precisely defining western scientific concepts. In terms of electrons, Brouwer and Franks (1988) make a distinction between the concept of an electron and a precise definition of one. They quote Jauch (1973) who "...is clearly one of those physicists who believe that an electron is a useful invention which helps to make predictions about experiments, but has no fundamental existence in any reality." From an instrumentalist approach, the use of the concept of an *electron* is given meaning only when applied to an experiment conducted within the western scientific paradigm; the electron's existence in an external reality is not addressed. (More recently, however, Greene (2004) has assumed its existence as one of twelve basic particles. His definition of the characteristics of this particle (p. 347) is based on the assumption of its existence). Although we may have a precise empirically derived definition of an electron, it may not exist in reality. In this case an empirically derived scientific definition does not guarantee its existence.

Similarly using this approach to precisely defining traditional knowledge may not encompass its full meaning.

Western scientific concepts change and evolve over time. Just as a Newton's construct of the physical world, classical mechanics, gave way to quantum mechanical and Einstein's relativity constructs and then included Heisenberg's uncertainty principle, what was once thought of as precise scientific definition later changed (Brouwer & Franks, 1988). This is not to say that precisely defining temporally derived factual knowledge is not useful; rather, I wish to emphasize that knowledge based on temporal facts evolves. Knowledge based on facts gained from a western scientific methodology alone, does not necessarily lead to a complete description (or explanation) of natural events. Traditional knowledge also explains and describes natural events. Although both may perceive and interpret the same event in nature, because their approaches are different (op. cit. Levi-Strauss, 1968, p.11), it would appear that their resulting concepts are irreconcilable. This research however, aims at penetrating this appearance and finding ways in which the approaches can complement each other.

Definitions of traditional knowledge itself have also undergone conceptual changes from a western scientific perspective, in a similar way to what Kuhn (1970) describes as paradigm shifts in science. In one example from this perspective, Lucien Levy-Bruhl, a respected French philosopher living between 1857 and 1939, developed general theories about "primitive" peoples. He was influential during that time in claiming that these people held collective representations that were mystical and prelogical. Recently he has been criticized as presenting a relativist focus on non-scientized ways of thinking (cited in Oxford Dictionary of Sociology, 1998, p. 366). Cajete (2000) in Native Science characterizes a more current reiteration of this western scientific view in: "Western scientists believe that non-western societies relate to nature only in ways categorized anthropologically as folktales or cultural technology, and these ways are not science in their (i.e. western scientific) experience of the term" (p. 78). Conversely, some western scientists give recognition to the importance of traditional knowledge: "Traditional native knowledge about the natural world is often supremely sophisticated and of considerable practical value" (Suzuki, 1997, p. 12).

To expand on a previous point, traditional knowledge focuses on knowledge that has been passed on from generation to generation in indigenous cultures. Traditional knowledge is thus interpreted by the people (e.g., Elders) in the community through which this knowledge is transferred (Ross, 1992). The expression "coming-to-know" describes a method, not necessarily oral, of acquiring this knowledge. Translations that encompass the English noun *knowledge* include the Cree verb *kiskeyittam*[10]–he knows (Beaudet, Cree–English Dictionary, 1995, p. 52) and *tanisitohtahk*—he will understand, comprehend; to become; in a state of awareness and knowledge (Lightning, 1992, p. 34). The term

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[10] The root *Ktam* meaning looking ahead, implies awareness (Cora Weber-Pillwax, personal correspondence).

Nehiyaw (Cree) is translated as 'four bodies' or 'a four part person'. Cree coming-to-know involves all four parts of a person: mental, emotional, physical and spiritual (Henry Laboucan, personal correspondence). This suggests that traditional knowledge includes a continual active process of coming-to-know (rather than a completed end product of knowing) by using all four parts of understanding to give meaning to concepts (The Four Worlds Development Project, 1984).

Battiste and Henderson (2000) devote their entire second chapter in Protecting Indigenous Knowledge and Heritage to defining indigenous knowledge. Their suggestion is that, unlike western definitions that demand controlled and exact detailed simplifications, any definition of traditional knowledge here would, for example, include:

- a contextual reading of this thesis;
- a coming-to-know (as I have begun) of an interconnected weaving of conceptual thinking including the context in which this knowledge was passed on;
- the personally derived meaning [for me] of traditional knowledge;
- its connection to the authenticity, integrity and wisdom of the knowledge carrier (Elder), located in place and time; and
- an understanding that my interpretation of this term, when viewed from another cultural background, will be incomplete.

Battiste and Henderson begin their definition of indigenous (traditional) knowledge culturally with the question "What can savages know or how do they think?" (p. 35).

Definitions of traditional knowledge can be placed in an historical context. Examples of a Euro-Canadian view that no distinguishable education or educational thought patterns existed within indigenous cultures can be found in Chamberlin (1975), Fisher (1977) and Wright (1992). Although criticized as speculation, previous to these references, Claude Levi-Strauss (1968) theorizes that scientific thought existed early in the 'savage' (Native?) mind: "I see no reason why mankind should have waited until recent times to produce minds of the calibre of Plato or Einstein[11]. Already over two or three hundred thousand years ago, there were probably men of similar capacity"(p. 11). Thus according to the three authors above, although traditional knowledge carriers were thought to have existed, in Canada a cultural perception persists that identifies indigenous peoples as having no knowledge. From this Canadian standpoint, if traditional knowledge did not exist, there was no need to identify or define it educationally from a western scientific viewpoint.

Other, more specific, attempts to clarify the meaning of traditional knowledge have recently been made. Knudtson and Suzuki's (1992) definition of traditional knowledge include the following highlights:

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[11] This quote also ignores the contribution of women.

- nature is viewed as sacred, not as inert matter;
- wisdom and environmental ethics are seen as residing within the very structure of the natural world, not as products of external human reason;
- traditional knowledge tends to view time as circular as characterized by natural cycles, rather than as a linear escalator of human progress;
- spirit is identified as an attribute of all things; this differs from western science's reading, which differentiates between living and non-living components;
- traditional knowledge does not hold that nature is completely decipherable to the rational human mind; the natural world contains rationally inexplicable but not incomprehensible mysteries. Knudtson and Suzuki (1992) point out, "We (i.e. western science) have no theories with which to make sense of many of the phenomena that indigenous people describe" (p. xxx).[12]

In addition, van Kessel (2001) underscores the importance of diachronic data (information that has been collected over a small region over many generations) in defining traditional ecological knowledge. She contrasts this with western scientific synchronic data, which has been collected over a large region but during a comparatively short time period. Aikenhead (1997), too, has further

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[12] An acknowledgement of the limitation of the explanatory ability of western scientific methodology has been described by Max Plank (1858-1947): "Science cannot solve the ultimate mystery of nature. And that is because in the last analysis, we ourselves are...part of the mystery that we are trying to solve" (Translated by Braden, 2007, p. 3).

delineated traditional knowledge to include the immediate world of personal and tribal experiences. Finally, Peat (2002) includes myths and languages as components of traditional knowledge. I use this term with an understanding that it includes process and relationships between objects. All of the above approaches to defining and solidifying an exact definition for this term do not, I believe, fully encompass its meaning but exemplifies western science coming-to-know traditional knowledge.

A more useful approach might include the constructivist use of the term *bricolage* to mean the difference between a logical, exact and precise definition (product), and an approach to the process of constructing a conceptual framework of understanding—given our own different and evolving constructed meaning assignments and worldviews—which can be applied pedagogically to the above definitions of traditional knowledge. I begin to define traditional knowledge from the descriptions given above and develop a further understanding of it through this research.

In summary, for the purposes of this research, unless otherwise referenced, the term *traditional knowledge* is applied to my interpretation and/or synthesis of the various meanings outlined above, and is combined with meanings obtained from interviews and dialogue with Aboriginal peoples, mainly Alberta Cree. My understanding and use of *traditional knowledge* is one of an evolving process in my coming-to-know the meaning of this term. My sources attempted to inform me of its meaning to them; however, I take full responsibility for the use of this term.

1.4.3 Cursory Examples of Traditional Knowledge

Briefly, a few examples of Northern Canadian traditional knowledge (such as isostatic rebound[13]) will be provided here. These limited examples exist within the larger geographic background of North and South America, and as isolated facts within a larger paradigm. In one example, Cruikshank (1980) outlines traditional knowledge of isostatic rebound as it is contained within oral tradition. Thematically consistent Inuit oral accounts, occurring over a century, were documented by J. Spink (1969), who found a reliable correlation existed between oral accounts and the effects of isostatic rebound. Although Bird (1967) contests the accuracy of these claims within a man's memory (Bird, pp. 144–45), Pentland (1975) asserts "No one ever told him (an Inuit trapper) about isostatic rebound, but he knew what was going on, if not why" (p. 154). This knowledge, recognizing a pattern in nature, fits into a scientific description called diachronic knowledge (for definition see p. 22).

Other examples of accurate oral historical accounts can be found in Inuit traditional names for animals that are now extinct (e.g., mastodons), and in their accounts, three centuries later, of foreign explorers (Cruickshank, 1980). Similarly, Irving (1958) found that the Gwi'chin (Kutchin or Old Crow) language contains detailed names and classifications of plants and animals in their

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[13] As the ice from the last glaciation melted, the land, formerly depressed, began to rise. The term *isostatic* refers to this gradual rise in landforms. Western science has measured this at a rate of one-half metre per century (Bird, 1967, p. 145).

environment. Both Irving (1958) and Burch (1971) concluded that Athapaskans consider western science impoverished because it encompasses only a part of nature, often related only to economic usefulness.

Using these two examples, Cruickshank (1980) carefully connects these two knowledge bases using this assertion: "oral tradition (i.e., traditional knowledge) and science (i.e., western science) are each capable of contributing to an overall field of knowledge, [and] that knowledge has both linguistic and cultural components. The intellectual value of understanding other linguistic and cultural forms, [and] the kinds of distinctions which they make [,] may be important to the development of knowledge generally" (p. 76). Traditional knowledge thus informs western science by adding to its scientific knowledge base.[14]

Other, more explicit, examples can be found in Cajete (2000), who gives descriptions of native science under the general chapter headings of eco-philosophy; plants and the foundation of wholeness; the ecology of native healing; native gardening; American Indian animal husbandry; applied technologies of mining, hydraulics and transportation systems; and Navajo perspective on cosmology and astronomy. More specific examples of traditional knowledge are given in Theoretical Framework, chapter 3; however, from a western scientific perspective two salient points emerge here. First, a traditional

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[14] Because I am not grounded in traditional knowledge the converse question: How does/has western scientific knowledge inform(ed) traditional knowledge? will not be directly addressed here.

knowledge of making things work (technology) and explaining how they work did (and does) exist. Second, the use of this knowledge resulted in time-tested practices and the survival of a people.

Other examples of the combining of the knowledge of these two worldviews can be found in newspaper articles. One (*Edmonton Journal*, February 19, 2004) describes traditional knowledge being used by western scientists: Francis Ruben, an Inuvialuit Elder, has accompanied the Canadian Arcticnet research team to act as an advisor and wildlife observer. His presence attests to the importance of the inclusion of diachronic knowledge in scientific research. The article indicates, "The Inuit have inhabited this land for thousands of years. Through oral traditions passed on by Elders, they have developed detailed insight into the Arctic and to the plants and animals that inhabit the region"; the Inuit, the article continues, "have such an intuitive sense of the environment that certainly we don't have" (p. A15). In another article, in the *Saskatoon Star Phoenix* (June 26, 2004), a cardiovascular research group (CVRG), under the guidance of Rui Wang, is identified as interviewing Elders in Lac Laronge and English River, Saskatchewan, in order to isolate active components of 26 medicinal herbs at the molecular level. However, this approach alone might not provide a full description of why the herbs aid healing (Peat, 2002, pp. 109–152). More recently (2008), the University of Alberta, Edmonton, has proposed the establishment of an academic institute entitled: Canadian Center for Traditional Medical Knowledge of the Indigenous Peoples as well as begun establishing a Masters program in indigenous knowledge. My research reveals further examples of Alberta Cree traditional knowledge that has relevance to western science.

These examples of traditional knowledge do not occur as fragmentary isolated events; rather, they come from a wholistic worldview (as in a Khunian paradigm), elements of which emerge in the course of this study.

1.5 Contextualizing The Study[15]

Aboriginal youth have had only limited success within the current educational system (Canada Census, 2002). Various reports have outlined the importance of focusing on the success of Aboriginal youth within the extant provincial educational system (Alberta Learning Recommendations, 2003; Aikenhead & Jegede, 1999). Some reports suggested incorporating Aboriginal knowledge into today's educational curriculum, and doing so with the intent of fostering student attendance and increasing the high school completion rate (Social Sciences and Humanities Research Council (SSHRC)—draft summary paper 2003, Dialogue on Research and Aboriginal Peoples; Alberta Learning: First Nations, Métis and Inuit Educational Policy Framework, 2002; A Progress Report, May, 2003). Of course, there are many factors that prevent Aboriginal youth from learning science.

Some studies have focused on the importance of "border-crossings," which occur when students attempt to navigate between two worldviews

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[15] One of several Federal initiatives was a meeting held between the Prime Minister and Native leaders concerning Educational initiatives (March 12, 2004).

(Aikenhead, 1997, 2006). Increased awareness within educational systems of the difficulties that confront students who negotiate these border-crossings may result in the development of pragmatic pedagogic strategies (e.g., the initial use of the sharing circle and the interpretive use of the medicine wheel)[16], which, in turn, may affect success at school. Such changes can be accomplished if there is awareness of the underlying cognitive structures that exist for students and an examination is undertaken of the intersecting and parallel conceptual structures within which both knowledge systems operate: a "shared paradigm" for educational purposes. This study reveals some of these connections. The initial inclusion of traditional knowledge within mainstream science courses will occur if traditional knowledge itself is presented, and if a methodology for its use in classrooms use is put in place (e.g., through the participation of Elders).

1.6 Significance of the Study

Generally, this study is significant in two ways. First—by answering the question, "How are western science and Aboriginal ways of knowing related?"—it begins to identify and detail epistemological connections between western science and traditional knowledge. Second, this study can begin to inform educational institutions of the importance and relevance of the relationship

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[16] These will be further discussed with reference to the interview responses to question 2 (p. 3) in Chapter 5 and 6.

between these two knowledge systems of thinking and knowing (epistemologies), specifically in science. [17]

If traditional knowledge is to be included by Alberta Education in the existing science curriculum, then educators need to be aware, from the outset, of the relevance of this way of knowing. Many parallels between western science and traditional knowledge exist. The history of western science contains, for example, concepts put forward by Heisenberg in his uncertainty principle, and by Bohm's (1980, 1987) description of implicate order and explicate order. Heisenberg's proof demonstrates that if you know one element of information completely (the velocity of an electron), you cannot know a second element of information (the electron's location in space). The concept of uncertainty is enmeshed in traditional knowledge approaches to the mystery of natural events (Peat, 2002). Although not a universally accepted theory, Bohm's explanation of the structure of nature (see p. 57) shows correspondence with that found in many traditional knowledge systems (Peat, 2002). E. O. Wilson (1993), who employs the term *biophilia* and coined the term *biodiversity*[18] in 1986, emphasizes the importance of maintaining relationships among living organisms, an example of long-held traditional knowledge of the Alberta Cree. This scientific

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[17] There is a distinction between knowledge systems and knowledge forms. Here I use knowledge systems to mean sets of epistemologies. Knowledge forms include subset categories of knowledge such as causality, necessity, possibility and others used by Kant.

[18] Biodiversity or biological diversity is the diversity of and in living nature. Biodiversity is a neologism and a portmanteau word, from bio and diversity.

understanding, recently adopted by western science, is particularly relevant in light of the current worldwide environmental loss of diversity. Recognizing the importance of Aboriginal knowledge systems could thus have an impact on successful Aboriginal education and on supporting universal concepts of science for the benefit (and possibly survival) of all humanity (Erlich, 1986; E. O. Wilson, 1993).

A traditional ecological knowledge (TEK) approach (Snively & Corsiglia, 2000) is based on three premises: first, that destruction of the environment is occurring; second, that traditional knowledge is based on environmental harmony; and third, that we should try to understand the basis of the connection between traditional knowledge and nature in order to learn how to care for the environment (Vecsey & Venables, 1980). The exploration of the specific relationship between western science and traditional knowledge may fit into a larger dialogue that concerns the relationship between globalization, economics and environmental degradation (Smith, 2002). Globalization will only be indirectly addressed in relationship to historical antecedents and to my responses to them from the interviews. Although larger hegemonic issues of the political economy of power and privilege emerge from this study, a full examination of this larger dialogue is beyond the scope of this thesis. I will limit my focus to scientific knowledge: the research questions I have identified will further narrow this focus to include only selected aspects of scientific knowledge and the pedagogical implications which emerge from this research.

Although individual accounts exist contradicting the assertion of the potential lethal effects humans have on the planet (Simon, 1995), 1,600 scientists, including half of the world's living Nobel Prize Laureates, signed the World Scientists Warning to Humanity on November 18, 1992.[19] In it, the scientists plead for a redirection of scientific research funding towards examining the sustainability of human life on earth. Further, the Intergovernmental panel on climate change (IPCC) of the United Nations released a report (2007)[20], reviewed by 620 scientists, which states that human activity is responsible for climate change. Much of the scientific data in it has been popularized by Nobel Prize Laureate A. Gore (2006) who illustrates the potential lethal effects of global warming. Although there may have been more diverse species on the planet in the past, to repeat a previous point, the Nobel Laureate E. O. Wilson (1993, 1994) suggests that maintaining present biodiversity is one step towards maintaining an ecologically healthy planet. To demonstrate human's effect on the environment, Wilson estimates that if the entire world's human population were to use the same amount of natural resources that western cultures currently use, we would require at least four worlds to provide these resources.

In 1999 Suzuki suggested that, even though we know and can document some environmental events now occurring, western cultures are doing little to

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[19] Henry Kendall, chairman, Union of Concerned Scientists, press release, November 18, 1992.

[20] Fourth Assessment Report, IPCC, Climate change 2007, February 2, 2007.

prevent the escalation of such potentially lethal changes such as global warming. Cultural anthropologist Ronald Wright (2004) describes this as an example of a "runaway train" civilization. These issues are not considered as an important part of western scientific knowledge, except modestly under the category of sustainability. If maintaining the present western cultural model is not sustainable, then examining other cultural models, such as Cree, might be significant. Sustainable traditional knowledge methodologies might be examined in science classrooms. Western science, as it is currently taught in Alberta schools, includes little in the curriculum that directly addresses these methodologies (Alberta Learning, 2002), even though traditional knowledge approaches (not taught in schools) do include ecological awareness and maintaining sustainability as basic elements (Cajete, 2000). Some Aboriginal participants whose culture has survived thousands of years living with nature, are alarmed at the present rate of degradation of the earth's "resources", and the absence of recognition in school science of their way of knowing (quotes, Chapter 5).

Of direct relevance to my second question (i.e., pedagogic implications), traditional native cultural values do address the problem of humankind's survival in its relationship with nature. A western scientific perspective places native cultural values under a western scientific category called traditional ecological knowledge (TEK). Aikenhead (1997) asserts that aspects of this traditional ecological knowledge should be actively incorporated in the present science curriculum. Various authors have presented arguments from a pedagogic standpoint that suggest teaching 'native science' could be beneficial for native students who have difficulty in mainstream science classes by actively promoting widespread engagement (MacIvor, 1995; Kawagley, 1995; Snively, 1990; Snively and Corsiglia, 2001, Cobern & Loving, 2001).

To this end, institutions that aim to engage native students in society's educational systems (schools) have generated various written statements (Alberta Learning, 2002; 2003). Generally, these statements attempt to provide answers to the following questions: What needs to be incorporated into the curriculum that would help to engender success for Aboriginal students? What does "coming-to-know" mean pedagogically for educators of native youth? How can the present educational, institutional models adapt (i.e., change) to allow for the inclusion of traditional knowledge as a valid way of knowing the world? And, What is the role of Elders as teachers, and what would their inclusion mean for classroom teaching?

Equipped with a basic epistemological understanding and acceptance of traditional knowledge as a way of knowing the world, educators could begin to make pedagogical decisions that address the inclusion of this knowledge in curriculum. For Aboriginal students, it has been suggested that an attempt to engender an approach that supports an Aboriginal way of knowing the natural world would nourish the success of native youth enrolled in science courses (MacIvor, 1995). Facilitating the inclusion of this knowledge in the present science curriculum in educational institutions might be an important first step towards successfully educating Aboriginal youth (Aikenhead, 2006; Alberta Learning, 2003; Battiste, 2000; MacIvor, 1995; Smith, 2002, p.77). The examination by educators of the epistemological congruity existing between western science and traditional knowledge might allow science students to experience less conflict as they negotiate cultural border crossings (Aikenhead 2001; 2006). The result would have consequences for all science students, both native and non-native, who might be able to revisit the meaning of science as a relevant discipline that is located in, and is a part of, natural events and not relegate science simply to the memorization of objective facts.

This study is thus significant for two reasons. First, it examines intersections of western scientific knowledge and traditional knowledge and the claims each makes to describe and explain nature. In doing so, this study poses the ontological question—are both forms of knowledge about nature true and the epistemological question—are both forms of knowledge valid? If so, these answers demand the inclusion of all scientific knowledge [21]upon which humankind's survival may depend. Second, it suggests that the inclusion of traditional knowledge concepts in science classrooms provide one major step towards meaningfully educating native students and allowing non-native students to gain an understanding of an alternative worldview.

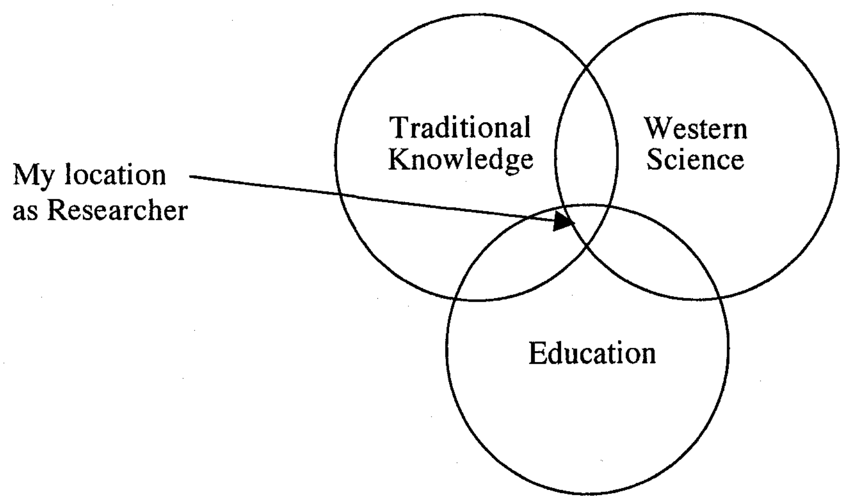
[21] This study focuses on the study of North American traditional knowledge mainly from Alberta and makes limited use of including 'earth based' knowledge systems from other parts of the world and cultures.

Chapter 2

2. Summary Review of the Literature

In order to avoid repetition, a detailed review of the literature will be found in the Theoretical Framework section, Chapter 3 where the theoretical framework for the study is enmeshed with concepts found in a literature review. Briefly, chapter two will review the overlapping of three areas (Figure 2.1). This study investigates elements of western science (including empirical and theoretical) as they relate to traditional knowledge. These areas of intersection will then be located in a Canadian native education context. Figure 2.1 has proven useful as an introductory point of discussion (adapted from Mike Beaver, personal communication, 2004).

Figure 2.1: Researcher Location



Examining the complexity behind this figure will form the content of this thesis. The interlap between western science and traditional knowledge represents the examination of theoretical epistemological congruencies. The educational intersect with these two knowledge systems represents a practical application of their congruence. Other examples of models illustrating these interrelationships exist (Battiste, 2007[22]; Cajete, 2000, pp. 64-65; Fleer, 1999, p. 122; Hiebert, 1976; Van Kessel, 2001, pp. 42, 47); however, the above model is useful because it illustrates my location as a researcher at the nexus of three interlapping circles.

Detailed accounts and comprehensive research into the relationship between traditional knowledge and western science are lacking in the literature. Scientists David Peat (2002) and David Suzuki (1997; Knutson & Suzuki, 1992) have, nevertheless, each given descriptions of this connection, and Rupert Ross (1996, 1992) has approached this intersection from a legal perspective. Although Suzuki has been criticized for taking an extreme ecological approach towards science education, his notions strike a popular chord among science teachers, as has been evident in numerous ATA Science Council guest speaker presentations (most recently in 2004). For Suzuki, all science is firmly rooted in the natural world; all scientific study occurs within man's connection to nature. Suzuki (in agreement with footnote 19) claims that humankind is currently doing irreparable damage to the life-sustaining elements of the world namely the air, water and land that are necessary to sustain life on earth. Although critics (e.g., Simon, 1995) claim that his views are inaccurate and that life is getting progressively better for mankind, Nobel Laureates Erlich (1986) and Wilson (1994) maintain that species need genetic diversity: within individuals, between individual species, and among

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[22] Nation conference, Canadian Council of Learning (CCL), Aboriginal Learning Knowledge Center: Modern knowledge, ancient wisdom, an integration of past and present, Edmonton, March 7-9, 2007.

species in order to adapt to changing environmental conditions. They extend this biological concept to include cultures: without different cultures, different ways of knowing the world, or different worldviews, humankind's ability to adapt diminishes. The suggestion here is that traditional knowledge, embedded within Aboriginal cultures, has much to offer that can inform modern (western) science. Scientific knowledge is firmly grounded in our relationship with nature. For example, Erlich and Wilson emphasize the interconnectedness of all living things, a concept embedded in traditional knowledge (Black Elk, 1959).

David Peat (2002), who couples his own research findings with the insights of physicist David Bohm (1980), outlines connections between western science and traditional knowledge. Using his experimental results, Bohm describes a dynamic universe that comprises energy (implicate order) that manifests itself as matter (explicate order). Unlike Cajete, Peat provides specific accounts from a western scientific perspective of traditional knowledge that outlines both empirical and theoretical detail from Inkan, Mayan, Navajo and Blackfoot cultures. Many of these knowledge systems, which predate the Judeo-Christian calendar date for the birth of Christ, incorporate the mysteries of the universe (the spiritual domain) with practical technological science (e.g., mathematics and astronomy). Peat further outlines the ontological connections between Bohm's western scientifically derived theory of reality and that found within specific traditional knowledge systems (see Chapter 3, Theoretical Framework). These connections will be more closely examined giving specific examples of early science. Finally, an examination of scientism's application to western science and contemporary scientific pedagogy, through the use of Midgley's (1992) four epistemological bases of western science (chapter three), will be examined.

Chapter 3

3. Theoretical Framework for the Study

In examining the intersection of western science and traditional knowledge (definitions 1.4, pp. 6-24), crucial aspects of western science will first be looked at historically. Selected examples of western science that demonstrate a correlation with traditional knowledge will be explored to establish a basis for scientific knowledge that derives from both worldviews. Scientism and other reasons for rejecting traditional knowledge as an informed source of natural events will be examined. Peat (2002) has examined ontological coincidence and epistemological divergence, many of which will be revisited here in order to frame approaches to the two thesis questions. Elements of culture, causality, objectivity and fragmentation will be discussed as they relate to the intersection of western science and traditional knowledge. This articulates my first step as an educator coming-to-know traditional knowledge. My evolving understanding of traditional knowledge will then be discussed in relationship with educational praxis.

3.1 Introduction—Historical context

Some early common conceptual threads run through both these two knowledge systems, showing a unified scientific epistemology based on an experiential understanding of the natural world. Two of these roots still found in today's scientific endeavour consist of technology: the use of tools to modify the environment for our use, and the development of complex but utilitarian abstract thinking. The sophistication and practical value of traditional native knowledge about the natural world has been emphasised by Suzuki (1997, p.12). Science emerged from humankind's relationship with natural events. Scientific truths were based on a lived reality. Echoing Kant's connection of categories of knowledge to experience, Abram (1996) asserts, "Every theoretical and scientific practice grows out of and remains supported by the forgotten ground of our directly felt and lived experience, and has value and meaning only in reference to this primordial and open realm" (p. 21). Eisner (2002) asserts that truth is lived experience with: "Truth is shaped to meet experience" (p. 97).

What common origins of early western science and traditional knowledge have now resulted in society's development of different perspectives about what constitutes scientific knowledge? Because scientific activity involves acquiring knowledge about the natural world, the development of these perspectives began early, as Bronowski (1973) describes:

> [K]nowledge in general and science in particular does not consist of abstract but man made ideas, all the way from its beginnings to its modern and idiosyncratic models. Therefore the underlying concepts that unlock nature must be shown to arise early and in the simplest cultures of man from his basic and specific facilities. (p.13)

One example of physical representation of abstraction can be found with the Inka. *Qupis*, strands of string with knots tied at various intervals, served as representations of a person's life. These abstract accounting systems, which substituted actual events with physical symbols, are among the first pieces of physical evidence that early man grappled with abstraction, by representing natural human events with a model that changed through time. Bronowski (p.95) adds that the use of modified building blocks to construct structures represents a major breakthrough in preliterate abstract scientific thinking (see opposite contention of Norris and Phillips, 2003).

Early humankind was scientific in the sense that individuals used an empirical method of recording (a reality test) and constructed abstract theoretical knowledge systems. Archaeological studies give evidence of this. Jeffry Goodman (1981) suggests that *Homo sapiens* arrived in North America from 50,000 to 250,000 years ago, using an archaeological survey of the Bering land bridge which found no evidence of human habitation. Earlier studies by Dzeniskevich (1976), by comparing Asiatic and Alaskan versions of the Raven myth, concluded that Athapaskans did migrate from northeast Asia. More recently, early cultures are thought to have arisen in North America some 15,000 to 35,000 years ago when early people crossed the Bering land bridge (Cavalli-Sforza & Cavalli-Sforza, 1995).[23] These early people carried with them their culture and language. Scientific concepts embedded in words can be found within these languages today (Cajete, 1999). The Arctic Inuit have, for example, over 40 different lexemes (base words)[24] for snow (Ritter, Coombs, Drysdale, Gardner &

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[23] There exists conflicting evidence of earlier habitation, however. The Santa Rosa California hearth is over 40,000 years old. In Brazil, the Peter Furada rock shelter, with stone tools, is also estimated to be over 40,000 years old (Peat, 2002, p.102).

[24] A lexeme can be thought of as an independent vocabulary item or dictionary entry. A lexeme can give rise to more than one distinctly inflected

Lunn, 1993 *Nelson Biology Text*, p. 78), and the Cree retain over 20 other, more subtle meanings for the lexeme *maskwamiy*, which is translated in English simply as *ice* (*Cree–English Dictionary*, p. 347).

These two examples illustrate that the meaning of words in oral tradition reflect a western scientific knowledge of natural events in that they give accurate detail of the natural world obtained through the senses. Words in turn form languages which in North America resulted in a complex development within a context of direct relationship with the natural world. "Languages developed in at least 55 different nations containing some 2000 societies" (Dickason, 1992, p.29). At present, there remain six major indigenous language groups in North America, including Athapaskan, Algonkian, Caddoan, Iroquian, Siouan, and Wakashan. Each cultural group, living within a natural environment, created their own distinct oral traditions. The understanding of the world experienced by each group, their worldview, was directly related to their life on the land—their connection with natural events. With exceptions in Aztec, Mayan and Inka cultures, traditions and understandings of the world were commonly passed on orally to subsequent generations. A concept of scientific knowledge emerged that connects the world to the individual self; "There is no word for science in native languages" (Cajete, 2000, p. 2). This fact does not, however, imply a lack of

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word. Inuit lexemes are so inflectionally complicated that each single noun lexeme may have 280 distinctly inflected forms (Jacobson, 1984).

science. Cruickshank in offering the following perspective gives direction for a western scientific approach to traditional knowledge:

> Oral tradition has particular goals, methods and questions, but they differ from those of European science and history. Beginning with different questions, oral tradition, science and history provide us with different but equally valuable ways of understanding relationships among environment, animals and humans. Because translation is such an imperfect process, it may be that cultural outsiders can best begin by trying to understand the questions raised by oral tradition rather than trying to extract easy answers or 'facts' from it (e.g., How do we know what we know? What kind of evidence do we use? What is evidence anyway?). (Cruickshank, 1992, workshop)

Because there exists little in the way of written records for this early time period, it is described as 'pre-history' (Quinn, 1992). What were early humans doing during this early, 'pre-historical' time? Rather than seen as only struggling for survival, many of these early groups are thought to have had a rich and artistic existence.[25] Sahlins (1972) characterizes this life as "the original affluent society" (p.23).

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[25] Early representations of humankind's reality can be found in images in the caves of Lascaux, France, and Uluru (Ayer's Rock), Australia (*National Geographic*, 1988); in North America, medicine wheels provide a similar kind of representation.

From pre-history to the present, indigenous people within their cultures have developed sophisticated concepts of the natural world. By the time of European contact in America, there existed the following general cultural groups in North and South America: the Inka of Peru, the decentralized Mexica empire; the city state of Chokia, the upper Mississippi area; confederacies that included the Powhatan, Five Nation and Huron; and chiefdoms including the Timacuans, Natchez, Creeks, Cherokees, Haida, Kwakiutl, in addition to various mobile hunters and gatherers (Dickason, 1992). In general, these cultures shared a common worldview: "Humans were part of the cosmological order depending on a balance of reciprocating forces to keep the universe functioning in harmony" (Dickason, 1992, p. 12). This contrasts with the Judeo-Christian worldview of "a cosmos dominated by a god in the image of man" (Dickason, 1992, p.13). Traditional knowledge developed within and reflected the former context, while western science eventually began the process of separating science from religion, particularly in the 17th century with Bacon, and expanded into the 18th century Age of Enlightenment.

A present link between science and religion of western cultures is exposed in a concept of hierarchy (from the Greek *hierarkhes* meaning sacred priest or ruler) that affects the definition of science. Beginning with Aristotelian organized levels of being (i.e., soil, plants, animals, and man) and continuing with the Judeo-Christian worldview of humans as the only conscious animal, western science conceived of humans as residing at the apex of all living organisms. As Aristotle argued, the rational capacity of humans removed them from the category of animals, a concept later challenged by Darwin (1859). To the Cree, in contrast, humans are not seen as higher than other life forms, many of which are seen to have superior qualities. This Cree view of the human place in nature characterizes all organisms as interrelated, interconnected within the circle of life (Lightning, 1992).

Western scientific thought has developed its own ontology—a theory of the nature of reality—and an epistemology—a system of thinking and knowing. In western science, the basis of this scientific knowledge rests on four basic axioms:

1. There exists an external real world
2. The senses are accurate informants
3. Memory is accurate and reliable
4. Logic provides a valid construct of the natural events or reality (Midgley, 1992; Battiste & Henderson, 2000, pp. 24-27).

3.2 Scientism

Western science provides one of the most powerful and effective ways of knowing the physical world. However, this method of interpreting the world has generated a belief system that regards the scientific understanding of natural events as objective, empirical, rational and thus, singularly truth confirming (Aikenhead, 2006). The descriptor "culturally unbiased" might also be added to this belief system, which is otherwise labelled as scientism (Nadeau & Desautals, 1984; Ogawa, 1998; Ziman, 1984; Johnson, 1992; Peat, 2002). Scientism, which asserts that science is the only valid way of knowing, is worthy of examination here because it excludes other forms of knowledge, notably traditional knowledge (MacIvor, 1995). "Science teachers often harbor a strong allegiance to scientism by viewing science as: authoritarian, non-humanistic, objective, purely rational and empirical, universal, impersonal, and unencumbered by the vulgarity of human imagination, dogma, judgements or cultural values" (Aikenhead, 2000a). Cobern (2000) more moderately maintains that teachers have a " scientistic view roughly embracing classical realism, philosophical materialism, strict objectivity, and the hypothetico-deductive method" (p. 233). When scientism shapes or predominantly informs the presentation of science in contemporary Alberta classrooms, then the accuracy of such portrayals warrants re-examination, particularly in reference to traditional/Aboriginal knowledge. The belief that western science provides the only scientific way of knowing the world prevents the inclusion of traditional knowledge in the science classroom.[26]

Habermas's (1975) assertion, that "scientism also sets standards by which it can itself be criticized and convicted of residual dogmatism"(p.84), leads one to question the foundation on which this dogmatic belief in science (scientism) rests. By dismissing other knowledge claims (e.g., Flanagan, 2000), western science exposes itself to the following types of questions: What beliefs support western scientific claims to true knowledge? Can we derive a scientific meaning for knowledge from perspectives other than western cultural viewpoints? Do tests for

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[26] Examples of inclusion attempts include Alberta Education revised Programs of Studies in the sciences 2007.

truth and validity apply equally to both western scientific and traditional knowledge base claims? These questions emerge from an examination of the initial research question (p. 2) and are further examined in Table 6.1.

The application of scientism has often resulted in the general dismissal of the epistemologies of traditional knowledge and the establishment of the epistemology of western science as central to today's science educators. At the time this thesis began Alberta Learning was addressing this issue in the Alberta Learning Curriculum Guides for Science 7, 8 and 9 (2003), which previous to this showed few science references to traditional knowledge. The criteria used by scientism to exclude traditional knowledge as a valid way of knowing the world may well fall short when those same criteria are applied to validate the western scientific view, a possibility supported above by Habermas (1975).

Feyerabend makes the claim that "science has no special features that render it intrinsically superior to other forms of knowledge" (Feyerabend in Chamlers, 1999, p. xxi). Chalmers, in support of Feyerabend's argument, links science to scientism, and scientism with dogma: "According to Feyerabend, the high regard for science is a dangerous dogma, playing a repressive role similar to that which he portrays Christianity as having played in the seventeenth century, having in mind such things as Galileo's struggles with the church" (Chalmers, 1999, p. 155). Although the quotation cited above does not differentiate between scientific theory and technology, Feyerabend does make a clear second claim, one echoed by MacIvor (1995) and Aikenhead & Jegede (1999), when he asserts that one of the results of scientism is the rejection of other forms of knowledge. This is articulated by Peat (2002): "When western science claims to be speaking the truth then, by implication, other people's truths become myths, legends, superstitions, and fairy stories. A dominant society denies the authenticity of other people's systems of knowledge" (p. 42). [27] In locating scientific approaches within western culture, Suzuki critically suggests that the inclusion of traditional knowledge would give "an alternative to the western culture's narcissistic self-preoccupation coupled to an ecologically destructive worldview" (Suzuki, 1997, p. xxv). This idea is presented less severely in *The Sacred Pipe, Black Elk Speaks* (1953): "the ecological crisis has forced us to look at our relationship with nature" (p. xiv).

Arguments that link a restricted concept of knowledge with culturally perceived definitions of scientific truth are also be found in works by Berman, Bordo, Spangler and Thompson, and Jardine (2000) (Jardine, 2000).

A definition of science when authenticated from one cultural perspective carries with it certain pedagogical implications. Jardine (2000) outlines one concern when he writes, "science curriculum embodies as well a particular Eurocentric history in which particular spiritual and epistemological forces are at work that have profound and convoluted ecological consequences" (p. 88). I take this to tangentially allude to a concept of controlling nature which is presently associated with, for example, global warming and threats of pandemic disease. When science is teleologically defined by a culture, the relationship between that

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[27] The role of colonialism in this traditional knowledge/western science discussion will not be directly addressed. See Willinsky, J. (1998). *Learning to divide the world.* Minneaoplis: University of Minnesota Press.

culture and science often remains obscure. Aikenhead (2000a) calls this the 'subculture of science' and likens teaching this uncritically to students as colonizing them.

3.3 Cultural Influence

Outside of the Americas, the connection between political culture and science has been explored by A. Nandy (1988). Nine East Indian scholars, in this collection of essays, take a socio-political view of science as a new political justificatory principle and as a technological intervention in politics (p. 4). Seen from these perspectives, science is used in India not only for political purposes to maintain hegemony, but it is a culturally biased endeavour used to provide technological development that ensures or increases the power of the state and decreases the power of nations outside India. Not only is technological development used for these purposes, but, these authors assert, practicing scientists operate under a "scientific vision which legitimizes 'rational' patterns of behaviour and lifestyles being imposed on citizens in areas such as social organization, agriculture, medicine and environment" (p. 4). They further contend that, "What is good in the Indic civilization …is exactly what is good for modern science [,] and what is defective in the civilization is exactly that which impedes modern science" (p. 8).[28] In India, these authors call for the inclusion of

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[28] This practice is reflected in Canada, where many teachers claim to present culturally unbiased science in their classrooms. Scientific research is funded according to its value-use to society, from a cultural reference point. The

traditional science, and call for the following step to be taken: "Instead of using an edited version of modern science for Indian purposes, India can use an edited version of its traditional sciences for contemporary purposes" (p. 11). It is interesting to note, in conjunction with the Indian authors' arguments, Peat's (2002) parallel contention that "modern science [is] the dominant cultural principle resisting the emergence of new cultures of knowledge" (p. 11).

Using the term *ecopedagogical*[29], Jardine (2000) describes how, in science education, ecology is relegated to a conceptual bottom rung. He claims science subsumes an ecological perspective because of its cultural Eurocentric bias. For him, ecopedagogy would return the interpretation of the interconnectedness of humans and the environment to an interrelationship, and not a separation, of scientific concepts. From his cultural pedagogical stance, Jardine boldly asserts: "Becoming thoroughly versed in the methods and corpus of scientific knowledge, if this is pursued out of [sic] relation to a broader, more integrated sense of the rich array of human life, is, in fact, a form of institutionalized illiteracy" (pp. 102–103).

3.4 Causality

Western scientific questions are formulated by means of an analytical process, of which causality forms a major conceptual component. For example,

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dismissal of traditional knowledge as non-scientific implies a dominant cultural reference point.

[29] Jardine does not use this term to differentiate between two interpretations of ecological perspectives: a scientific ecology perspective or a wholistic approach.

Aikenhead (2000b) describes different ways of seeing the northern lights: the Cree ask, "Who did this?" and "Why?" while western scientists ask "How does it work?" Western science, however, does not always follow a direct linear cause-effect relationship, as Miller (1999) indicates: "The end of subscribing to Newtonian physics marked the end of our belief in (absolutely) predictable causality as the basis of descriptions of physical structures" (p. 121). A newly evolved western scientific view of causality correlates here with that of the Waswanipi Cree. Rather than view natural events as directly causal, Suzuki describes them as extensions of the Cree's own close personal relationships (1997, p. 57). Feit (1973) finds another commonality between these worldviews: "[while] the causality that animates the Waswanipi ethnic-ecosystem model . . . is very different from a [western] scientific account, the structural relationships are for the most part [similar to] those of a scientific account of the relationship of hunter-animal population" (p. 115–25). Thus, although the causes are seen differently, actual descriptions of relationships are similar from both worldviews. Feit calls this convergence "shared ecological principles" (p. 115). Snively and Corsiglia (2000) have identified other examples of commonality under the category of traditional ecological knowledge (TEK).

Additionally, the limitations of simple cause-effect relationships (the presence of element A directly causes event B) can be found in Pert (1997), who points to the causes of human sickness, which are indeterminate and unpredictable (labelled *idiopathic* or *primary*), and in physics, where Pauli suggests synchronous patterns (such as circularity) in the universe emerge from "an acausal connecting principle" (cited in Peat, p. 259). Indeed, human life itself is regarded as an enigma when viewed and described simply in physical or chemical terms. Synergistic effects, emotions and health are among the most common examples that contradict simple cause-effect relationships (Pert, 1997). This is not to deny the existence of causal effects demonstrated by western science, but this raises questions about the paradigm western science is operating under and suggests the investigation of other paradigms.

3.5 Objectivity

As previously referenced by Bohm (1980, 1987) and Peat (2002) in science, ontology—the theory of the nature of reality—has correspondence in both western scientific and traditional knowledge systems. Differences emerge when examining methodologies. The dominant western scientific method is often held to be objective (Alberta Learning, 2003).

One tenet of western science is that it is objective; however, objectivity of western science can be questioned from a philosophical perspective. This is not to say that science is not objective, but western science can be looked at from a different perspective than that of a narrow rational empirical stance. Philosophically, there are other descriptors of the truth of statements than can be found in rational empirical western science (Chalmers, 1999). Traditional knowledge uses a methodology which includes subjectivity to arrive at a shared human understanding of nature, and because of that it has been rejected from the western scientifically defined domain of truthful knowledge. Partly because of this, specific philosophical views of western scientific knowledge have come to be discussed in terms of objectivity. If objectivity is not necessarily a criterion used to arrive at conclusions for western scientific knowledge, then this criterion cannot easily be used to summarily dismiss traditional knowledge as non-scientific. Instead, a more inclusive approach to science allows for a common knowledge base of the understanding of natural events.

Plato's metaphor, articulated over 2000 years ago, is today still able to capture a philosophical rational view of the nature of reality. He symbolized humans as chained in one location, looking at the wall of a cave and interpreting, through reason and the senses, the shadows they see.[30] That we cannot know things in and of themselves, that we can only know our interpretations of them, has more recently been taken up by the phenomenologist Husserl (1954). The reasoning of Baconian epistemology, during the Enlightenment, looked upon scientific knowledge as objective and as knowledge acquired without subjective intervention. Jardine (2000), however, questions the use of mathematical validity as final determinant of the truth of factual evidence: "Under the Enlightenment legacy, only to the extent that the earth can be mathematicized can the claims we make about it be said to be true" (p. 89). Furthermore, the use of an Enlightenment determination of truth contrasts sharply with Husserl who states, in his theory of intentionality, that he never thinks in general, or purely, about the world in an objective sense, but only in specific relation to specific things in the

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[30] One of the chained prisoners escapes, and going to the mouth of the cave sees the light and is thus enlightened.

world. Three principles identified by Husserl—the world is in me I am always in the world; I am the world that I am trying to describe; and, I think against a background of myself—underscore the concept that he gives meaning to the world through his own personally constructed worldview. Husserl thus promotes the notion that he is not separate from the world that he observes; he is a part of the world. In contrast to this phenomenological stance, western scientific thought objectively places the scientist doing the experiment outside of the experiment. Western scientific methodology demands a separation that distinguishes between the knower and the known.

Objectivity in science is addressed in Kant's *Critique of Practical Reason* (1781) wherein he takes the philosophical Platonic stance that what you see is a reflection of the world, not the world itself. According to Kant, we structure what we see according to our mental constructs, called categorical imperatives. Our belief systems, ways of seeing, are the "lenses" through which we structure our experiences and our understandings of the world. According to Husserl, only Kant is concerned with overcoming the fault of objectivism, wherein the world becomes the objective world (rather than a representation of the world), and thus truth becomes objective truth. Science, when donning this cloak of objectivity, lays claims to determining objective truth. Kant disagrees with this and claims that scientific knowledge is based on "naive realism": we believe that what we are really talking about is really out there. In a Kantian sense, we cannot know the world; we can only know what we believe we have taken to be true through our senses and filtered through our experiences. Husserl reasons that phenomenology will overcome this problem in determining the meaning of the truth in science by acknowledging the influence of human subjectivity and by expanding scientific constructs of explanation and description which are based on this single unified worldview (Kant, 1781).

Western science operates from a worldview, a *paradigm* (Kuhn, 1970). One of Kuhn's many definitions of "paradigm" identifies it as a commonly agreed upon worldview, arrived at through consensus by a number of individual scientists, each with their own perspective. Although paradigms are useful, and perhaps necessary for scientific research, paradigms nevertheless change when they reflect a new way in understanding nature (a scientific revolution). A paradigm change necessarily makes problematic the notion of a stable static objectively defined reality. If the reality being observed remains constant, then simply changing an observer's perspective can effectively change the paradigm under which the observer is operating. Why, one might ask, would some scientists hold to the 'old' paradigm while others embrace a 'new' paradigm when faced with the same factual evidence? In traditional knowledge, the observer is not regarded as separate from that which is observed; traditional knowledge focuses, instead, on such elements as consistency, integration, harmony and balance (Peat, 2002, p. 255). These elements are used to form an ontological construct of the nature of a fluctuating reality that is more in accord with a quantum mechanical model.

Further discussions of the ability of an observer to be either independent or objective with respect to "reality" have come from three different camps: the philosophy of science (Bronowski, 1973; Feyerabend, 1964; Scheffler, 1967), from scientists (Pert, 1997; Suzuki, 1997) and from science educators (MacIvor, 1995; Hampton, 1995).

As a scientist, the biochemist Pert (1997) outlines a description of human objectivity. As she describes it, humans process information coming into the brain through neural pathways, some of which transfer electrical impulses using sodium and potassium electronegativity differentials. Information is stored by means of neuropeptide ligands, which bind to the receptor sites of specific neural cells. Pert asks the question, "What selects the incoming information?" and identifies emotions as her answer. Emotions here, have a physical definition: when cells secrete a peptide, which attach to receptor sites on other cells, they cause a physiologic change that, in turn, affects other cells. One relevant example Pert gives is that of native North Americans' first viewing of tall masted European ships. Although the image of these ships was undoubtedly impressed on the back of their retinas, they did not describe seeing anything. She concludes that biochemically we select our own reality, which calls into question our ability to determine objective reality.

One implication from this scientific subjectivity is that what is acquired from scientific activity is not something real but something ideal, a representation. For Bronowski (1973), when we use the scientific method to generate models, "we slip back into making some model whose pieces are not observations, but idealized things" (p. 103). This representational element allows for prediction: "it will work well enough as an approximate model of large events, such as eclipses and hydro-electric dams and the action of penicillin in arresting the multiplication of bacteria . . . we must use science as it is, and that is an assembly of observations so ordered that they tell us what we may expect to observe in the future" (Bronowski, 1973, p. 103). Here, from an instrumentalist view, observations work in terms of predictability, but they do not necessarily capture reality. This fits with models taken from Pert (1997), Bohm (1980) and Peat (2002) who indicate a similar orientation. For these individuals, the map—western scientific description/explanation—is not necessarily the territory—reality.

Feyerabend (1964) argues for the tolerance of competing theories, particularly when each is based upon similar empirical evidence. Peat (2000) extends this plea for tolerance to include traditional knowledge, partly because this knowledge has supported the survival of native people for thousands of years. He demonstrates a similarity between Bohm's ontology and that of traditional knowledge systems; Peat also contrasts a western scientific focus on "certainty, predictability and fixed laws with an Indigenous science describing flux, change and transformation" (p. 44).

Traditional knowledge uses metaphoric models in its epistemology (Lightning, 1992). These models of the universe have often been transferred orally in 'stories' (Cruickshank, 1991). Such oral accounts can represent society's relationship with nature, and emphasize elements of respect, reciprocity and relationship. This study attempts to identify elements of these relationships in connection with western scientific approaches.

From an educational perspective, Davis and Sumara (1997) posit an enactivist model at work in classrooms, including science classes. According to their concept, the milieu of the classroom is determined by a complex array of factors, all of which influence the teaching–learning event. Davis and Sumara hold that "knowledge tends to be discussed as if it were an object" (p.109) and that teachers assign a place value to each bit of knowledge in the curriculum. Their enactivist concept, derived from Capra (2003), suggests an indistinct separation between the knower and the known; this is a notion rooted in Husserl's philosophy and one that is also echoed in Heidegger's (1968) suggestion that we cannot separate the knower from the known. An ecological view of cognita, in which the knower and the known co-emerge, has also been described by Maturana and Varela (1989), Samara and Kaplan (2000), and Capra (2003). By initially taking the knower and the known as separate entities, cognitive theorists such as Varela (1991) and von Glasersfeld (1995) develop representationism to describe the level of correspondence between the subjective (inner) world and an objective (external) world (Davis and Sumara, p.107). By distinctly separating the subjective from the objective, most cognitive theorists describe learning as making meaning (for example using schemata or models) out of what is perceived externally. This view holds that the knower in schools (i.e., a person or student) is, by definition, separated from the known (i.e., the topic or subject). Davis and Sumara's pedagogical enactivist model in which all elements are connected attempts to break through this separation; it lends support to the Aboriginal wholistic concepts of relationality and interconnection (Hampton, 1999).

When Aboriginal concepts of relationality and interconnection are applied beyond classroom interactions to knowledge itself, from an Aboriginal philosophical perspective, the knower and the known become interconnected. Suzuki (1997) suggests the conceptual framework for this interconnectedness grounded in a scientific worldview when he articulates this paradoxical physical description: "We are the air" (p. 32): the scientist studying nature is, her/himself, an inseparable part of nature.

3.6 Fragmentation

The Descartian (1596–1650) splitting of thinking from being, separating humans from the world in which they live, has promoted the reductionist view of "[r]ationality as a form of dominion over things," and "thus the methodological isolation of a separate 'I' becomes coupled with the belief that to understand is to dis-integrate, to divide, to separate, to disconnect" (Jardine, 2000, pp. 88–90).

Habermas (1975) describes the above Cartesian methodology as the monological character of scientific discourse. This disembodied sense of self—"thingified," in Aokian (1991) terms; or "encapsulated man," in Royce's (1964)—becomes entrenched in a conceptualization of science and curriculum defined as separate bits of information, discrete pieces of knowledge, presented as facts, independent of their connection to the knower. Norris & Phillips (2003) assert that scientific knowledge has often been presented "as facts, laws and theories in isolation from their interconnection" (p. 233), and points to the National Science Board assessments as evidence of their claim. Although texts contain implicit interconnections between scientific concepts, Norris et.al. do not support the notion that texts alone convey scientific knowledge. Norris proposed that narratives, in the form of explanatory stories, are an important aspect of scientific literacy (2002, IONCMASTE discussion group paper, October 9); he is conducting a study of texts to analyse their elements into argumentative, expository and narrative genres (p.15). His assertion here is that narratives themselves constitute scientific knowledge because they contextualize meaning.

Narratives have long been used to convey knowledge in Aboriginal communities. The Cree describe oral history narratives in terms of: *Atayohkewin or atayokewina* (i.e., legends), *Acimôwin or ocimowena* (i.e., stories) (Lightning, p. 3), *Tipacimôwina* (i.e., personal or historical) and *Mamahtawacimowin* (i.e., creation stories or origin of spiritual ceremonies). Some of these narratives may contain a metaphoric understanding of natural events based on intuition, emotion and relationship to the listener.

Although Norris and Phillips (2003) initially argue against the possibility of having a scientific theory without a text (p. 231), Bronowski (1973) suggests a more inclusive concept of science that includes preliterate, detailed scientific constructs of the natural world with attending technological knowledge. The Pueblo civilization in the Canyon de Chelly reflects the monumental development of construction using the "splitting or analytical action of the hand" (p. 94). To Bronowski this represents a beginning of theoretical science, where humans begin exploring the underlying structure of nature. Additionally, Peat (2002) combines examples of scientific technology with metaphysics in traditional knowledge, and compares this pairing with cultural values embodied in western science.

According to Peat, traditional knowledge includes more than the technologies of the Clovis spear point, birch bark canoes, tepees and longhouses; the development of corn and tobacco, farming methods, and observational astronomy; and record keeping and preparation of medicines. It has a metaphysics and philosophy that, today, contrast with "a [western scientific] worldview whose values are dominated by the need for progress, development, improvement, evolution, and the linear unfolding of time" (p. xiii).

While western science fragments nature in order to understand it, oral tradition reveals a more wholistic approach towards nature. Aboriginal cultures, using oral tradition, display a wide definition of wholistic knowledge (Battiste & Henderson, 2000). Aboriginal narratives contain knowledge that lies beyond a western scientific interpretation in terms of both the storyline and the listener's interpretation (Suzuki & Knudtson, 1992). Jardine (2000), for example, compares western scientific objective truth with truth found in traditional narratives:

> Any talk of the earth which carries with it ambiguity, narrativity, metaphor, multiciplicity, contradiction, or the like cannot be considered true because the truth of things is assumed at the onset to be itself clear and distinct. Tales of how fish came to the river—tales that implicitly and necessarily contain a deep mystery and multivocality, tales that are told differently to each child, to each generation because their living sense depends on a nest of intimate, power-laden relations, tales that bespeak an obligation, a fleshy attachment of fleshy consequence—all this under the

> Enlightment legacy is banished from the realm of that which could be considered 'true.'(p. 91)

In Indigenous science, meaning is context-dependent rather than objective, absolute and free of context. In western science, natural systems are abstracted and broken down to determine logical relationships between simpler parts. Quantum theory, however, may demonstrate a link between these two apparently disparate approaches by incorporating context into its explanation.

3.7 Heisenberg's Uncertainty Principle

For Heisenberg, the operating paradigms of Einstein's and Planck's quantum mechanics proved inadequate to explain his probability results. Heisenberg's uncertainty principle is the resultant mathematical proof that we cannot precisely measure—simultaneously—the speed of an electron and its location in space. This knowledge is inaccessible to science: not because our instruments are inadequate, but because western science cannot observe reality in any other way. The quantum measurement problem is that when we observe nature, we affect it.[31] Bohr interpreted Heisenberg's uncertainty principle to mean "quantum reality is basically ambiguous" (cited in Peat, p. 46). Bohr described a system of complementarity in which a single, static, consistent description of

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[31] "I remember discussions . . . which went many hours till very late at night and ended almost in despair, and at the end of the discussion I went alone for a walk in the neighbouring park, I repeated to myself again and again the question 'can nature possibly be absurd as it seems to us in these atomic experiments?'" (Heisenberg cited in Herbert, 1993, p.55).

events is insufficient to describe the dynamic event happening; he suggested with complementarity that mutually contradictory events are occurring at the quantum level. Electrons are thus both localized and particle like, and delocalized and wave-like (Bohm, 1980). Similar concepts regarding the ambiguity of nature itself have also been described by Capra (2003), Miller (1999) and Greene (2004).

Although the concept of predictability is a basic characteristic of the practice of western science, "events taking place in nature all the time are unpredictable, even in principle, since quantum phenomena are important in energy absorption, chemical bonding, and radioactive disintegration" (Miller, 1999, p. 203). Using a biological example, Gould (1989) applies Heisenberg's uncertainty principle to the evolution of fossils found in the Burgess Shale of Alberta. He states that we cannot determine why some now-extinct phyla did not survive, but others did. He notes, "The natural history of evolution is unrepeatable because the nature of matter made it unpredictable in the first place" (cited in Miller, 1999, p. 212). Although Popper (1968) contends the scientific validity of any theory holds only if its predictions are capable of being falsified through experiment, the examples noted here indicate this criterion for the falsification of predictability does not directly apply to (western scientific) theories of quantum phenomena or evolution. Some elements of nature are essentially indeterminable to western science.

One western scientist, Bohm, initially uses generalist terms in his description of the nature of reality (ontology). Although he has been criticized for his theories (Gardner, 2000, p. 77) they have direct application here. He describes the implicate order as manifesting itself or unfolding into an explicate order, and does not use predictability as a criterion for understanding this unfolding. Similarly, in traditional knowledge, because time is not seen to unfold in a linear fashion, events are cyclic and understood in terms of relationships and harmonies. In one case, Mayans used wheels of time that emphasized the exact dates of eclipses and planetary motions. Time was viewed in relation to these natural events. These concepts of harmony and relationships, rather than the mechanical influences of forces on bodies, extend into western scientific quantum physics to include descriptions of basic particles such as charm-quarks and strange-quarks (Greene, 2004, p. 347).[32]

In the Newtonian mechanistic view, time is linear, independent of physical laws and people. But in Einstein's relativity, time, as interpreted by observers in space, is different for different observers. In traditional knowledge the concept of time also highlights the ambiguous description of the nature of reality. Peat (2002, p. 253) compares the Hopi concept of time with that of Bohm's concept of manifesting the explicate order. Bohm describes physical reality as manifested from a flux in the implicate order in a manner similar to that in which the Hopi describe physical events as emerging out of a set of relationships (Peat, p. 203). In both worldviews, time is not a linear event and therefore cannot be conceptualized using a Newtonian paradigm.

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[32] Nima Arkani—Hamed, particle physicist, suggests the existence of more than 3 dimensions resulting in multiple, infinite universes of partner particles.

Peat describes time as an element outside the intersection of these two worldviews. In traditional knowledge, the phrase "When the time is right" takes into account many factors, such as harmony and the existing relationships between events (Peat, 2002, pp. 200–202, 252) that happen to converge at a certain time. For Peat, the concepts of linear time in western science and cyclic time in traditional knowledge are diametrically opposed; each view requires a different paradigm, but each can represent an aspect of nature. Initially, from a western scientific perspective, the question emerges: Is this is a description of nature, as a given reality, being described from two different perspectives, or is such a question, in itself, the reflection of a limiting western scientific view? Insights into answering these questions have been offered by Miller (1999).

In an effort to answer these questions, the nonlinear concept of time is extended by Miller (1999) to combine the limitations of knowledge as garnered from a western scientific perspective with the "scientific recognition that matter in the universe behaves in such a way that we can never achieve complete knowledge of any fragment of it" (p. 213). Miller contrasts this statement with a Newtonian reductionist-empirical view that we will eventually 'know' the basic structure of matter. However, western scientific theory has now encompassed traditional knowledge concepts such as nonlinear time, acausal synchronicity and physical manifestation of energy as described by Black Elk (1959)[33].

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[33] This is not to imply a value that traditional knowledge is necessarily more valid simply because western science acknowledges some of its' concepts. It

3.8 Models

Many models have been advanced that purport to compare traditional knowledge and western science (Hiebert, 1976; Ferguson & Dunnigan, 1998; M. Fleer, 1999; L. Peters, 1999; van Kessel, 2001; Peat, 2002). However, the codification of these two worldviews in a linear, either–or perspective with a line separating them may be too simplistic to be very informative and may not generate substantive understanding of existant interconnections. Presenting these types of charts as models of knowledge systems (Table 1.1) is only a first step in coming-to-know the epistemology of traditional knowledge and may, in fact, hinder an understanding of traditional knowledge (Weber-Pillwax, 1999). Additionally, "one faces a great danger of believing that the only way of understanding indigenous science would be to explain it in terms of the truths of western science" (Peat, p. 39). Peat continues with, "thus other cultures and ways of knowing are given their authenticity and validity, not from within the roots of their own tradition, but by using the yardstick of the economically dominant West" (p. 39). Kuhn also adds to the prevalence of the western scientific bias in describing the educational process in which scientists, through apprenticeship, learn how to think and approach knowledge within an existing paradigm. Both paradigm examples from Kuhn—quantum theory and relativity—provide for a

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does, however, indicate a conceptual connection between western science and traditional knowledge; aiding my process of coming-to-know traditional knowledge. Other concepts are in direct divergence with an indigenous approach to knowledge (see p. 235).

structure of concepts, a model, within which scientists operate (Kuhn, 1970). This approach, itself, calls into question the nature of objective truth and challenges whether assuming a solely objective western scientific approach imposes any conceptual limitations on the formulation of an understanding of natural events.

Israel Scheffler (1967), in discussing science and subjectivity, identifies coherence as a central theme in the belief structure of science: "Faced with a conflict between my observation reports and my theory, I may freely alter or discard the former or the latter or both, so long as I replace my initial set of inconsistent beliefs with one that is coherent" (p. 92); as a consequence, "the dogmatism of certainty has given way to the dogmatism of coherence"(p. 99). Thus, if scientific statements are coherent—that is, meaning is consistently and logically held together—then such statements can be regarded as true. This poses a problem when two conflicting epistemologies both demonstrate internal coherency, as is the case with traditional knowledge and western science.

Kuhn and Popper have each presented general models in which scientists operate. Kuhn describes the activity of science as one in which the researcher asks questions for which she may find solutions while she operates within a distinct paradigm. A change in that paradigm results in different set of questions being asked. Such a fundamental change in the way scientists look at nature (a paradigm shift) is a prerequisite that will enable new problems and discoveries to emerge. The emergence of new discoveries here depends on the paradigm within which the scientist operates. Popper uses a different model and contends that the established laws of nature are immutable unless they are falsified using experimentation. For Popper—once scientific knowledge has passed the test of falsifiability—the laws of nature hold true and are observer-independent. Thus, for Popper, the facts are independent of the knower: they have a separate existence from the knower. For Kuhn, facts only exist within the context of the knower; when we change the context (paradigm), the truth of the facts change. For Kuhn, there is no ultimate truth; for Popper, however, the rigorous test of falsification brings scientific models closer and closer to truth.

Bohm provides an ontological description of reality based on his own experimental results. For Bohm, the reality we see and observe directly with our senses forms what he calls an "explicate order." This directly observed explicate order is the result of being manifested by an "implicate order." For Bohm, the methodologies of the scientist will always result in a model of reality that is in a state of flux: "such quantum wholeness of activity is closer to the organized unity of the functioning of the parts of a living being than it is to the kind of unity that is obtained by putting together the parts of a machine" (p. 38). Pert (1997) supports this model from a biochemical stance, and includes a biological concept of synergy from which an unpredictable whole emerges that is greater than the sum of its parts. Although predictable experimental evidence forms a major component of high school science (Alberta Learning, 2003), nature itself contains unpredictable elements.

As Roberts (1995) identifies with the term companion meanings, many science texts still approach scientific knowledge from the realist perspective; that is, they progress from the observation of (true) facts to initially fallible theories that eventually result in a single, unique true description of reality. However, scientists themselves report, as Smith (2002) cites, "[what] honest scientists today . . . say about their work; namely that it is 'riddled' with ambiguity and uncertainty and is always largely interpretive (hermeneutic) rather than factual" (p. 181). When static Newtonian models of reality are being presented as factual scientific information and as companion meanings in school texts, they give little room for the inclusion of other knowledge bases, in particular traditional knowledge.

3.9 Educational Relevance

In this attempt to visualize an educational space where western science and traditional knowledge overlap and intersect (Figure 2.1), two main points will be pursued. First, the need for a new educational paradigm will be explored, and second, some educational models that have been advanced will be presented.

Western science, itself, provides evidence of difficulties inherent in the preservation of a curricular concept of science as objective, causal, culturally unbiased and value free. Some of the views noted above (see Chapter 3, Theoretical Framework) have focused on the importance of the connection between the learner's experience and the subject material.

The following observations reflect a view of science education from outside of the present, commonly held perspective: "In most science classrooms around the globe, western modern science has been taught at the expense of indigenous knowledge" (Snively & Corsiglia, 2001, p. 6). Cruickshank's claims, that "western education systems are heavily weighted against indigenous systems of knowledge," and that "knowledge becomes reinterpreted to fit the dominant scientific framework" (p. 77), highlight a need to re-evaluate the predominant approach to science education. Battiste and Henderson (2003) point to a more general educational necessity to include traditional knowledge:

> Indigenous knowledge and heritage and elders, though accessible to public schooling, have not been included in the curriculum of the public school at any significant level. Texts and public schools provide only Eurocentric knowledge bases, thus denying Indigenous children their cultural inheritance and perpetuating the Eurocentric belief that different cultures have nothing to offer but exotic food and dances or a shallow first chapter in the history books. (p. 84)

If the current approach towards teaching science is conceptually limiting, then alternative approaches warrant investigation.

In 2002 Alberta Learning had a mandate to "[e]nsure that First Nations and Métis are directly involved in the development of curriculum and learning resources for and about Aboriginal people in all subject areas" (p. 4). In spite of this 2002 initiative, Battiste and Henderson (2003) reiterate "although it is clearly in the interest of the educational system to encourage the full academic and human achievements of Indigenous students, at present the federal and provincial governments of Canada have not responded with a remedy to this educational problem" (p. 83). Their remedial suggestions include an increased awareness of and thoughtful assessment with respect to understanding the meaning of Indigenous knowledge, supporting Indigenous languages and presenting, in the curriculum, knowledge from viewpoints other than the prevalent (Eurocentric) perspective. When applying this last point to scientific knowledge, Alberta Education addressed this issue, as it is articulated in Goal 2, Strategy 2.3 (2007): "Increase awareness, knowledge and understanding of First Nations, Métis and Inuit history, lands, rights, languages, cultures, and contemporary perspectives on governance, education, *science*, wellness and other issues" (italics mine). The reasons why this undertaking is occurring are not clearly addressed.

3.10 Theoretical Constructs

Various theoretical constructs of education focus on the relationship between the learner and the learned material. Conceptually, student cognition is often separated from the actual course content. For Davis and Sumara (1997), this approach isolates the learner from the subject material. They contend this approach, while broadly used quantitatively, as in applying the scientific method, is limiting and does not encompass a full description of student learning. Radical constructivism has been described as more inclusive in its attempts to make connections between the learned material and the learner (Nunez et al., 1999). In this view, individuals actively construct their knowledge based on pre-existing cognitive structures (Confrey, 1987; Steffe & Kieren, 1994; Steffe & Weigel, 1992; von Glasserfeld, 1995; von Glasserfeld & Steffe, 1991). If the teacher can ground the subject in previously learned material (such as traditional knowledge), then learners can build additional concepts and constructs (scaffolding) directly on to their pre-existing knowledge base. When their knowledge base conflicts with the subject material to be learned, then difficulties are encountered, such as are described when navigating a cultural border crossing (Aikenhead, 1997). These blocks can prevent students from learning science in school. The converse may also be true for non-Aboriginal students learning Aboriginal ways of knowing, as well as new scientific terminology.

The view of dichotomizing the learner from the subject to be learned holds that knowledge is separate from the individual (see Chapter 3, Theoretical Framework). In contrast to this approach MacIvor (1995), in discussing the inclusion of traditional knowledge in school curriculum contends that the relationship between the student, teacher and subject is all part of the whole learning complex. According to her, if knowledge is viewed as wholistic and facts as interrelated, then new methodologies for presenting knowledge to students (pedagogy) are required (pp. 73-100). When acquiring traditional knowledge Ross (1996) suggests an examination of the key role played by relationship and reciprocity.

Ross's (1996) description of the differences between Aboriginal and western justice systems parallels that of the two more general knowledge systems of traditional knowledge and western science. He states that in an adversarial system, justice is achieved by argumentation, adherence to the facts, and assumptions about linear time, causality, objective reality and the power of language to describe the world, including the categorical use of Aristotelian logic. Western science uses the term *law* in this judicial sense when it refers to laws of nature. Ross's description of an evolving reintroduction of sentencing circles, arising from an Aboriginal knowledge base and moving into the judicial system, has positive implications for education and curriculum development. If traditional knowledge can be used in the judicial system, then perhaps its use in science education warrants examination. It might be beneficial, particularly for Aboriginal students in the classroom, for educational systems to expand the western scientific view of knowledge in order to provide a more balanced approach to the role of science in their lives.

Inclusion of elements of traditional knowledge in the present science curriculum has also been suggested by Cajete (2000), Aikenhead (1997), and MacIvor (1995). Specific strategies have been advanced, such as a hands-on approach[34] (Kawagley, 1995; Boult, Pokiak & Weihs, 1991, p. 36; Lawrenz, 1988, p. 681; Green & Brown, 1976, p. 6; Science Council of Canada, 1991, p. 35), the use of stories (Caduto and Bruchack, 1989), and the use of activities that foster social cohesion and cooperation (Hodson, 1992, pp. 19–20).

This application of educational research must eventually be influenced by how students think and learn in real classroom settings. This particular component has been of keen interest to educational researchers. Demographics and learner characteristics have been outlined by Pepper and Henry (1986), who identify eight learning preferences of native students:

1. They are skilled in nonverbal communication.
2. They are less skilled and have low frequency in verbal coding.

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[34] Kawagley (1995) has translated this simplistic rhetoric into action in his fish camp approach through the Alaskan Native Knowledge Network (ANKN).

3. They are skilled and have high frequency in processing visual and spatial information.
4. They are skilled and have high frequency in holistic processing on both verbal and nonverbal tasks (i.e., able to see the whole versus the parts).
5. They have relative strength and high frequency in imaginal coding.
6. They use a "community learning style." The child observes carefully over a long period of time followed by practice of the process (direct experience), with a minimum of verbal preparation or interchange . . . (takes longer).
7. They are group oriented and prefer to work in small groups.
8. They prefer an informal setting with freedom of movement. (p. 58)

In a separate study Irvine and York (1995) also identified similar characteristics of Aboriginal learners; they did so with the intent to use these characteristics to design curriculum. Irvine and York indicate Aboriginal learners' characteristics in suggesting that they:

1. Prefer visual, spatial and perceptual information rather than verbal;. . . .
2. Use mental images to remember and understand words and concepts rather than word associations;
3. Watch and then do rather than employ trial and error;
4. Have well formed spatial ability;
5. Learn best from non-verbal mechanisms rather than verbal;
6. Learn experientially and in natural settings;
7. Have a generalist orientation, [and are] interested in people and things;

8. Value conciseness of speech, slightly varied intonation and limited vocal range; prefer small group work;

9. Favour holistic presentations and visual representations (pp. 490-491).

The importance of these descriptions is not their content but their implied relevance. Instructional approaches such as the above that purport to use learner characteristics to inform pedagogical strategy have an anthropological basis; they suggest that for learning to occur, the classroom teacher has to accommodate culturally defined characteristics (in this case, those of Indigenous learners). The implication is that the teacher need only accommodate different learning styles in order to ensure student success with the instructional content.

Reid (2001) agrees that "cultural dissonance" is an underlying problem; she disagrees with the type of learning-style theory outlined above and suggests that students' success in school is also affected by a "cultural powerlessness" and "inequality of social groups" (p. 27). Stereotyping Indigenous students with specific characteristics, she suggests, represents a "social determinism" based on a static, cultural, anthropologically derived model. Just as presenting western science from one cultural perspective may be conceptually limiting, so too, can categorizing students by a set of characteristics be limiting.

Rather than describe students' strengths and weaknesses, Aikenhead's (1997) cross-cultural approach begins by using a model of negotiation. He defines 'border crossing' as a movement through a negotiated space between two worldviews; where one of the teacher's roles is that of a negotiator or 'culture broker' (Stairs, 1995). This concept is based on the notion that western science is a paradigm that is bounded by a cultural knowledge system (Pickering, 1992) and that student's lives encompass many different cultures, including school subjects, locations, genders, languages, religions and nations.

Aikenhead (2000a) also addresses the connection between the subject and the student in discussing scientism and culture. He specifically suggests various pedagogic strategies in presenting two views of science in a multiscience classroom using a cross-cultural teaching method; including the use of two blackboards: "one for Aboriginal science, and the other for western science" (p. 26). Aikenhead adds another critical point with "Cross-cultural teaching helps students gain access to western science without losing sight of their cultural identity" (p. 26).

Two models emerge here specifically for Aboriginal education. For Aikenhead, the border-crossing concept pragmatically helps students and teachers in the lived-in reality of a bi-cultural classroom. It is apparent here that two distinct worldviews exist as physically demonstrated by two separate blackboards, two separate languages, and two separate curriculums. This distinction makes sense from a western scientific perspective. This thesis supports another possibility (Hampton, 1999). In it, an overview of science as explicitly expressed in traditional knowledge forms the first unit of study. Students come to know a wider definition of (scientific) knowledge. Western scientific knowledge can then be presented under this umbrella as a useful subtext for a more inclusive traditional knowledge. Again, the reason that these (two) types of curricular responses have been presented is in reaction to a cultural alienation of Aboriginal youth towards present science curriculum.

Grounded in actual classrooms, Aikenhead (2000b) has helped in the creation of Saskatchewan science curriculum units (Rekindling Traditions) that incorporate traditional knowledge into the provincial science curriculum[35]. This is based in part on the pedagogy that students make personal meaning out of material that is relevant to them, rather than simply memorizing disparate facts. Learning science grounded in a student's tribal roots, motivates Native American students to learn science related to their own heritage (Cajete, 2000). Support for this multicultural approach to teaching school science can also be found in New Zealand (Baker, 1998), Australia, (Ritchie & Butler, 1990; Read, 2002), and Hawaii (Meyer, 2001), where these authors give both curricular and pedagogical examples.

In summary, various pedagogical overviews have been presented with the intent of including elements of traditional knowledge in science classrooms. This attempt to give meaning to education has been carefully summarized by Lightning (1992)

> Perhaps if we as educators, administrators, leaders, and parents were to begin seriously to consider and then to introduce a philosophy of educating for balance, harmony and well being for the human condition,

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[35] The incorporation of such material into the science curriculum has not, at the time of this thesis, been created in Alberta.

we would be doing something that would truly have meaning in our lives. (p. 87)

It may be, by re-examining our educational intent in science education, that we may able to help create more meaningful learning for science students, particularly Aboriginal science students.

Chapter 4

4. Research Methodology

4.1 Epistemological Context

Traditional knowledge is embedded within a cultural context. Elders are an integral part of this context; they are the knowledge carriers. Elders are regarded with respect in their communities. One participant (L.) compared the death of an Elder with the wealth of knowledge lost when a library disappears. (I revisit this in chapter 5: 5.9.2 Elders). I was approaching three such Elders who died during the six years of this research. Working with Elders requires an understanding of protocol; an awareness of and a working inclusion of relationship and reciprocity. Proper protocols indicate to the Elder the intent of the person approaching them. MacIvor (1995) writes, "[w]ork in this area requires new approaches to research which allow intellectual exchange while honoring both the knowledge and the people as partners in the research" (p.86). Understanding traditional knowledge requires a reorientation towards science in that "we must create for ourselves a sense of place within the biosphere that is steeped in humility and reverence for all other forms of life" (Knudtson & Suzuki, 1992, p. xxiv).

The intersection of two systems of knowledge—one generated from a formalistic, problem-solving methodology, and one generated from the experience of thousands of years of survival—is problematic in that it represents the melding of two belief systems. However, each does not necessarily exclude the other. I have already demonstrated some convergence of these systems in their description of natural events and in their metaphysics (see chapter 1: Traditional Knowledge). The intent of this research is to investigate where these two systems of knowledge overlap and then examine conceptual frameworks that would facilitate their inclusion in science curriculum. A curriculum based on a common epistemological base might then be used in the science education of both indigenous and non-indigenous students.

4.2 Research Methodology

A western scientific model of research results in emerging themes or concepts as an end product of the research process. One methodology used to interpret interview responses categorizes elements of the response into these themes (Cobern and Loving, 2001; Denzin & Lincoln, 2000). This allows for the development of categories or emergent themes which are created by the researcher/interpreter. Using direct analytical methodology (quantative) the emergence of trends occurs through application of mathematical statistical formulae. But as has been noted by Guba and Lincoln, (1994) using one type of statistical analysis chosen from a vast array of analytical methods highlights one trend; while the use of another statistical analysis highlights another trend. The close association between emergent trends and the objectivity of the researcher can be questioned. The emergence of trends here, rather than being objective, can be related to the choice of analytical tool used by the observer/researcher; where the tool used determines the outcome. Different statistical analysis results in different emerging trends.

In qualitative analysis, it is also possible to predetermine the emergent themes and use an interview response to fit these preconceived themes (Eisner, 2002). However, these emergent themes themselves are usually regarded as having been dictated directly as results or outcomes from the interviews. In approaching the question 'How do these themes emerge?' Eisner addresses the issue using the term imagination. Imagination is used here to include the affective domain of researcher, similar to a wholistic Cree description of a four-part person. Steier (1995) addresses the inclusion of the researchers themselves using the term 'reflexivity' where he acknowledges the interactive role of the researcher in interpreting objective data. These views conflict with the notion of an objective reality existing independently of the observer.

A metaphor for an evolving research methodology can be found in descriptions of the dual nature of light (Capra, 2003) where the observer's methodology affects the outcome of the experiment. The main difference between this example and the one above is that this dialectic is identified in a scientific context as an element of the relationship between the observer and the observed whereas this element is often not acknowledged when using quantative statistical analysis methodology (Denzin & Lincoln, 2000).

Given this apparent conflict over objectivity between quantitative and qualitative methodology, qualitative methodologies are most appropriate here, where the observer/interviewer is included and results are not interpreted as objective data.

Various analytic designs, such as phenomenology (van Manen, 1984), ethnography (Woolcott, 1995), action research (Fals-Borda & Rahman, 1991),[36] and grounded theory (Glasser, 2002) are consistent with the intent of my research. From the research questions, more specifically, three methodologies emerge when I question the objectivity and meaning of the western scientific approach: phenomenology, constructivism and Indigenous research methodology. Although with respect to traditional knowledge, biological (e.g., ecological) and phenomenological perspectives have already been advanced as conceptual approaches (Chapter 3), more recent educational approaches such as constructivism may also prove promising for classroom use. A metaphor that Davis and Sumara (1997, p. 109) apply in their discussion of the term *constructivism* suggests a shift in the description of the relationship between the learner and the learned from a language of physics to a language of biology. To simplify, if the language of physics deals mainly with direct causes and mathematical representations, the language of biology grapples with life, constant change, evolving constructs and complex interdependencies (p. 109). In support of this assertion, ecological views of *cognita* suggest that the relationship between

[36] In particular, action research design demands a working hypothesis that the researcher attempts to verify or refute. As can be seen from the literature review there already exists ample evidence (the greatest of which is the survival of a culture and language) of the existence of traditional knowledge. A question for me as a researcher from a western cultural perspective is to clarify how this knowledge might be used for creating a (unified?) framework for describing or explaining nature and reality; and which might be useful in the creation of science curriculum in schools.

the knower (i.e., the individual) and the known (i.e., the environment) co-merge in the process of living in the environment (Maturana & Valera, 1989; Capra, 2003).

Charmaz (2000) presents a subjective interpretation by the researcher of the interview data that uses a constructivist grounded theory design, adapted from the work of Glaser (2002), and Strauss and Corbin (1998). Data here means information that is applied in the context of schools and classrooms. Indigenous research methodology, although it may indirectly have application to classrooms, will be used as the main research methodology to help define the relationship between two knowledge bases. While the constructivist approach is applicable as a means to answer the second research question I've proposed—"What are the pedagogical implications of these connections for teaching science?"—it is Indigenous research methodology that lends itself best to answering the first research question: "What connections exist between western science and traditional knowledge?"

Constructivism begins with the belief that learners, using their pre-existing knowledge base, actively construct new knowledge (Geelan, 2003). This includes Glasersfeld's (1989, 1993) "radical constructivism" wherein "knowledge about the world serves an adaptive function, rather than yielding objective truth about an observer-independent external reality—a perspective shared by many other forms of constructivism" (Geelan, 2003, p.1). Although constructivist perspectives may be criticized for looking restrictively at the identified process or subject, and ignoring the product or object, it has been evident, from Heisenberg (in Braden, 2007) on, that clear distinctions between these elements cannot easily be made. Likewise, summarily grouping western scientific knowledge in one camp labelled 'the truth,' and traditional knowledge in another category identified as 'a belief,' can only be accomplished if one disregards Midgley's four concepts that address the basis of western scientific knowledge (Midgley, 1992).[37] If traditional knowledge is dismissed because it is thought to be based on a belief system (Blades, 1996), then Midgley's assertion would also support a dismissal of western science for the same reason. The use of constructivism in reconceptualizing the objective nature of science allows for the inclusion of traditional knowledge by examining the relationship between science and the nature of reality.[38] Although both worldviews look at the same element: natural events. From Battiste's (2005) suggestion that a piecemeal, fragmented approach to adding on bits of traditional knowledge to an already existing knowledge structure doesn't work in Aboriginal education, a direction for my second research question emerges. How then can we as educators best organize western scientific knowledge and traditional knowledge for all students *and* teach science to Aboriginal students?

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[37] Midgley goes on to claim that none of the beliefs upon which the constructs and the activities of science are based can be objectively proven using western scientific methodology.

[38] Although both worldviews may be said to "look at the same element: natural events" this is an example of Eurocentrism where "looking" and "natural elements" or "nature" is implies a colonial view of a more complex relationship. Aikenhead suggests terms such as "when an elder inhabits what is taken by English speakers as 'a natural event'." (Aikenhead, personal communication).

The use of narrative nets, as presented by Geelan (2003), is an insightful means to describe and analyze the complexity of teaching within a 'real' school environment. Focusing on the complexity of an individual (radical constructivists) who acts externally in the world, followed by the complexity of the relationship of that individual with another individual, and then moving to examine the complexity of relationships among multiple others (social constructivists) and, finally with the world, a synergistic effect emerges wherein the whole is much greater than the analyzed sum of its parts. To address this synergistic effect from a narrative perspective, qualitative research subsumes the quantitative (Denzin & Lincoln, 2000; Eisner, 2002). Weber-Pillwax (2003) gives a more detailed account of intersubjectivity from an Indigenous research methodology perspective (p. 25-48). This is key to my research where the narratives told to me are subject to my interpretation. Elders do not necessarily explain the meaning of what they tell; it is up to the listener to create meaning from the Elder's words (Lightning, 1992; Hampton, 1999; Wilson, 2001).

As a means to approach the first research question using Indigenous research methodology, Weber-Pillwax (1999) points in the most promising epistemological direction because her work includes crucial elements of individual interpretation, collaboration that generates communal meaning, and further, it attends to the respect paid to both persons and the material that is explored (in this case, traditional knowledge). Weber-Pillwax (1999) outlines an inclusive description of standards for authenticity and research critique that identifies seven aspects of indigenous research methodology. These aspects include "considering the [following] principles:

a) the interconnectedness of all living things

b) the impact of motive and intention on person and community

c) the foundation of research as lived indigenous experience

d) the groundedness of theories in indigenous epistemology

e) the transformative nature of research

f) the sacredness and responsibility of maintaining personal and community integrity

g) the recognition of languages and cultures as living processes." (pp. 31–32)

If a conceptual framework for traditional knowledge is to emerge from Indigenous perspectives in this research, all of the principles identified here by Weber-Pillwax must be attended to. As a researcher coming from a western cultural worldview, I am most acutely aware of item (d): "the groundedness of theories in indigenous epistemology." A conceptual understanding of how these two knowledge systems are related cannot occur without closely attending to my interpretation of Indigenous epistemology.

One critical aspect of this research is that I am not Aboriginal. I have not been trained or educated, nor do I have lifetime lived-experience to see the world from an Aboriginal perspective. However, my grounding in a different cultural perspective allows me to look at traditional knowledge from the outside (etic), from a point of not knowing, as I come-to-know traditional knowledge. I can only interpret what I hear and see through my own perspective, my own schema, perhaps using Kantian "a priori" knowledge categories. The question Aboriginal Elder Dan Alexis asked me— "What can you teach me about my culture?"— helped me orient myself in this research and aided the selection of appropriate methodology. As the researcher, I locate myself at the intersection and the overlapping of two worldviews (Figure 2.1). As a former classroom teacher of native students, I 'come from' a western scientific perspective but became aware that I was presenting only one narrow perspective of nature, paired with the message that this was the only true or valid perspective. Other ways of knowing science emerged from listening to my students. As the researcher, I inhabit this subjectivity when I select particular research methodologies in my attempt to come-to-know indigenous scientific epistemology.

Qualitative research acknowledges subjectivity. My personal bias, predilection, and desire to understand traditional knowledge are inherent requirements to entering into this research. As well, patience is often a personal subjective characteristic of indigenous researchers (Ross, 1996). I draw attention to the importance of subjectivity here because the use of quantitative research (i.e., the collection of data for formal, usually statistical, analysis) does not plainly reveal subtle but meaningful connections between traditional knowledge and western science, wherein understanding may be characterized in terms of qualitative elements. By using quantitative methodology, the researcher is separated from the data because it is commonly considered objective, in the sense that a specific, often mathematical analysis is engaged to clearly expose previously undefined trends that emerge solely from the data itself. However, this meaning, nature and validity of objectivity has been questioned by many, including Eisner (2002), Glaser (2002), Smith (2004) and Scheffler (1967).

From a constructivist-oriented classroom, and from an epistemological approach to Indigenous research which differs between tribal groups, the interview emerges as a key methodology. Because traditional knowledge is often transferred orally from an Elder, the use of interview/dialogue is appropriate here. In qualitative research, the use of semi-structured interviews for data collection originally gained support from Bogdan and Bilken (1982), and Guba and Lincoln (1994). Rather than use a rigid set of predetermined interview questions, a semi-structured interview allows the interviewer to "approach the world from the subject's perspective" (Berg, 1995, p. 33). More detailed and focused data often emerge from a semi-structured interview because it allows for a more natural flow of thought through the use of "unscheduled probes that arise from the interview process itself" (Guba & Lincoln, p. 33). Such advantages are particularly relevant to this study, as Gordon (1975) observes: "The semi-structured interview gives the interviewer some choice as to the order of the questions, [the] freedom to attempt alternative wordings of the same question, and the freedom to use neutral probes if the first response to a question is not clear, complete or relevant" (p. 61).

In describing semi-structured interviews as "a conversation with a purpose" (p. 268), Guba and Lincoln (1994) point out that the use of focused, directed questions allow the interviewer to probe for understanding while maintaining a natural flow of conversation. This approach allowed for the emergence and evolution of my coming-to-know traditional knowledge and, if possible, the contextualization of its relationship to western science; and ultimately, its pedagogical use. In this regard, the interview itself includes queries about the connection between Aboriginal education and traditional knowledge (see questions below).

A discussion of my evolving research methodology here is useful in that this evolution can be seen as similar to using a western scientific worldview in order to envision traditional knowledge, finding the western scientific belief structure inadequate and requiring revision. (Little Bear, 1994; R. Ross, 1996; M. Smith et. al., 2003; Stewart-Harawira, 2005; Black Elk, 1981). Indigenous research methodology incorporates this methodological evolution (Weber-Pillwax, 1999).

Although I initially restricted my approach to a cognitive intellectual domain, the participants frequently described a worldview where cognitive and affective knowledge were not separated but formed an interconnected whole. In order to understand what was being presented to me I had to engage all aspects of my humanity. As a researcher, I began by accepting a worldview where knowledge includes a nexus of intellectual, physical, emotional and spiritual aspects. The resulting descriptions of this interconnected whole seemed too generalized a concept for me at first, but I began to realize that a wholistic approach was necessary to allow space for meaningful educational descriptions and implications to emerge in interview dialogue. I separated out seven strands of concepts: metaphoric meaning, narrative, language, oral tradition, Elders, community, and relationship while recognizing that each does not stand alone but acts in concert with the others. One Cree Elder describes this interconnected nexus:

I (interviewer): So if you were to have kids in school learning something, what would be the most important thing for them to learn?

R (respondent): It would have to be a number of things happening simultaneously. They would have to understand themselves, their emotional body. ...And the same with spiritual... So how you go about that 500 years ago, to find that sense of balance, that sense of discipline.

This was also reflected in my field notes (May 14, 2006) in conversation with the same Cree Elder about educating Aboriginal students:

I: How do we educate Aboriginal students?

R: Relationship plays a role in education. Community plays a role in education. The education of an Aboriginal child used to be connected to his environment: the community, the land, and Elders. Presently in a hierarchical model, students are to fit into the existing structure (draws a pyramid) of the institution; whereas Aboriginal learning took place with all educational elements interconnected (draws a circle). Home life was connected, not separate from school. The community and the language of the community were infused with children's education. The connections between self—family—community—job—culture—spirituality were all interrelated. These activities and concepts were not separate; they were not separated in the child's mind and were connected with all parts of the child's life. They formed an interrelated whole. Therefore a systems approach to attendance or achievement will not work, it has not ever worked. When all parts of the whole are addressed, when all parts of a child's life are considered, then there will be balance, harmony and peace. It all begins with the child and with nurturing: with supporting the child's sense of self. That is why the relationship between people has to be attended to. That is why relationship is a key ingredient in a child's education.

Today there is much dysfunction within the families; children are confused by separate worldviews.

One reason why families are dysfunctional is because there is confusion over economics. In a hierarchical model (he points to the diagram of a pyramid) power, control and money distribution is determined by the institutional structure itself, which has a basis in a monetary value placed on land. "I have heard that we are even beginning to pay for water and air" (direct quote). There is confusion about where to place value: culture, language, and community in traditional knowledge; or valuing economic determinism of the nation state. Education should include addressing these issues. Science education cannot be separated from these factors, attendance is not a separate issue; student achievement is separated from these but it is really a part of a whole.

In reconceptualizing this wholistic concept my methodology evolved as I underwent the research process. This is not unusual, as according to Eisner (1998)

> Qualitative research often takes weeks, months or even years to conduct. It is simply not possible to predict the flow of events as they unfold, so researchers must adjust their course of action based on the emerging conditions that could not have been anticipated. (p. 170)

During this research I encountered restricted access to information from Elders—the keepers of Aboriginal knowledge. One of the reasons for reluctance on the part of indigenous knowledge keepers is a past history of having research *done on* them (Weber-Pillwax, 1999). I encountered a history of previous experiences with researchers, after which the 'subjects' felt dehumanized, quantified, classified, misrepresented, and their knowledge and way of knowing being reinvented into the more powerful dominant cultural orientation (Smith, 2004). This history of misrepresentation permeated my attempts at dialogue with many individuals and at many locations.

While maintaining my original intent of investigating the connection between traditional knowledge and western scientific ways of knowing (Questions, p. 4), the methodological approach evolved from initially interviewing many widely scattered participants superficially to developing in-depth relationships with a few selected individuals who were trusting enough to carry on open and frank dialogue with me as an individual over a period of years. As in Smith's (2004), "dialogue across the boundaries of opposites" (p. 39), we attempted crossing the conversational bridge (*asokan*) between two cultural worldviews. Establishing this relationship based on trust has been identified as an essential element in the interview process by Denzin and Lincoln (2000). Weber-

Pillwax (2003) further identifies this: "Relationship is the critical factor in the development and establishment of respectful Indigenous research projects" (p. 38). This resulted in extended detailed dialogue from willing participants with whom, over the period of this study, I established a trusting relationship. This fostering of a relationship grounded in trust with individuals also resulted in revealing concepts from a different way of knowing which were at times incomprehensible to me: "Where did this knowledge, this metaphysical construct, come from? What is the meaning of this word? How did you come to know this? Are my questions Eurocentric in that I am asking for an implied answer?"

Concepts emerged from conversations representing a different way of knowing than that into which I had been indoctrinated. I reflected on these concepts while attempting to maintain my position as an *asokan* (bridge) between two worldviews (Figure 2.1). I constructed a metaphoric model: if western scientific knowledge is a sphere, to be put on a lab bench and looked at with 'scientific objectivity', then this seemingly solid sphere of knowledge might contain sieve holes, mysteries; to be acknowledged as relevant and warranting examination. This allowed the possibility of using other ways of knowing which might provide other insights into these mysteries. Surprisingly to me, many participants rejected this interpretation. By my questioning this model, a transformed worldview emerged for me where individuals acknowledged seeing the world from an interconnected web of personal perspectives based on constructed belief structures. One wholistic insight from this web is that we are all a part of nature; we are not separate from it. Western science dialectically incorporates a Cartesian principle here: our thoughts, while grounded in a lived-in-reality are distinct from it.

Discourse during this research, including interview and experience, became a conduit between my evolving perception of the nature of scientific knowledge and that of the participants. This is further examined under 5.3 Metaphoric Meaning and chapter 6: Conclusions and Synthesis.

During this study, conversations (often recorded as field notes) occurred across kitchen tables, at sweat lodges and sundance ceremonies, in a group classroom setting, at cafeterias and in other locations such as open natural areas. Some ideas resonated within me and others became an irritating burr under my skin. Many concepts were indistinguishable as emerging solely from an individual source; they were a composite of many successive conversations with many different individuals in many locations. I have not credited the sources of these concepts to individuals and have also respected the wishes of participants who did not wish to be identified. I have only directly quoted four Elders with their permission. I have included field notes from a class discussion—Aboriginal ways of knowing 601course –with permission from the instructor, Stan Wilson and have not identified any participants. This is in keeping with Weber-Pillwax's (1999) description of enacting honour and respect in using indigenous research methodology.

Even though I initially defined science education from within my western scientific conceptual borders, broader categories of the meaning of science education emerged in interview/discussions that were beyond my conceptual border constructs. Larger categories emerged when creating a flow of conversation (van Manen, 1991) that encouraged participants to directly discuss topics relevant to them. Although tightly focused teaching/learning science questions (below) directed participant responses, more open-ended questions and questions following directly from interview responses resulted in dialogue about what was considered most important for the individual participant in relationship to Aboriginal education. Although some interview discussions initially seemed "off topic", following the natural flow of conversation is in keeping with an Aboriginal methodology of circling the topic recursively while the listener/interviewer considers the relevance of the discussion, and finally a participant (often an Elder) brings the discussion back to coincide with listener/interviewer's intent (W. Lightning, 1992). I incorporated this aspect of indigenous research methodology (Weber-Pillwax, 1999) into my interview technique.

Some sample interview questions used in three categories were for Elders:

Who are you and where are you from?

Tell me what you know about traditional knowledge?

Tell me what you know about western science?

Should traditional knowledge be taught in schools?

What is the Cree way of life?

What are the beliefs, values or traditions of the Cree people?

How do Cree children gain an Aboriginal worldview?

What is the Cree way of knowing?

Tell me about the way life used to be a long time ago.

Tell me what you know about:

—what times were like a long time ago?

—being Cree was like for you

—school is like now

—what are the belief systems of the Cree people?;

for other community members:

This study is about the relationship between western science and traditional knowledge. Western science means many things, what does it mean to you?

What about traditional knowledge, what does it mean?

Can you give me any examples of what you mean by traditional knowledge?

What traditional knowledge do you consider to be scientific?

Are there any examples of where traditional knowledge is the same as western science?

What would be the difference between the two?

Is there a connection between western science and traditional knowledge?

Do only Elders know traditional knowledge?

How is traditional knowledge gained? Taught?

Are all things interconnected? In what sense are all things living?;

and for educators:

When teaching, should we include these cultural teachings at school?

What cultural teachings or traditional knowledge should we include?

If they were to be presented in school, how can they best be presented?

In teaching (western) science, how could this traditional knowledge be incorporated?

If traditional knowledge were taught like science is now being taught, would it still be traditional knowledge?

Can you put either knowledge into printed form? into textbooks, for example? What about videos or PowerPoint?

In what ways can this knowledge best be transmitted?

Is there a difference between the process and the product in traditional knowledge?

Some authors describe how it is for native students to learn science in school. Did you learn science, and if so how was it presented?

The phrase border crossing is used by some to describe an awareness of teaching western science to Aboriginal youth. Does this have any meaning to you in terms of teaching science?.

My initial structure of using specific science directed questions evolved to address detailed responses by participants concerning, for example, how their worldviews coincided with their educational experiences. I initially enacted a border-crossing model (Figure 2.1) of using dialogue to move from the culture of western scientific to the culture of traditional knowledge (Aikenhead, 2000a). In a semi-structured format I carried these questions into the interview. These specific questions may or may not have emerged, depending on each individual situation. However, they reflected the intent of this research.

The specific methodology used in this study is outlined in Ethics Review Appendix 1. The following is a summary.

A pilot study was conducted through interviewing University of Alberta colleagues. They were presented with a hard copy of the study and then interviewed directly to discuss their reactions. These reactions were incorporated into the study before proceeding to the second stage.

The research involving case study information adhered to the principles of indigenous research methodology where protocol and respect played an integral role in the research design. Participants were selected from among those identified by other indigenous researchers and community members known to the author as having an understanding of traditional knowledge and how it might relate to western science. My advisor Cora Weber-Pillwax, or someone known by myself to be a respected member of the community, initially approached potential participants. The intent of the study was presented to them and they were asked if they would agree to participate. Thereafter I maintained and fostered this gift of trust.

Cora Weber-Pillwax acted as my main advisor in both directing me towards communities and specific people within those communities, and advised me as I proceeded through the interview process; she acted as my advisor and guide as I gathered and interpreted data. Dougal McDonald also identified some communities as having a rich resource of people with a detailed understanding of traditional knowledge and how it might relate to western science. Community residents included Elders, the carriers of traditional knowledge. Other community members were approached whom I previously knew or were known to my other colleagues. I approached these individuals to demonstrate that I had no "hidden agendas" and to clarify my intent. If I established a level of trust I proceeded with a request for dialogue dealing more directly with research on traditional knowledge. Because my role was that of a visitor or visiting teacher/professor in a community, I established contacts within that context. Other community residents who had a stake in education (e.g., sit on various community organizations or act as advisors to the educational authority) or had a knowledgeable interest in this subject were also approached as contacts. These community members often provided invaluable direction in addressing the last research question concerning the inclusion of traditional knowledge in each community educational institution[39]. [40]No persons under 18 years of age were part of this study.

The pilot study consisted of interviewing fellow Aboriginal colleagues. I interviewed Dwayne Donald who has completed a M.Ed. from University of Lethbridge and is presently Assistant Professor in Secondary Education, University of Alberta. He has taught for a decade at Kainai First Nation, and

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[39] Once an initial level of personal trust was established, interested stakeholders including educational directors, teachers and parents were also approached.

[40] This could lead to a future development where I might be of use to the community in supporting the development of the inclusion of traditional knowledge in the existing science curriculum, enacting reciprocity.

provided similar constructive criticism of specific interview questions, intent and methodology from his experienced perspective.

In order to locate the areas of intersection between the traditional knowledge presented by individuals and the western science knowledge as presented in the present science curriculum, the initial step was to develop rapport and trust with the individual participants. The depth of knowledge exchanged depended both on my receptiveness and the participants' willingness to talk. I attempted to create an arena of mutual respect (ethical space) where meaningful dialogue occurred. Although my intent was to gather data concerning the intersection of these two bodies of knowledge, the individuals within the community had other intents; communities had other needs. For the discussion to proceed (although not directly part of the data collection), I kept the following reciprocity questions in mind: What can I offer to the community?; If the need emerges, how can I support the process of including traditional knowledge in the community's school science curriculum?; What are the wishes of the community?; How can I best respect the wishes of the participant individuals in the community?; How can I best facilitate the community's needs within the intent of my research?; How will my evolving understanding of this project be of use in each community?

As previously discussed, in addition to interviews, Aboriginal ceremonies also played a part in the data collection. Information and understandings of the contextual meaning of the words used in conversation and interviews were interpreted against the surrounding community milieu in which each individual participant existed. Sharing circles, feasts, meditation, prayer, sweats and participation in other community ceremonies all played a role in facilitating my contextual interpretation of data and developing within the community an understanding about how I was seen as going about collecting data. "The method of interviewing key people is used to best advantage when it is closely integrated with participant observation" (Pelto and Pelto, 1978).

Once participants were identified and agreed to discussion, interviews were conducted. Five participants agreed to taped interviews. The interviews lasted from 45 minutes to two hours, depending on how long each participant wished to talk. When responding to interview questions, in some cases, the speaker used narratives which contained the meaning of the intent of their response. Eber Hampton (1995) has reported that elders talk in circles and Suzuki (1997) has shown that narratives contain deep ecological understandings, which are often later supported by western science. Van Kessel (2002) additionally has identified the importance of diachronic data[41]. Interruption with questions at those times was inappropriate and disruptive to the speaker's flow of thought (Hampton, 1995).

Only one interview was conducted with each participant, unless the participant requested another for further elaboration, or if statements needed to be

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[41] Information that has been collected in a small region over a long period of time (chapter 1).

reconfirmed. Interviews were conducted in locations where the participant chose—in a home, restaurant, classroom, at a conference or in my office.

During my initial introduction to participants, I clearly stated the intent of the research project; what my purpose was in asking questions about traditional knowledge. Many participants, acting from previous experience, needed to determine for themselves if my intention as a researcher was 'pure'. Any hesitancy or caution on the participants' part in relation to my use of their words, or my interpretation of what they were specifically saying, was addressed directly and immediately and I respected their directives concerning my recording of any information. My intent here was to bring the element of respect to communication with each participant as we proceeded through the data collection process.

Depending on the wishes of the participants, I gave them copies of how their input has added to a knowledge base, which in turn might generate a unifying conceptual framework for science curriculum. Ancillary to the study, when I located pedagogical examples of the incorporation of both knowledge systems in the science classroom, with the author's permission, I made copies and distributed them to interested participants. The dissemination of this information took the form of public information sharing session and the distribution of hard copies (teacher's sessions at Erminskin and Jon d'Or Prairie Convention) where it was my hope that this initial research began the process of uncovering ways in which traditional knowledge can be pedagogically incorporated and embedded within each communities' science curriculum.

The interview questions themselves were generated from the literature and in consultation with my colleagues; they were further refined in revisions by four colleagues. A pilot interview was done with Stephany Jones, a non-indigenous researcher of indigenous ways of knowing.

Sometime during the interview, I requested permission of the participant to audiotape the interview and to later have the tape transcribed. The tapes were transcribed and a copy returned to the subject for any necessary deletion, addition or alteration. In addition, I kept field notes that recorded the date, time and duration of the interview, as well as my observations and thoughts. In discussions where the participants did not grant permission for an audiotaped interview, I kept extensive field notes and used them as the database that was subsequently checked and approved of by the participants or group leader.

The interviews themselves were analysed for specific scientific content that might detail technologies (such as the use of brains to tan moose hide) and for metaphysical descriptions (as are found in the use of metaphors). The baseline I used depended on my evolving personal perspective as a non-Aboriginal researcher but indigenous research methodology allowed it to be checked against the interviewee's reaction to my interpretation. The respect, reciprocity and relationship elements of indigenous research methodology help to prevent a purely personal interpretation of the interrelationships between education, western science and traditional knowledge examined in this study.

The use of indigenous research methodology allowed the evolution of wholistic and in-depth interviews to occur with selected participants with whom I developed rapport. This created an ethical space of dialogue (Ermine, 2006) in which participants were able to express their thoughts in a supportive environment in attempting a dialogic connection between worldviews. The evolution of methodological structure from large group with tightly contained interview questions to a more fluid development within a smaller group reflected Aboriginal epistemology wherein the process of the teaching/learning complex is attended to. This evolutionary process itself was a reflection of the connection between western science and traditional knowledge.

Specifically, the methodology evolved from one of sampling a large population over several areas in a short amount of time, to sampling a smaller population over a longer period of time (six years). The previously addressed importance of meaningful dialogue with individuals required me to carefully attend to process: Who was I talking to and who was I to them? This resulted in dialogue over a period of years with 38 people before I approached 10 individuals with my request for a taped interview. I met with J and JM (Elders) 42 times and was given permission to tape record one interview. Another Elder (not directly quoted) whom I met with 22 times allowed me to attend ceremonies including sweats, fasting, sundance, shaking tent and healing. One participant withdrew entirely from the study, one ignored the interview request but continued to meet, one stopped meeting and five agreed to taped interviews. Excerpts of these taped interviews are presented in chapter 5 mainly and a discussion of their overall significance within the context of my experiences and discussions with all participants is presented in chapter 6. I respected all wishes for anonyminity.

Chapter 5

5. Findings and Interpretations

5.1 Introduction

I am aware that these interpretations and discussions originate from my personal perspective, and as such I acknowledge them as mine only. This chapter may contain Eurocentric concepts about non-Eurocentric knowledge systems. However, in the process of locating the common space between two knowledge systems, this is an important first step for me and for those who participated in this study. It is within this ethical space between these worldviews, at points of intersection, where we can mutually come to know (Ermine, 2006).

From the many discussions and interviews conducted, several theme words emerged, around which these findings and interpretations are clustered. Many of the participants described interrelated concepts with nexus at: metaphoric meaning, the importance of language, use of narratives, the inclusion of Elders, affect of oral tradition, influence of community, and development of relationships. Because these were often presented as an interconnected web or complex in the discussions and interviews, I present some interview responses as larger wholistic discussions rather than using a more western scientific approach of analytically dissecting out small pieces. The presentation of this thesis reflects the process of my western scientific worldview coming-to-know traditional knowledge. This unfolding understanding of traditional knowledge is in keeping with Geelan's (2003) concept of verisimilitude.

The above themes emerged as true for me within the methodological context of this study. Using the two thesis questions (p. 4) as a starting point of intent for interview and discussion, and applying indigenous research methodology, these results reflect broader scoped responses than I initially expected from a narrowly defined western scientific perspective. The findings hopefully may more accurately reflect the views of the participants than of my personal constrained perspective (Geelan, 2003). In using myself as the research instrument, I, as the researcher, was allowed to enter an educational culture of traditional knowledge concepts from my western scientific educational culture. Using a western scientific perspective Aikenhead (2006) uses the term border crossing in reference to crossing these two cultural domains. Although many of the thesis findings have direct application to science education, responses were often framed within a different perspective of education than Eurocentric multiculturalism and are presented within this different context.

5.2 Methodological Evolution

5.2.1 Emerging developments

The evolution of research methodology over a six-year period has been outlined in chapter 4. Briefly, in the context of this thesis, the evolution towards the inclusion of process elements from a strictly product orientation occurred for me as researcher. My focus on detailed facts, fragmented from the ontology from which they were derived, evolved to include the spaces between the facts, revealing wholistic interconnections linking affective and cognitive domains. My focus on the noun knowledge as a cognitive, objective product evolved to include the verb coming-to-know as a subjective process. I came to view the nexus between knowledge and coming-to-know as a complete whole for science and science education.

5.2.2. Knowledge and economics

I was asked to omit from this thesis some of the knowledge I received and recorded. Personal stories were often told to me as we (the participants and I) developed a relationship. Aboriginal participants recognized this relationship as an important precursor to establishing a cultural bridge of dialogue between us. Sometimes conversations were unrecorded by request or were cut short by participants who requested, and gave reasons for, ending the conversation. In one case the reason given was that *wapiskasakay* (whiteman's world) had used and abused this type of information for their own benefit, often economic, which resulted in further restricting Aboriginal lifestyle. Another Elder from the same community said that he would not give sacred knowledge away to just anyone because it had been misused, sold for profit. It was better to keep it than to sell it for profit. He described traditional knowledge as carried within the culture; that it is not tangible in the western scientific sense of factual knowledge. This sentiment was also reflected in this response:

R: ...science is actually an adaptation of traditional knowledge....the only difference is most of the findings from scientific knowledge get turned into a commodity, whereas traditional knowledge isn't a commodity.

I: So commodity meaning—an economic package?

R: Something that's profit or gained. So like medicine...

> Even though it's scientific knowledge, it's like traditional knowledge comes from the earth, like herbs–tea is for upset bellies. Traditional scientific knowledge, ...scientists will take that and turn it into a commodity and sell it back to people and patent it so other people can't find out about it. (Aboriginal Teacher)

Economics is cited as an example of a difference in approach between the two knowledge systems. Western scientific approaches included economic factors such as institutional efficiency or funding for research; whereas approaching traditional knowledge, when regarded as sacred, was not associated with an economic value. Lewis Joseph, a Nuu Cha Nulth Elder stated: "We do not own ideas. In the academic realm, ideas are owned, attributed to individuals, here we do not claim ownership of ideas. They are given to us by the Creator, not to be used for making money for an individual".

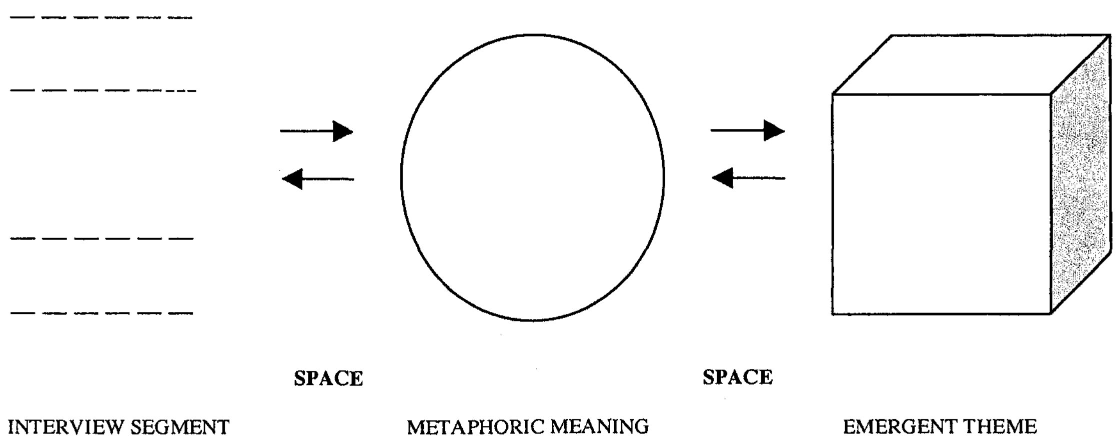
5.3 Metaphoric Meaning

5.3.1 Research process

According to Cajete (2000), "Native science is used as a metaphor for native [traditional] knowledge and creative participation in the natural world in both theory and practice" (p. 14). Indigenous research methodology is used in this study to approach Cajete's meaning of native science in coming-to-know the relationship between metaphoric meaning and traditional knowledge.

Narrative nets and constructive models include the concept that the researcher him/herself interprets the responses through the researcher's own constructed filter (schema) in order to gain understanding (Geelan, 2004). In this study the data/interview is interpreted through my worldview where I give metaphoric meaning to each individual case. Metaphoric meaning is defined here as using my interpretative process between incoming data and the resultant emergent theme. When several cases trigger the same or similar metaphoric meaning, a general concept emerges which I present as a resultant theme. This process is diagrammed below:

Figure 5.1 Metaphoric Meaning



Examining the intervening space in this figure generates methodological questions: 'From where does my metaphoric meaning originate? Is it specific to me or can it be generalized to others? What is lost in translation through this space? How does this model result in limiting the outcome of an emergent theme?' Indigenous research methodology is useful in examining the intervening space on either side of the metaphoric meaning as part of the research process, where interpretation occurs (Weber-Pillwax, personal correspondence).

The existence of this interpretive space has parallels in western scientific theory. Bohm (1980) explains the relationship between energy and particulate matter where the implicate order is manifested into the explicate order and back again in constant flux. The dynamic space between these two constantly changing events (termed holomovement) is affected by the observer and demonstrates anomalies which are not included in Newtonian physics such as Newton's Third Law as taught in high school. In Cree, the word for universe–*misiwe askiy* (Beaudet, Cree-English Dictionary, 1995)–includes both the known and unknown. Here, these unknown spaces are an acknowledged and accepted aspect of traditional knowledge.

Using this model in examining the space on each side of my metaphoric meaning, I move outward from the centre in describing myself as the interpreter/researcher. My filter consisting of past experiences, constructed neural networks and other unknown determinants, selected from a vast array of subtle stimulus input (including emotional responses) to coalesce into my personal metaphoric meaning of, for example, an interview or narrative. Good narratives trigger the listener/observer/researcher to respond; to apply their own metaphoric meaning to the interview story (King, 2003; van Manen, 1994). From an instrumentalist viewpoint, I, as the analytical instrument, present my emerging interpretation of metaphoric meaning as an emergent theme.

In this study narratives elicited metaphoric meaning. Cajete (2000) highlights the importance of the narrative in generating personal metaphoric meaning: "Language and its codified meanings are a created structure of culture… The metaphoric mind on the other hand communicates and relates to the world in the more [w]holistic structures of oral stories, linguistic metaphors, images and intuitions." (pp. 28-29). When orally passed on through generations, narratives, infused with traditional knowledge, elicit metaphoric meaning given to them by the listener. Subtle nuances that are not translated through the written word are included in these oral histories[42] (Cruckshank, 1980; S. Wilson, 2002).

In this model (5.1), I construct results as emergent themes, which then reflect back through a space to my personal metaphorically derived meaning. I, as a researcher, again reflect back to the original interview data through a space of personally constructed interpretation and reinterpret my metaphoric meaning, resulting in new emergent theme constructs as a continual process. New themes result in new reflections. Others give meaning to presented interviews through 'processing information' across their own intervening space. Once written down, an emergent theme becomes a static entity, which does not reflect this dynamic process (Aoki, 1991). In traditional knowledge Elders tell and retell stories, engaging the listener to find new and deeper meanings in them.

By engaging the listener/observer/researcher to re-enter the space between the spoken word and the emergent theme, the researcher asks the reader to continuously re-evaluate the meaning given to the raw data directly found in, for

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[42] See Chapter 5: *5.8 Narrative*.

example, a narrative or interview. I include samples of full interview responses in this study to aid in allowing the reader's own metaphoric meaning to emerge.

Similarly, teachers engage their students in the classroom by asking them to interpret the meaning of a narrative. Science teachers, when giving discursive explanations or descriptions of the natural world, often omit this intuitive mechanism whereby the students give meaning across this space to the story of science. Teachers of traditional knowledge incorporate this methodology of meaning-making within orality (Wilson, 2001). According to one participant (an Elder), Elders use metaphors to describe events that are connected wholistically (e.g., intellectually and emotionally). Understanding the meaning of a given metaphor may not occur immediately. Metaphors in the form of 'stories' are meant to give a deep personal meaning to the described event. The listener is intended to gain insight by reflecting on the metaphor in the 'story' (e.g., Chapter 5, *5.8 Narrative*).

Other participants told me that this element was missing for them in science classroom instruction. When science teachers engage students to give metaphoric meaning to the content of science curriculum, they are assuming the same methodology as is used when teaching traditional knowledge; they are demonstrating a methodological connection between western scientific and traditional knowledge pedagogy.

Few other methodological connections were given as presently existing in science classrooms. Students can become isolated in classroom cultures of western science. Although there is support for cross-cultural curricular material development, actual teaching materials are scarce (Aikenhead, 2006, p. 127). This is partially the result of solely utilizing a western scientific approach to developing science curriculum that does not allow for the conceptualization of other approaches, such as traditional knowledge.

5.3.2 Bracket fungus curriculum development

In education, Alberta Education is approaching traditional knowledge from a Eurocentric perspective; in viewing it as a 'product', it is 'infusing' Aboriginal knowledge into the present science Program of Studies. The basis of this approach corresponds to Ermine's (2006) appropriation model in which a western scientific approach to indigenous (i.e., traditional) knowledge is taken as scientism and directly transferred through education into western society. I have termed this specific educational methodology the 'bracket fungus' approach. It represents a hegemonic stance of the dominant western scientific paradigm as described by Aboriginal participants in chapter 5 whose etic views are outside of this paradigm as in Table 6.1 (see p. 239).

Traditional knowledge is newly discovered in that existing educational institutions are now recognizing this as a distinct body of knowledge and are designing curricular 'infusions' of this knowledge into such documents as the Program of Studies guidelines for science in Alberta (Alberta Learning, 2000). Historically, the 1998 Program of Studies for Science in Alberta contained no references to traditional knowledge, native science or the like. The 1991 Saskatchewan Program of Studies guidelines for science contained a guideline protocol reference for approaching Elders for knowledge. Recently published

(2007) science texts such as Nelson Biology, Chemistry and Physics have now included traditional knowledge information within the textbook, often as margination information (e.g. Jenkins, van Kessel, Tompkins, & Lantz, 2007, p. 222).

Specific to this study, in Alberta secondary science, the bracket fungus model has been applied mainly in Biology where most of the suggested curricular changes have occurred in the Alberta Learning Program of Studies; with the fewest suggested curricular changes occurring in Physics (Alberta Education Program of Studies, 2007). Educationally, this indicates that, at present, the western scientific approach to high school physics does not lend itself easily to 'infusing' traditional knowledge concepts. This conflicts with the findings of physicist David Peat who has shown a direct relationship between western scientifically derived physics concepts found in David Bohm's "Wholeness and the Implicate Order" (1981) and traditional knowledge worldviews (Peat, 2002).

Some examples of combining traditional knowledge and western scientific worldviews in the science curriculum have not used the bracket fungus approach. During 2000-2007, my colleagues and I included traditional knowledge material in science classes at Amiskwaciy Academy High School in Edmonton. This material included the presentation of Aboriginal perspectives in biology on such topics as Gaia Hypothesis, ecology, and health. In Saskatchewan, Aikenhead presented traditional knowledge curriculum developed through the Rekindling Traditions Project (1999); he also presented the promising approach of humanistic science (2006, p. 3). In Australia, Read (2002), in consultation with Aboriginal

Elders and community members, produced the Kormilda Science Project: An Indigenous perspective on the Earth Sciences. Beyond a science context, Alberta Learning's Common Curriculum Framework for Aboriginal Language and Culture Programs (2000) and the Aboriginal Studies 10-20-30 Option Units focus mainly on presenting a traditional knowledge perspective (Alberta Learning, 2000; Aboriginal Studies Draft, 2005) without using a bracket fungus approach or demanding acculturization by being directly embedded within a western cultural perspective.

Conceptually Alberta Education's present (2007) initiative (above) to infuse Aboriginal knowledge into the science curriculum is situated between the impossibility of making conceptual links/connections between two worldviews and the possibility of an open connection between Eurocentric ideas and traditional knowledge (Ermine, 2006). One participant's reaction to the incorporation of indigenous worldviews into western scientific curriculum was "that's pretty tough" (Cree Elder); he then terminated the interview. Another Cree Elder suggested, "the western scientific mind is now approaching our understanding of the world" (J. M.). Other participants applauded this initiative as an indication of an important first step of acceptance of the existence of traditional knowledge. Some regarded this as furthering the bracket fungus model of curricular development by grafting new information on to the main body of knowledge, while still retaining a western scientific cultural orientation towards teaching science.

While Alberta Education's initiative acknowledges the existence and the importance of traditional knowledge by attempting to infuse it into existing science curriculum, some critical curricular questions remain as unanswered space between the curriculum concept and the classroom activity: 'What is the origin and nature of indigenous (traditional) knowledge? How can we best teach it? Who is qualified to teach this knowledge? Can we use the existing educational science structure to accommodate this newly acknowledged knowledge, or is a new conceptual educational framework required?' This thesis directly addresses the first two of the above questions and in answering them peripheral answers to the other questions emerge. However, not all responses were clear-cut and some appeared to be contradictory: "It's not entirely the school's [fault] at all. It is educating them [students], but it's just like memorization: 'Here is just a life cycle—this is how it goes on the board,' and regurgitating. It's like getting back something that's regurgitated" (Aboriginal Educator).

An essential first step for establishing the connection between Indigenous worldview and the western scientific worldview is acknowledging the relationship between culture and knowledge. Aikenhead (2006) devotes his entire Chapter 7—Culture Studies: School Science as Culture Transmission (pp. 107-127)–to this concept that western scientific knowledge emerged from and reflects a western cultural orientation. Likewise traditional knowledge emerged from and is inseparable from thousands of years of cultural development.

The acceptance of western scientific paradigms is not independent of cultural context. As discussed in chapter 3, western science made an historic paradigm shift in the 16th and 17th centuries when Copernicus and Galileo suggested a heliocentric relationship between the earth and the sun; which was then culturally unacceptable. The heliocentric theory eventually replaced the geocentric theory. Bacon formulated a western scientific methodology represented by a shift in conceptual approaches to understanding natural events. He replaced a religious interpretation of defining prime causes for natural events with interpreting data, often mathematical, obtained by using the scientific methodology of experimentation (Bronowski, 1973). A new paradigm (belief structure) of modern science is emerging which incorporates Midgley's (1992) four assertions (p. 46). One use of the term paradigm by Kuhn (1970) describes a belief structure under which present day scientists operate. Today science teachers enact this paradigm: that mathematical/logical explanations of natural events can adequately and solely describe, explain and predict them. Few science teachers present science as a subculture within a larger western cultural context (Aikenhead, 2000a), although other epistemologies operate using other paradigms. Traditional knowledge describes, explains and predicts natural events using a different paradigm. Traditional knowledge is at worst rejected and at best not well understood by the dominant western scientific culture when that culture attempts to understand traditional knowledge from within its own western cultural scientific paradigm.

5.4 Holomovement and Metaphoric Meaning

An exception to this approach parallels traditional knowledge concepts using the terms wholistic and indeterminism to describe particle physics (Peat, 2002). Western scientist David Bohm (1980), in relating the conversion between energy and mass, outlines how an explicate (mass) order is manifested from an implicate (energy) order. He asks the question: How do we address the implicate order of the universe? His description of the underlying processes in particulate matter demonstrates concepts parallel to those found in traditional knowledge. Aboriginal people have long used a metaphorical understanding of how nature works, through oral tradition, where every 'story' told speaks of intuitive, metaphoric understanding (King, 2003). Both constructs indicate that matter in the universe, rather than being static solid physical particulates, is a fluid dynamic process.

5.4.1 Movement from static to flow

Bohm's theories are a point of intersection between western science and traditional knowledge. He states that the implicate order carries information which is translated into particulate matter forming the explicate order. Classical laws of physics apply to the explicate order. He uses the term 'holomovement' to describe that which carries or enfolds order and measure between the implicate order and the explicate order. Holomovement can consist of, for example, electromagnetic waves or sound. Bohm uses the terms "unbroken and undivided totality" (p. 191) for these three connected terms. Likewise, from a traditional knowledge perspective, JM states that we are part of the all and Black Elk (1959) states that everything is in a circle. Bohm suggests that the use of the term particle in descriptions of experimental results from using bubble chambers or photographic emulsions is misleading. Naming it a particle makes the assumption that "the primary order of movement is similar to that in the immediately perceived aspect" (p. 195). When we identify only with the physical particles, scientists are misinterpreting experimental results because they are only using a classical western scientific paradigm.

Here quantum theory indicates an anomaly in this type of interpretation. Discontinuous "quantum jumps" imply a well-defined orbit of a particle. But the wave-particle properties of matter here are inclusive of the experiment and the experimenter (Heisenberg). The descriptor 'autonomous motion of localized particles' loses its meaning when considered in this quantum sense where the observed and observer are interconnected. Traditional knowledge reflects a similar view when Cree Elder Jean Marie says, "Everything is connected to everything else".

5.5 Western Scientific Methodology and Traditional Knowledge Process

5.5.1 Understanding and personal interpretation

Participants in this study described a difference between methodologies used in western science from that used in traditional knowledge. One emerging aspect of traditional knowledge was its relationship to process. Process involving personal interpretation, which includes intuition and emotion, was considered an integral part of traditional knowledge; while the process of determining scientific facts using the scientific method was described as impersonal and objective and as of less value than the facts themselves in science classrooms (see quote below).

Western scientific methodology has clearly defined determinants for assessing the reliability and validity of conclusive scientific statements.

Statements stand as facts based on evidence obtained using experimental methodology. Once organized into subject areas, this scientific knowledge becomes a logical arrangement of those facts. Identification of the relationship between such facts forms the basis of a law or theory. The theory of evolution is based on the observation and description of different animal and plant species found in different locations, as synthesized by Darwin in 1859. This theory emerged from specific questions, which were asked by Darwin (and others) within a temporal cultural milieu and using western scientific methodology the answers supported the theory of evolution. Even though the western scientific criteria of falsifiability (Popper, 1968) as a truth determinant cannot be applied to this theory, from a western scientific perspective, the theory of evolution stands as the best logical construct from the given factual data. In traditional knowledge an understanding of natural events is arrived at using intellectual, emotional, physical and spiritual aspects of a four-part person (*Nehiyaw*), not just the intellectual rational/logical cognitive domain.

As referred to in Chapter 3, when using western scientific methods to define traditional knowledge from a Eurocentric perspective, the essence of the meaning of traditional knowledge can be obscured. Traditional knowledge includes personal interpretation. "I think traditional knowledge is more. It's [western science] not the personal feeling, it's to pass on the information" (Aboriginal Educator). When understanding is defined as making connections between discrete bits of information, as in synthesis, then from the data in this study, understanding in traditional knowledge can be described as a personal endeavour where the act of creating understanding emerges from an individual's own belief structure, including their experiences. The process of understanding includes connecting self-reflection with external content (Pert, 1997; Ross, 1992; Wright, 2004). During this research I encountered Elders with a highly developed ability to assess my personal understanding of their worldview, as in the example of my being held accountable for past Aboriginal genocide (see example below).

When the borders of our epistemology (as in systems of thinking and knowing) are defined by our culture, then by expanding our knowledge base we expand the borders of our understanding (Smith, 2002). From a Eurocentric perspective, when we encounter other ways of knowing, we accept or reject them using specific culturally determined criteria for truth, for example—by using western scientific methodology for deriving factual evidence. A static Eurocentric stance preserves the hegemony of that culture (Smith, 2002; Smith, 2004; Stewart-Harawira, 2005). From another cultural perspective, Cree stories of Windego give the possibility of a conceptual infection that allows an individual to kill and eat his/her own people, metaphorically representing of one part of humanity culturally 'killing' another part of humanity. Historically Smith (2004) and Stewart-Harawa (2005) give evidence that western scientific culture coming-to-know traditional knowledge has resulted in cultural genocide (Smith, 2004).

Outside of one sweatlodge, during my research, I was held accountable for this approach. An Elder asked me to account for my ancestors taking land and water from indigenous people through an 1858 Treaty (possibly referring to Treaty 8). His ancestors did not know what they were signing away. By assessing my responses to his questions he determined my intentions and ability to understand his worldview, and invited me for further conversation with: "You can talk to me now." His perceptual construct of the complete situation allowed him to open dialogue with me and demonstrated his understanding from a traditional knowledge perspective.

5.6 Language

5.6.1 Examples

In science education, language has been identified by many researchers as an important factor in Aboriginal education (Aikenhead, 1999; Battiste, 2003; Cajete, 2000; Cruickshank, 1992; Hampton, 1999; Kawagley, 1995; MacIvor, 1995; Shiza, 2005; Snively & Corsiglia, 2001; Wilson, 2003)[43]. The course content of high school science in Alberta uses detailed English definitions of words, often nouns, many of which are specific to one of three science disciplines: physics, chemistry or biology (as, for example: momentum, mole or symbiosis respectively). Western scientific terminology classifies objects in the natural world resulting in detailed sub-specialty studies such as psychoimmunoneuropharmacology. In contrast, verb-based Aboriginal words in, for example, Cree, Blackfoot or Dene/Sioux languages are used to describe wholistic interrelated processes (Peat, 2002). The use of Aboriginal language in the science classroom was identified in this study as one aspect of an

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[43] Scientific language (terminology) has also been identified as a barrier for non-Aboriginal students and science. A border-crossing model could also be used in this context.

interconnected nexus of metaphoric meaning, narrative, Elder, oral tradition, community and relationship.

Specifically, place names were used as an example of wholistic language use by one Dene Elder, John B. Zoe (Tlicho)[44]. The Dene use a place name to locate more than a position in space: it describes a relationship between humans and the surrounding environment. For example seven types of tree names are related to the soil in which they grow (muskeg, clay, sand, gravel, rock, silt or black soil), which in turn suggests animals present and method of travel. A place name can include information about mammals (e.g., moose and mink), fish (e.g., jackfish, whitefish and trout), the method of hunting and the method of traveling in that area. It suggests what other living things exist there, what methods of harvesting can be used (e.g., rules of hunting), and the relationship between types of soil and plant or tree growth. A place name provides a "knowledge structure/framework" of an area. The place name *Ewapi* (Dene) means "poke it in the mouth" which describes a time for fishing when fish can be caught using a hooked stick. In Cree the place name *Aniipsiskaach* is "a damp place where willow grows" and means that beaver live there, the bottom has mud, the water is warmer, and *wiiskitimwii* (water lily) and *niipisiy* (willow) grow there. Place names such as these demonstrate embedded diachronic knowledge within the name.

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[44] Canadian Council on Learning (CCL) Conference, March, 2007)

5.6.2 Language and science teaching

In addition to using language which expresses diachronic knowledge (above), Aboriginal languages contain scientific concepts (Cajete, 2000; Peat, 2002).

According to Aikenhead (2006, p. 107-109) using Aboriginal language in the science classroom is a positive pedagogical methodology when teaching both native and non-native students. Aikenhead also suggests that the use of Cree in teaching a class that includes Cree students pedagogically demonstrates valuing the language and culture of those students. This, in turn, affects the student's view of western science, school science, their science teacher and their views of self (p. 108). This principle can also be applied to other cultures in a multicultural classroom.

One participant explained that when instruction was in only in English, Cree speaking students were disadvantaged. For students not fluent in English, reconceptualizing concepts formerly familiar to them in their own language is problematic. Additionally, new concepts using English scientific terminology present problems that English-speaking students do not encounter. Abstract conceptual words (such as mass or energy) might not be associated with the same definition in the student's own native language. Conversely, some abstract conceptual woodland Cree words such as *sakawaskum* (from Leonard Cardinal) cannot be simply translated by the English word forest. Directly translating the Cree verb *noetin* to the English verb 'catch' omits a scientific meaning found in Cree, where the integrity of the object is preserved in the transfer (Wilson, 2002).

Another participant (Aboriginal educator) described the use of English-only discourse in a classroom including native students as reflecting a hegemonic stance, devaluing native students' culture and eroding their self-esteem. In Zimbabwe, Shiza (2005) observed that in a Shona Grade 7 science class the students did not respond to teacher initiated questions when taught only in English. The result was that "students become reluctant participants in class discussions and withdraw from interaction with the teacher" (p. 106). For Aboriginal students this may result in students becoming what Aikenhead (1999, p. 105) categorizes as "I don't know" or "outsiders" in science classrooms. Unlike their non-Aboriginal counterparts, students with an Aboriginal first language must adopt strategies for coping with the foreign language and concepts of western science education (C.C.L. Conference, March, 2007).

Another participant (Cree Educator) identified the triad of language, teaching and culture as part of an interconnected nexus, where teaching and learning in Cree occurred concurrently in pedagogy of actively engaging in cultural activities. This is in keeping with Kawagley's (1995) approach, where a fishing camp experience was used to teach high school science concepts.

Historically, hegemonic approaches to education have typically resulted in the rejection of the use of Aboriginal language, as occurred in residential schools (ref. pp. 136-137). Aboriginal language fluency by teachers was suggested as a requirement to facilitate understanding of traditional knowledge. This conversation with a Cree Elder highlights Cree use of diachronic knowledge:

JM: A lot of the wisdom people are dying off. That's one of the ways of cutting the branch we're sitting on. The wisdom that has helped mankind has been outlawed. So it's actually in the BNA and under the Canadian government, Sir John A. Macdonald and others; illegal to speak our language and *our language is one of our foundations of knowing.* All things have root words in traditional language and the root words… once we understand them we see that the next [connection is the] spirit of things.

I: Can I understand traditional knowledge without knowing the language?

JM: Up to a point. But a lot of it is *thousands of years of being in certain geographic regions.* We all have slightly different interpretations, I guess, to different languages of traditional people.

Language also forms a nexus with community where language and community are interconnected through narratives. Community is located in a specific place (i.e., landscape). The use of native language in narrative can create an understanding of an individual's location in that community which cannot be reproduced by using another language. As one respondent put it: "The story makes the community because it comes from the landscape" (Stan Wilson class, 2002; Chapter 5, 5.12 Community, p. 172).

5.7 Language and Narrative

5.7.1 Metaphoric meaning and language

Metaphoric understanding is often transmitted through narratives in traditional knowledge. Narratives can generate metaphoric understanding through suggesting common experiences. Knowledge enfolded within 'stories' can reflect a relationship between people within a community and nature (Cajete, 2000). The use of strictly noun-based English words in science classes leads to an exclusion of this understanding of relationship through common experience. Although narratives have previously been considered "non-scientific", ecology, by using a concept from complexity science, is presently using narratives to expand a restricted noun-based understanding of scientific knowledge to include the process of interrelationships. Aboriginal science teachings can thus inform western science. This learning can come about either directly or by reflecting on epistemological differences between western science and traditional knowledge.

The Cree Elder JM quoted above described the importance of traditional knowledge using a tree metaphor and linked, through the activity of cutting a branch, the difference in approaching natural events from a western scientific perspective and from a traditional knowledge perspective. The loss of the buffalo and the Buffalo People historically represents the result of using a strictly western cultural (scientific) perspective as a basis for social government action. This Elder further explained this historic influence of western scientific culture using a tree branch metaphor in an interconnected nexus:

JM: We don't have that much time. Because we put all our emphasis, maybe Dr. Suzuki would say 'old grandpa said', in overemphasizing western scientific knowledge and not enough of natural laws. And natural laws are basically to know *all is part of me*, but I can't overexpose or manipulate the other. Whether the other is a person or water or air. I can't overexploit nature and so it contaminates layer by layer. So it's the balancing of the two. And along with discipline and wisdom it can be related to my appetites. Emotional appetites or physical appetites like sexual appetites without discipline promotes overpopulation of the world. And when you have overpopulation, each will also influence the other. Its wants and needs are self-satisfaction, instant gratification is self-satisfaction of sorts. And then you need to kill more trees to provide more material for housing, for furniture and so forth. This is how we slowly kill life in a branch and instead of trimming off the small part of the branch; *we're cutting off the branch that we're sitting on* that's next to the tree itself. We're cutting ourselves down. That's basically the traditional [knowledge] concept that western scientific knowledge hasn't [got]. Balance and discipline would be: cut the smaller part away from the tree, so that you have the stability, the balance.

I: So would western scientific knowledge be the ability to cut and it's missing the understanding of where to cut and how to cut so you're still keeping the tree alive?

JM:And yourself. You're cutting yourself off. Like, you're sitting on the branch that's connected right to the tree and you're sawing it down. But you're cutting the opposite way…and that's, I think, one of the ways to look at science. Wherever we go now we hear stories of making deserts out of lands and as we do that, we over manipulate, exploit resources, we cause extinction of certain species. Each has its own place here and then

> when we put ourselves ahead we also sacrifice for mental extinction. So a little bit of ourselves is gone. Our self important...[pause]
>
> So traditional wisdom [knowledge] is to understand that and not to cause extinction of any other. And the prime example of that would be the story we hear again and again from the buffalo tribes, south of where we are, the U.S. The buffalo tribes depended on the buffalo for everything and every part of the buffalo was used, right up to even its spirit. They have a direction even in some of the ceremonies—a buffalo skull. And when another culture comes in and guns them all down, it not only kills the spiritual belief of the people, but it also causes the extinction of what belongs here, is part of here, the buffalo. So the near extinction and the culture that uses every part of that, that culture is going to get undermined by the dominating culture. If my sole belief and purpose is only western science alone and, of course, with power and technology put into play. And so that's part of balance, part of the natural laws is how [if] these people [i.e., Eurocentric] have been into their own power and understanding they would never have done that.

One approach to this tree branch narrative is that humans are one species branch of many species branches, we are not the tree trunk; the interconnection with all the other branches provides sustainability for all other life forms. JM. is suggesting that a purely western scientific approach does not distinguish between the branch (i.e., humans) and the tree trunk (i.e., nature) but that this distinction is made in traditional knowledge. An approach of focusing on economic determinism, self-pleasure, or elevating the human condition above that of the natural world, cuts off humans from the "source of life on earth" (i.e., the tree trunk). The result of this separation hurts humans, and affects the environment on which all life depends. Overpopulation, accumulating material possessions and food, global warming and potential viral pandemics are natural results of human action taken based on a perspective where humankind is unaware of "sitting on the branch he is sawing off".

Bohm's (1980) description of holomovement where light, for example, has within it an enfolded (implicate) order which connects it to the universe as a whole (pp. 190-199) corresponds, it could be argued, to what this Elder identified as a Cree approach to viewing objects in the world. Where a western scientific noun-based language places natural objects as fragmented things, a verb-based traditional knowledge language presents things in relationship to each other and the universe as a whole, identified as Natural Law by this participant.

In English scientific terminology, waves on a water surface are defined as individual objects; independent of the medium they are traveling through or other proximal waves. Hopi describe waves on the surface of a lake by their relationship to each other and the whole body of water. " Hopi say *walalata* meaning 'plural waving occurs', and can call attention to one place in the waving..." (Whorf, 1950, p. 262). From this wholistic perspective Hopi have superior scientific terminology (p. 262). "[W]ithout the projection of language no one ever saw a single wave" (p. 262)[45]; because individual waves rarely exist in nature. A Nuu Chah Nulth Elder used the expression *hishtukish ts'a wak* (everything is one) to express this wholistic concept.

The English noun 'knowledge' has no direct translation in Cree. Empirically derived western scientific knowledge comes from actions taken in the world using a specific methodology: experimentation. From a reductionist perspective the accumulation of detailed facts results in analytical knowledge. As referred to in Chapter 3, an underlying assumption of this perspective is that the observer is distinct/separated from the observed. The noun knowledge is used in this sense in western science to identify a collection of accumulated results derived from this methodology. In Cree, the language used is more fluid. Dynamic action indicated by verbs is understood to be a primary element, as in *kiskeyimew ttam* where the use of the term 'way-of-knowing' reflects an activity (Wilson, 2002). If the English noun 'knowledge' included the meaning 'way-of-knowing' as a methodology from which it is derived, then this definition of knowledge would more accurately correspond to the Cree phrase, where the meaning of knowledge includes the relationship between facts and how they were derived. This would result in a broader meaning of knowledge, encompassing

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[45] The Whorf Hypothesis (formerly Sapir-Whorf Hypothesis) combines linguistic determinism: what one thinks is determined by language; and linguistic relativity: different languages reflect different worldviews. From a Eurocentric worldview, Kant argues that all humans structure reality into specific categories (S. Romaine, (1994). Oxford: Oxford University Press).

wholistic concepts such as metaphoric understanding. These concepts are included in the Cree term *kikeyimew ttam*; not in the English noun knowledge.

Within the context of relating western science and traditional knowledge, another meaning emerges from the phrase "the story makes the community because it comes from the landscape" (5.10 Community): language, stories, narratives and relationship form an interconnected nexus with community. The implications of this meaning would not be well understood, however, by a typical educational science curriculum development committee, where the focus is on which facts are deemed important, how they should be arranged as 'product' and how they can be assessed as 'learned'. Participants in this study suggested including an examination of the way of knowing or process as integral to curriculum development.

5.8 Narrative

5.8.1 Example

> Discoveries like the use of fire, coming-to-know key ecological relationships and responsibilities to the natural world, having a sense of how things began and how things are in the natural order, the domestication of animals and plants through agriculture, the innate affiliation humans have with nature, and understanding the order and cycles of nature are among the first elements of science. From this view, science becomes essentially a story… (Cajete, 2000, p. 13)

In traditional knowledge 'stories' have been identified as general stories, legends, personal or historical stories, and creation or spiritual stories (Chapter 3).

One type of 'story' or narrative describes an event or experience of the storyteller. My use of the word narrative here specifies an instructive story where the intent is to attribute personal meaning for the listener/reader to the 'story' through insight. In science, it has been suggested that narratives be included within the content of the body of knowledge, not only for pedagogical support to pique student interest, but to give meaning and insight to the curricular material itself by presenting western scientific facts within a cultural context (Norris et. al., 2003; Aikenhead, 2006). Shizha (2005, p. 102) and Geelan (2003) have identified this use of narrative in science teaching as important in order to go beyond knowledge of objective detailed facts to an understanding of the individual's personal connection with scientific concepts. Aikenhead (2006) terms this 'humanistic' science (p.3).

The following is an example of a narrative. I have been given permission to recount it here by the storyteller. It illustrates to me how a narrative can give metaphoric meaning to a scientific concept of human's relationship to and understanding of nature. In writing this down the richness of orality is lost, including subtle vocal and facial nuances, texture, relationship with the listener and my own remembering of it (Wilson, 2002). It was not tape-recorded; I write it as I remember it:

> A tribe was traveling to a new camp. The last person was a mother leading a horse with a travois that contained a tightly wrapped comfortable papoose. When passing a buffalo herd, the papoose fell off, unnoticed by the mother. The tribe continued traveling and did not return for the baby.

A bull buffalo approached the strange bundle and found a child. He carried the child between his horns to the herd where the buffalo sensed the child's plight and adopted him into their herd and looked after him. He stayed with the buffalo for many years and gradually became a buffalo. When he heard his own original tribe calling for the buffalo he led the buffalo herd to them where a few of his herd gave themselves to the tribe. Over the years he never felt that he was completely a buffalo and longed to return to his tribe. One day he left the herd and returned to his village. The Chief recognized a kinship with the buffalo/boy and welcomed him back to live with them. The buffalo/boy lived with his tribe while still retaining his buffalo form. Although happy to be once again with his tribe, he felt a longing to rejoin his buffalo herd. He could not do both. He asked for advice from the tribe's medicine man. He was told to go out into the prairie and to roll. Rolling once would return him to his human form, twice and he would assume his buffalo form, three times and he would become a rock, part of the prairie; worshipped by his people and (rubbed against) by the buffalo. He went into the prairie. He rolled over once and became a man. He decided to roll over twice and assumed his buffalo form. He decided to roll over a third time and became a rock, which was located as a buffalo rock—*Mistaseni*—in central Saskatchewan.

The narrative continues into modern day. *Mistaseni* was to be covered in water by the Qu'Appelle Dam in 1960. Holes were drilled into it and it was dynamited into fragments.

To me this narrative evokes metaphoric meaning. A human relationship with nature can be interpreted by the listener (reader) of this narrative. Although Campbell (1991) identifies similar myths of "the Hero's Quest" (pp. 151-206) and "The Hunter" (pp. 90-101), the above narrative specifically gives metaphoric meaning to the dilemma of humans being dependent on nature (for food) while still being a part of nature. Other layered meanings may be understood by different individual listener/readers in different contexts. By bringing the narrative into modern context, where the physical object is destroyed from another cultural approach, fragmented by modern scientific technology, the narrative itself remains as traditional knowledge, where it continues to give metaphoric meaning by retelling it, often orally, by Elders in their own language.

5.9 Oral Tradition and Elders

5.9.1. Oral tradition and community

The use of oral tradition has been shown above to be interconnected with the use of narratives in classrooms, to the concept of community and to metaphoric meaning. Oral tradition is one methodology in which 'stories' can be told in relationship between the storyteller and the listener; eliciting metaphoric meaning, and creating and recreating community context (Cajete, 2000).

The absence of oral tradition in education is illustrated by Silko (1981) below. Oral tradition is used in a traditional knowledge teaching/learning complex. The ability to listen and remember what is heard (and for the listener to continue the story) is an Aboriginal educational methodology (Wilson, 2002).

Silko (1981) uses narrative and metaphoric meaning to illustrate the extermination of this methodology in residential school structures:

> She must have realized
>
> That the atmosphere and condition which had maintained this oral tradition in Laguna culture
>
> Had been irrevocably altered by the European intrusion—
>
> principally by the practice of taking the children away from Laguna to Indian schools,
>
> Taking the children away from the tellers who had
>
> In all past generations
>
> Told the children
>
> An entire culture, an entire identity of a people.
>
> ....
>
> As with any generation
>
> The oral tradition depends upon each person
>
> Listening remembering a portion
>
> And it is together—
>
> All of us remembering what we have heard together—
>
> That creates the whole story
>
> The long story of the people. (pp. 6—7)

Although a part of any discussion of Aboriginal education includes the genocide effect of residential schooling, detailing this genocide is beyond the scope of this study. One participant identified the importance of the inclusion of experiential learning, narratives and orality in Aboriginal education using a residential schooling example:

> I believe that 40% of Aboriginal people over the age of fifty-five—I believe that is the stat.—have been in residential school or were in some form of an institution when they were younger. This created kind of that...barrier in negative feelings towards institution. So they, kind of practice, even their children... have lots of anger towards it and then their kids go to school and they still have that... do you know what I mean? It's like a vicious cycle that keeps going. So I think that's one problem and then also, Aboriginal people seem to value things differently. They don't value sitting there reading their textbook. Some may, some may—but not all. (Aboriginal Educator)

Another participant described his experience as: "When they kidnapped me, I lost being educated. Only when I escaped, did I begin my re-education." (JM, Cree Elder)

Framing of Aboriginal ways of knowing culturally has undergone a transition from E. R. Young in 1890 (cited in Urion, 1999) who posed the question: "Which must come first—'Christianization' of the 'Indian' or 'his' adoption of 'civilization'? " (p. 7). Although a different framework is used today, Eurocentric culture continues to separate 'Indian' from 'Non-Indian' thinking. However, Aboriginal ways of knowing are becoming valued in education; they have something to contribute to the science classroom (Jenkins et. al., 2007; Alberta Education, 2006). A change in the concept of bracket fungus curriculum infusion to include metaphoric meaning, relationship, community, language, narratives, oral tradition and Elders from an Aboriginal perspective would represented both worldviews in the science classroom. Aikenhead (2006), for example, includes indigenous sciences in his description of humanistic science (pp. 112-114).

The use of narrative in oral tradition is inextricably interconnected within the web of community, relationship, language and metaphoric meaning. Community involvement plays a critical element in orally retaining and passing on traditional knowledge. As each person contributes their piece of personal understanding of a narrative to a group, the group as a whole (the community) develops a larger concept (Wilson, 2002). Statements that resonate within—have meaning to—an individual (Aoki, 1991) elicit an emotional response; they generate synthesized understanding, which differs from knowledge of accumulating detailed facts. Participants indicated that science classes assess the latter; traditional knowledge values the former.

5.9.2 Elders

In response to question 2 one participant (L) asked: "How about incorporating Elders more in the classroom?" Another participant reiterated this suggestion giving such reasons as: Elders carry with them the knowledge of the community, gained through the Elder's experience and expressed as wisdom; and Elders design discussions to fit the needs of the listener. The absence of Elder presence in classrooms was suggested as reflecting a difference in worldview where one cultural orientation depends on institutionally defined accreditation for defining a teacher, while the other cultural orientation values community supported individuals tested by life experience as teacher determinants.

Some participants again pointed out that educational institutions such as Alberta Education have demonstrated overlapping worldviews by recognizing the importance of including Elders in developing curriculum materials (e.g., the course entitled Cree Language and Culture) and in guiding school (e.g., Amiskwaciy and Ben Calf Robe) administrators and teachers. Saskatchewan Learning presently funds the Aboriginal Elder/Outreach Program to bring Aboriginal Elders, cultural advisors and other Aboriginal resource people into schools and to link students to Aboriginal traditions and knowledge.[46] However, most Aboriginal educational institutions are administrated and taught by non-Aboriginals (Battiste, 2005). Participants in this study described this as a deficiency rather than a positive element for Aboriginal education.

Elders were specifically valued in education for imparting their wisdom as teachers:

> L: I think it's getting to the point where we have to–because its not enough interest—there's not enough people or even like Aboriginal youth who are willing to learn and go to an Elder and give an offering and take what they have to say and come back and wait. I heard an Elder speak once and he said it takes four years to get a university degree. It will take sixty years

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[46] C.C.L.: The Cultural Divide in Science Education for Aboriginal Learners, Februrary 8, 2007, (www.ccl—cca.ca/CCL/Reports).

and you will still not know (become) an Elder, in terms of traditional knowledge.

She continued describing the difference between learning from an Elder and learning in school:

L: And whereas traditional knowledge...if you go to an Elder and ask them for their advice or for help on answering a question, they're not going to say: "um a, b, c: these are the answers." They're going to say something like tell you a story or you'll have a conversation with them, and you'll have to find the answers yourself. So you have to think. It's not like handing it to you on a silver platter.

She compared an Elder's knowledge to that found in libraries:

L: You, you can record information and put it in print form, if you have permission from Elders, like…videotaping. I read a poster once on one of my prof's door that says every time an Elder dies it's like a library is burning down. They have so much information that isn't … if they pass away before someone has caught that information or knowledge, then it's lost.

Interviewees gave the inclusion of Elder teachings' within a community school as a critical element in Aboriginal education. The following example includes education as one part of an interconnected nexus of relationship, community, and experienced Elders:

L: ...some of the people that should be in the profession [teaching] aren't because they didn't get the grades to get into the faculty or they don't have the finances to do it or there's politics around it–you don't have a degree. One example was there was a professor here who taught [ ]and [ ]. Amazing—one of the best teachers I've ever had. She was fired because she did not have a degree. Then they brought in another woman who had a degree… and then she up and left half way through the semester, and then they called the original lady who didn't have a degree, to come back. Had they just kept her—the one who was passionate about her job, loved her job, but didn't have the formal education to do her job…there would never have been…[this problem].

Elders' value in creating humanistic relationships with students was contrasted with an institutional concept of impersonal teachers:

L: …youth or children: they can also be knowledgeable. You can learn from them. They show something and then you're like, "wow, why didn't I think of that?" Some teachers will look at children and "I know more than them". Whereas a traditional, like an Elder, wouldn't say, "I know more than someone". They would never say that. They would be like, "I may know this, but I don't know this. I don't know everything."

My uses of Elder quotations in this thesis indicate the central value of Elders as educators. In conducting this research from a western scientific perspective, I was being educated in the process of coming-to-know traditional knowledge by Elders. While a western scientific approach analyses Elder comments as "data", from these comments I identify my interpretation and elicit from the reader their own interpretation. In this way I respectfully present Elder comments as "data" for this thesis.

5.10 Wholistic Education

5.10.1 Eurocentric thought

A difference in worldviews as expressed in educational institutions was described here as a difference between wholistic (in Aboriginal) and economic determinism (in Eurocentric). Aboriginal Educator L described science taught in classrooms as culturally biased, and criticized the Eurocentric context of western scientific thought:

L: They're all those scientific people that are...from the same social class, same race, probably had most of the same beliefs and western science [is the] basis [of] all their views and opinions, or stems...their research stems from the research of western scientists, so it kind of funnels down. It doesn't really...it doesn't really change because it doesn't ...it's creating Eurocentric minds here, I guess. Eurocentric thought.

I: So what's wrong with that?

L: It's destroying the entire world. It's destroying that world that's supposed to house everybody for the next...I don't know...ten thousand years. It seems like this is, I think this is the main difference: Aboriginal people want generation after generation, my grandkids, my great grand kids, my future generation. Whereas people like scientists, engineers... they look in the next ten years we will do this. But they don't think in a hundred years...up north may be like this—because we destroyed all of it.

She identified western scientific research methodology as flawed, when based on economic determinism, and applied this concept to learning from the results of residential schooling:

L: Look at that drug Vioxx. That is a huge stain [error]. It's great for the arthritis, you just take Vioxx. They didn't research long enough and look at what it did: it killed a guy—he had a heart attack from Vioxx—it causes cardiac arrest. So that's what I mean: they find this medicine and you know, and they push it into the public and then they don't wait long enough to find out the actual results of what's going to happen. Like look at residential schools—I mean eighteen sixties and you know when the last one closes? in nineteen ninety six. Had they known what the results from those would happen....what's going on today...I don't know if they would have done it. Maybe they would have, I don't know.

Her last statement parallels that of JM (above) for whom the concept of Residential Schools would not have occurred if traditional knowledge epistemology were educationally applied instead of using a western scientific cultural epistemology.

5.10.2 Teachers and cultural hegemony

Teachers exhibiting racism as part of the school community was given as one reason for Aboriginal students not attending science classes. L related the development of the student's self-image to western cultural school norms in classrooms:

L: I think one of the other problems is a lot of kids are stereotyped when they're Aboriginal—like who they are as Aboriginal people.

I: By their science teachers?

L: By the teachers, by society, by everybody: that they don't want to accept or like… adopt that portion and be proud of it and who they are. Like I'm not saying all, but a lot of them—and they'll make jokes about it—like they aren't comfortable with who they are yet so…

I: So the kids make jokes?

L: Yeah.

I: About themselves?

L: About themselves being Native. Or, um, they joke, I'm going to quote them: "Oh you're just another drunken Indian"—like that kind of stuff stigmatizes children so that they don't want to learn, so they don't want to learn what the Elders know—traditional knowledge, how to balance your life. You're not going to be able to, there's going—its still going to be there—unbalance and …

I: Yes, go ahead.

L: There was an article I read, um, putting the elephant back into the refrigerator and one beige crayon, and it talked about people who aren't accepting of who they are often will crack jokes and little comments and if someone else makes a joke, they'll laugh about it; but deep down, they're really upset about it—like they don't say "Oh you offended me" and like

"You really shouldn't say that"—they just haven't come to terms, but maybe later in life they will.

L discussed school culture as affecting student achievement in science. In reference to an urban Aboriginal school where she had been a student teacher, she compared transitory teachers to more permanent community Elders in terms of teacher commitment:

L: You must be willing to put the time in. And there are some teachers—even in inner city schools—who go there, and work there eight till four, then they leave. Then they don't stop doing everything else—like this may be a safe haven for the kids—they, do you know what I mean? They [students], this is maybe the only time they eat here, is at school for the hot lunch. I don't know, there's some people who don't think—factor in—that until afterwards.

The importance of a teacher's ability to recognize students as individuals, and a teacher's ability to express empathy for students (humanistic education) also emerged:

L: We're missing empathy. Understanding the kids, looking at the kids, and finding out more than just their name and their favourite music or what are their...because maybe if we looked at their interests in science: 'what do you want to learn in science?'

Participants in this study described Elders as critical in Aboriginal education for their wisdom, their way of regarding students, and their way using cultural knowledge to support student's self image. By excluding Elders in schools, school communities were described as exhibiting racism, ignoring a source of knowledge and helping create conflict between Aboriginal student's cultural norms and Eurocentric norms.

Although initial questions for participants were specifically directed towards science education (Appendix 1), participant responses often addressed education in general. The following examples portray interconnected educational concepts of language (animate), experience, four part person, balance and discipline.

5.10.3 Animate and inanimate

Western scientific logic clearly defines the difference between animate and inanimate by using Aristotelian categories of A and Not-A.[47] Traditional knowledge descriptions of nature centralize the existence of an interconnected whole as animate (Peat, 2002). This ontological difference is reflected by two languages—one using nouns to describe fragmented objects in the world—the other using verbs to describe interrelated objects and processes. Cree language describes an animate world where objects exist in relationship with each other (Peat, 2002) and "[i]n Blackfoot there's nothing inanimate" (Little Bear, 2004, p. 17). One response to Question 7 ('Are all things interconnected? In what sense are

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[47] Inuit have sophisticated non-Aristotelian classification systems of animals and plants based on an interrelationship between their relevance or practical use, behaviour and appearance. Ptarmigans (*aquiggit*) belong both to part of a group that stays north all winter (*ukiuqtait*) and to a group of herbivores, those that eat the products of the earth (*nunatuqtiit*) (ANKN, p. 73).

all things living?', Appendix1) by an Aboriginal educator was this description connecting animate and inanimate, and discussing living with spirit:

L: Yes, they are connected. Even rocks are alive. Even dirt. Most people look at dirt and they think "Oh no its not" [alive]. Well, if your dirt is dead, plants won't grow in it and survive. It has to be alive. Rocks are like grandfathers. Some friends were going on a tour through the forest and she kicked the rock and the guy [said] "today you just kicked someone's soul".

5.10.4 Experiential knowledge

This Aboriginal educator compared learning in a fishing experience with learning in a science laboratory:

R: ...and my dad would take me fishing, and stuff like that, and I used to get upset in school in science where I'd have to dissect a frog. Dissect these big gross crickets—like grasshoppers.

I: Locusts? Yes?

R: Yeah—huge grasshoppers. Yeah, he would take me fishing and we'd, he'd catch a fish, and he'd cut open the fish and he'd show me the anatomy of the fish. And he'd clean it, and he'd cook it and eat it. It wasn't like it was science....

I: It made sense?

R: Yeah. It wasn't like it was just the...its this big locust, that was bred to be taken apart by kids in the seventh or eighth grade or whatever grade it was, like I, I think that [fishing example] needs to be incorporated into the classroom where its just—like baby pigs in bio.—that's horrible...[continued below].

R continues identifying respect for life as a missing element when using a western scientific approach to dissection of an inanimate object in school laboratories, describes nature as an interconnected whole, and values experiential knowledge:

R: Think of it, it's like you're wasting it. It's uh...I'm sure that if the Creator thought that...I don't know how many baby pigs we use in a year for bio... but if they thought that many baby pigs were going to be grown just to be stuck in formaldehyde for kids to dissect, I'm sure something different would happen. Whereas...I don't hunt, but my dad hunts...and he'd show...they use everything! Everything, nothing's wasted.

I: So would you be missing something if you're learning western science and dissecting pigs and frogs and locusts?

R: Yeah. I think you would. Because everything, like life, it's all connected, it's all interconnected...

I: Yes?

R: ...and if you don't leave the classroom, and you're just in there dissecting all this stuff, honestly, I would learn better by going into the woods and learning the lifecycle of a coniferous tree than I would reading in a textbook.

I think it would be more memorable; it would be more empowering. I don't remember the life cycle of a coniferous tree...

I: Right

R: …but I remember I studied that [in school]. I don't remember anything about dissecting an eyeball, but I did that. The one thing I do remember is going and seeing the lungs of a smoker at the hospital.

I: An experience?

R: An experience! Because that was unbelievable!

5.10.5 Four part person, balance and discipline

Many participants claimed that including experiential knowledge in the science curriculum adds an element of balance: "You need balance in the curriculum, if there's no balance, it's not going to work" (Cree Educator). In science classes participants suggested including experiential learning to achieve a resulting balance, typifying a wholistic approach for Aboriginal education:

R: Yeah, the whole wholistic approach, the balance of a medicine wheel. Cause if you look, they [Aboriginal people] have this physical, emotional, mental and spiritual… [but western] science is like physical and mental, only those two.

When asked the question: "In teaching western science, how could traditional knowledge be incorporated?" (Chapter 4, specific questions for educators, q. 4, p. 96), this respondent, using a wholistic concept of traditional knowledge, connected her previous comments about pig dissection with balancing the physical, emotional, mental and spiritual elements of students:

R: Yeah, whereas traditional knowledge includes spiritual and emotional. So I would think that maybe creating that connection more…like balancing more...like balancing it out, so kids have a...there's some meaning behind the dissection of a baby pig.

To her, a *Nehiyaw* concept of engaging all four aspects of being human applies to science education for all students. Traditional knowledge is again described as engaging the student as a whole person by this Cree Elder:

JM: We see it as maybe water, we see it maybe as oil or gas, and when you suck it out and then you burn it...how it affects everything else.... There's a complete recycling of all things but when you start to burn gas and oil it's no longer a recycle. It's out there now, it's in the air and today you know of acid rain and so forth, burning a hole in the ozone layer. These are all things they could have asked us years ago and we would have told them. But [western] science sees itself as the only thing, the only way [of knowing]. They can't see we're actually driving ourselves out of existence and I think that's the difference between the two disciplines: physical, tangible, western scientific knowledge and the authentic traditional wisdom. One that acknowledges the head, [while in] the other wisdom is in the whole being. (Cree Elder)

Another aspect of science education is described when scientific knowledge excludes ethical considerations. Science in this respect can be understood wholistically by engaging the whole person (Cree: *Nehiyaw*–four part person). Again this Cree Elder suggests that by teaching students as whole persons, ethical considerations become included:

JM: You totally overlook the balance of all things and the good in one another when we rely only on a degree and nothing else. Do I use it [western scientific degree] to manipulate and exploit other people or do I use it to exploit nature? If that's my sole effect and, this is what I said earlier, this is how we are beginning to garbage ourselves out of the system because we are only looking at western scientific knowledge... in order to ease the work, the labor, it's more like pleasure, instant gratification. And that's all we go by and the degree we get, it's supposed to make it easier. For physical well being, mental well being, emotional well being and spiritual well being—that's not being addressed.

Fostering this balance and discipline in individual students was given as an educational goal by Cree Elder J:

J: ...in order to coexist with all things that are here you have to find a way to balance yourself: body, mind, heart and soul. The choices you make, where you put your focus of attention, whether it's western scientific knowledge or traditional wisdom. And that in turn partners with earth, water, air and fire. So if any of those are over tampered with, it begins to throw things out of whack, like a car tire that is out of balance and wobbling. I can actually do that to somebody else when I deliberately go out and try to maim and injure them emotionally. I may not realize that I am also maiming and injuring them spiritually and to a degree mentally; and that in turn will have an impact on their physical body. So when you look at earth, water, air and fire it's the same thing. I have to find that discipline and I have to find that balance and I have to live within that balance with all things.

He further describes a nexus where self knowledge and emotional well-being are an integral part of Aboriginal science and suggests an educational implication:

I: Should traditional knowledge be taught in school? If you were to have kids in science learning something, what would be the most important thing for them to learn?

J: It would have to be a number of things happening simultaneously. They would have to understand themselves, their emotional body. They'd have to look into that whatever way they can find whether its nature, fasting or vision quest. Whatever way they can find to connect with truth fully, something transcending within themselves. Whatever way they can find. You know when it works; you can see it in their attitude and their choices, what they make for themselves, and how they treat people. And the same with spiritual, emotional. So how you go about that 500 years ago, to find that sense of balance, to find that sense of discipline. So in the school systems today here's a lot of different things that pull them in every direction. You have cell phones, all of which distracts them, so the discipline gets slowly undermined. And they have videotapes and so forth when they go back home. The parents might be working so they're not there to discipline and maybe role model. So all they have in many cases is just a world of school, which is only geared to degrees and their own physical well being, making it easy.

You have to find a way, some form of human relations, something that will guide them towards their own self-discipline and balance-finding. And maybe nature walks periodically. Instead of just taking notes—memorize a smell, memorize a sound. Just be there, and maybe go and find your own place to sit and try to block out your own thoughts, your own feelings, and just try to pay attention to what's around you. Finding your own sense of rightness and see what comes to you.

5.10.6 Wholeness and fragmentation

Using the water cycle as an example, J (Cree Elder) contrasted a fragmented western scientific worldview with a wholistic traditional knowledge worldview:

J: The trees are the lungs. They're the hair of our mother earth and it takes in the moisture and puts it back up. And while it's up there, [it] helps shape the clouds until there's enough condensation to form a single raindrop. And on its way down, if that little rain drop could think and talk, it might think of itself as an individual until it hits the big lake and only then it sees that its part of the all—collective body of water. Water is individual on one level. Its part of the all on another level. And so this is where I think science doesn't address that well enough. You can't see the tree for the forest. Not only that, it hasn't experienced enough of it. (Cree Elder)

This response reflects a basic ontological difference in worldviews. It is in keeping with Michie, Anlezark, and Uibo (1998) who point out a specific difference between Aboriginal perspectives and western scientific perspectives where people's place in the environment is described as "part of the environment (i.e., animate)" (p. 21) by Indigenous people whereas westerners see themselves as separate from it; reflecting the difference between a wholistic worldview and a fragmented one. One implication of this conceptual difference in western science is that by distancing ourselves from nature humans can own and control it. Recently references demonstrate that some western scientists are now beginning to accept the notion that we are a part of nature, not separate from it (Maturana & Varela, 1989; Suzuki, 1997; Gore, 2006). A wholistic approach requires an acknowledgement that there are elements of nature we don't understand, and that our interpretation of how nature works has the limitation that human thought imposes a structure on natural events, which are only reflective understandings of the event, not the event itself (as in Plato's allegory).

Science education is often approached using Aristotelian logic. A paradigm, once absorbed into scientific educational pedagogy, becomes a powerful operating metaphor. Bohm (1980) cites an example of how western scientific paradigms are influenced by culture. In this example, circular motion was seen by the Greeks (Aristotle) as perfect. Any aberration from this motion, as in planetary movement, was described by epicycle movement. Thus, for over a thousand years, observed planetary movement fit into the framework of epicyclical motion (Ptolemy), in spite of detailed observations of parabolic movement. Bohm suggests that today physics is operating under a similar illusion of reality, where "the concept of order is adjusted to fit the facts" (p. 143). After Kepler, Galileo and Copernicus, the operant western scientific concept or paradigm was one of mechanization, consisting of analyzable parts. Thus the use of Cartesian coordinates (implying order) became the prominent operating paradigm. Using these coordinates to order cognition about space and time still fits into the mechanical ordering of our cognition today. A Greek (Aristotelian) worldview could comprehend coordinate cognition, but it would have little application to a general wholistic concept of, for example, an animate (living) organism as given by Aristotle (p.144). Newtonian physics, as presently studied in Alberta Physics 20/30, is also based on a mechanical model: "As the apple falls, so is the motion of the moon, (i.e., A:B::C:D)" (Bohm, p.17). The operating paradigm of fragmented nature presented this way in high school science is not in keeping with more recent western scientific approaches to nature of a unified field (Einstein). Unified field theories are more synchronous and congruent with traditional knowledge descriptions of nature as a whole (Peat, 2002).

Two Nuu-Chah-Nulth Elders, David Frank and Lewis Joseph explained their concept of nature using metaphoric understanding of wholeness. They asked me, "How do I approach nature?" Using a coffee cup as representing nature, I pointed to the outside of the cup, indicating that western science approaches it from many directions. Lewis Joseph asked, "How do we Aboriginals do that?" When I replied, "I don't know", his answer was "*From within the cup*" [italics mine].

I interpret his response in the following way: All descriptions here come from a view starting within the cup and looking outward. If your approach is from within the cup, you will be able to encompass all directions. Western science, by approaching nature from outside, objectively, is seeing only one view. In looking at the metaphoric cup from the outside we need only one perspective to do so. From this single Eurocentric realist perspective, events 'in nature' can be categorized using binary Aristotelian logic as diametrically opposed: positive or negative, correct or incorrect, logical or illogical, and/or real or imaginary. However, when viewed as a part of the contents of the cup from the center outward, "nature" (see footnote 39) can be described as an interconnected whole such as when Suzuki (1997) states that we *are* the air, water, soil—not in a metaphoric sense, but literally. From this view we are connected to all things. When seen from the center outward, there are no dualities; dualities balance themselves. Polar opposites, as poles on earth, exist in relation to the center, the equator (Chapter 6). In stating this, I interpret the meaning of Lewis Joseph's metaphor through my personal subjective (phenomenological) understanding as: you do not objectify nature, you are nature. By combining metaphoric meaning with my experiential understanding, Lewis Joseph presented to me a model of a traditional knowledge approach, which I understood from my western scientific background (again, see footnote 39). Using my background as reference, through dialogue I understood the connection which existed between worldviews when presented from a traditional knowledge perspective. From a Eurocentric realist perspective, though their approaches are different, both western scientific and traditional knowledge perspectives are approaching a cup. This is not to say that it *is* the same cup for each person approaching it; only that when, for example, western science is taught from a quantum mechanical paradigm, some ontological concepts are coincidentally correlated.

A correlated western scientific example of this concept of wholeness is found in the work of David Bohm (1980) who ontologically describes wholeness from a theoretical physicist's perspective. In particle physics, Bohm explains the conceptual shift from viewing finite particles of determined motion and mass to viewing overall interconnected parts called 'undivided wholeness' (p. 159). He cites Einstein, who replaced rectilinear order and measure with curvilinear order and measure in describing gravitational fields. For Einstein, time and space are relative and connected to the observer. "Time and space have always been the same thing in Blackfoot, in Cree and many other native languages" (Little Bear, 1994, p. 70). Aboriginal people have long held the concept of a circular motion of natural events (Black Elk, 1959; Peat, 2002); and have used metaphoric meaning, such as living organism analogies[48], to explain natural events (Cajete, 2000). Conceptualizing wholeness in nature, where all parts are interrelated, would require a Kuhnian revolution in the present western scientific paradigm of approaching the natural world from specific determined points of reference to

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[48] "...for the circle helps us remember Wakan-tanka, who, like the circle has no end. There is much power in a circle, as I have often said; the birds know this for they fly in a circle, and build their homes in the form of a circle; this the coyotes also know, for they live in round holes in the ground" (Black Elk, 1959, p. 80).

include one of flexible, flowing movement; where specific points of reference are no longer central (Bohm, 1980; Greene, 2004). Although newly arrived at in western scientific theories of Einstein (relativity), Bohm (implicate order and wholeness), and complexity science; traditional knowledge has long held a wholistic concept of process and flow in describing nature (Peat, 2002). "In Hopi view time disappears and space is altered, so that it is no longer the homogenous and instantaneous timeless space of our supposed intuition or of classical Newtonian mechanics" (Whorf, 1950, pp. 58-59).

The above connections have not been addressed in Alberta science curriculum. The study of science (specifically classical Newtonian physics) in the Alberta high school curriculum does not reflect this ontological understanding of wholeness found in the western scientific theories of Einstein and Bohm, or in traditional knowledge. Ontologically, western scientific approaches in high school (e.g., Physics 20-30, Alberta Program of Studies) do not identify nature with a complete flowing of non-specific events, each one merging into the other. Thus, although the above examples demonstrate congruence in western science and traditional knowledge views of nature, in 2003 this concurrence was not addressed in high school science courses (Alberta Learning, 2003, Program of Studies). Some reasons for this discrepancy are given in 6.6 Relevant curriculum and 6.13 Hegemony. Inclusion of wholistic traditional knowledge in western science educational curriculum calls into question the nature of science and theories of knowledge—topics which are beginning to be implemented in Alberta science programs. Table 6.1 identifies some conceptual shifts necessary for this to occur. Participants did not give reasons, other than hegemonic, for this. Some suggestive reasons include: teacher unconsciousness—they have never thought about it; as education students they are not taught this topic; no foundational knowledge base, as in theories of knowledge, has been has been emphasized to support this expression; and this topic threatens the present *status quo* of western scientific ideology, supporting social privilege and power of an elite.

More recently (2007) however, the Physics 20 Program of Studies includes an initial framework for developing a nature of science emphasis where a discussion of this discrepancy can occur (Alberta Education, 2007). A specific emerging western scientific example of this is Peter Mahaffy's 2007 (King's College, Edmonton) computer visualization applets of individual versus communities of molecules.

5.10.7 Cultural implications

Cultural implications arise from the above discussion. Imposing one order of thinking on another–infusing one way of knowing into another—may be justified by a hierarchically determined order of knowledge value: one order of thinking is better than another. Imposing a western scientific worldview exclusively (without acknowledging other worldviews) in education is akin to teaching the Newtonian mechanical theory in the absence of relativity theory. Elements such as acausal synchronicity, uncertainty principle and discontinuous field theory become regarded as anomalies to this dominant theory. Starting from a wholistic viewpoint, using experiential understanding and gaining personal insight through a metaphoric story are regarded as 'non-scientific' in this dominant worldview and are ignored in the education curriculum as useful methodologies for obtaining an understanding of natural events such as described by Bohm (p. 171 and below).

Bohm argues that quantum theory, by definition, attempts to define 'states of systems' that have 'separate and autonomous' (p. 174) existences. But this is in conflict with the notion of giving meaning to particles through relativity, through the relationship between position in space and velocity. "Relativity theory is not compatible with such an analysis of the world into separate components" (p. 175). Traditional knowledge includes a concept of wholeness within its ontology. As a western scientist, Bohm presents an ontology that includes this concept of wholeness. Both ontologies coincide, as in the overlapping circle diagrams (Figure 2.1; Figure 5.1), but high school science courses in Alberta do not include this connection in their program of studies. One reason for this is a hegemonic disparity between the current western scientific thought presented in high school science courses and traditional knowledge.

Bohm uses metaphoric meaning to explain, from a western scientific perspective, the definition of wholeness by using the example of a carpet where the leaf pattern in a carpet is not relevant as a separate object, but as a whole pattern. He compares separate descriptions such as the observed object, the observing instrument, etc., as "aspects of a single overall pattern" (p.169). Likewise, the " relevant change in descriptive order required in the quantum theory is thus the dropping of the notion of analysis of the world into relatively autonomous parts, separately existent but in interaction. Rather, the primary emphasis is now on *undivided wholeness*, in which the observing instrument is not separate from what is observed" (p. 169, italics mine). This was expressed in this study by a Cree Elder as: "We are part of the all" in using the raindrop metaphor above.

5.11 Relationship

5.11.1 Nature as an object vs. nature as relationship

Relationship in traditional knowledge is described by participants as meaning more than a relationship between individual humans: it extends to a personal relationship with subject matter:

> M: What science calls ecosystems, I call my relations…and [I am] part of the all and the all is part of me. But [western] science…its like all of mankind is putting itself above and it could prove that mankind is higher than all. And those are all signs of weakness from the Native perspective, when one person puts themselves higher than a blade of grass. If they look at the DNA, the only thing different about it is the genetic coding or the formula, the [whole concept of] DNA is all the same. I think in traditional wisdom this is what they meant by the life experience as a nature of being. And I think this is where the difference is in [western] science: it wants to exploit and manipulate through all the variables and the 'tangibles' into mathematical equations. It [western science] sees nature as an object where we see it as a relative, that's the difference. (Cree Elder)

5.11.2 Relationship, experience and community

A Cree Elder suggested that now is the time for disclosing Elder's wisdom to those who have the capacity to understand/assimilate it into other existing belief structures. When western scientific knowledge, solely based on Greek *logos* (reason) with a limited/constrained perspective on nature, forms a barrier belief structure- it is termed scientism. Scientific methodology demands that only certain questions be asked which when scrutinized, reveal specific knowledge. Other questions, termed non-scientific, are beyond the boundaries of a western scientifically defined and circumscribed natural world. Participants suggested that from another perspective, because we live in nature, we are nature, and understanding 'how nature works' emerges from that lived in experience.

Competition was given as another barrier to connecting the western scientific and traditional knowledge approach:

L: Maybe create more of a community as opposed to individual things that [?] the individual, that whole aspect. Like competition—there's that competition in there that creates problems too. (Aboriginal educator)

The process of how students gain knowledge was considered as important as the knowledge itself. Here biology lab experiments are described as objectifying living things:

L: [...]med. students came and all these baby pigs, and the kids were suturing them up. It was good experience but I could..., I heard a couple of students say "What happens to the rest of the pig?" Or like "Why do we just have legs?" So they were kind of questioning that whole [concept],

> because usually when we take an animal out of context, most traditional kids would take an animal out of the environment and then they give an offering: they thank their spirit or something like that. (Aboriginal educator)

J, a Cree Elder, further suggested that the process of gaining knowledge, as in coming-to-know, included the emotional content of experience. He described experience based on relationship with nature:

> I: What is learning?
>
> J: It's from experience. Its just like it's a part of the all and the all is a part of us. From that standpoint, that physical body is not much different from the physical body of other things. And so my experience of that, the sounds and the sights, the smell of it and the sense of it on your skin and body hairs. That experience would stay in your mind, memory and your molecules of emotion and your body cells.
>
> I: So learning is not just memory but the experience of learning?
>
> J: Absolutely.

5.11.3 Wholistic experiential education and relationship

Wholistic education is described here as including all aspects of being human where one of the outcomes of this approach is a balanced four-part person. From this educational standpoint science is not considered separate from other subjects. Experience is one method of achieving this balance. Education is described by Cree Elder JM as a disciplined interconnection between experience and ideas, where the word 'discipline' refers to the activity of the mind's effort of synthesizing multiple aspects of experience into a single abstract idea and forming a concept outside of natural experience:

JM: We have to discipline that idea, collect these experiences of the natural world, through sound and smell and to experience it! And then that discipline and that experience combined, that's your education. Again that's the difference between reading and writing. It's not a total experience. It's only maybe mental, visual and maybe only hearing a little bit the way that the teacher is saying. But you haven't *gone out to learn to make that world.* It's in the book, inside of a pencil, onto the paper. It's still not the experience. (italics mine)

From a western scientific theoretical approach, factual knowledge is not necessarily directly connected to experiential knowledge, whereas to JM knowledge includes a relationship where humans are viewed wholistically as nature itself, not separate from it:

JM: You have to transcend beyond. You have to have the discipline. There's more to life than the world of academia and that knowledge. They've got to experience the natural way, that's sort of overlooked. When you experience...when you see a little bird falling off the nest, by people of the natural world (i.e., traditional knowledge worldview), they can really appreciate that, but if you read about it, it's totally different. You're not experiencing it anymore. If you see a picture of it but you're not lifting up the little bird and putting it into a nest and experiencing the mother screaming at you and laughing at you with the winds. It's just a story in the mind, but it's not an experience therefore it will have a totally different impact. So in the natural world, experience is totally different than in class, somebody else is sharing their experience but it's still not your experience.

It's not the person's experience, it's somebody else's experience and they're sharing it with you. So at every [other] level it has to be an experience in order to totally appreciate and understand all the different variables and the disciplines at every level. To begin to understand that we're part of nature and nature is part of us. Nature is not just something we can manipulate and exploit to make things easier for ourselves, like material things that come from nature. That is a separate experience altogether. To appreciate all of that you have to be in it. It's like somebody was telling me they'd gone to A. A. for thirty years until somebody tells him his attitude was still a 'sucky' attitude and then the guy told him; "You've gone to A. A. but have you been in A.A.?" So that is a delicate difference.

In reference to wholistic experiential education, L described Aboriginal education historically:

L: Wasn't that it was there prior, like say 100-150 years or 300 years ago? Isn't that [the] kind of approach we took for science, back then, I believe it is...I'm not quite sure. And somehow it's just adapted [evolved] .... (Aboriginal Educator)

When educating the whole person, R addressed the teacher's personal relationship, with and respect for the student was addressed:

R: Some frown upon crossing the… that fine line between professional teacher and personal one. I mean don't go over to their house and have dinner, but to know if your student likes to play basketball, they like hockey, what kind of music they listen to, that's fine. Half the time I had no clue what the music was, but I'm interested. To show an interest.

I: Because?

R: Because it shows a level of respect if you are interested in what your students do outside of the classroom.

Aboriginal education is described here as giving personal meaning to what is being learned. This respondent connected giving personal meaning to understanding the cycle of life with teacher's empathy: "Maybe if people understood that with death and you know like birth, toddlers, youth, adult, elder, and then death. Maybe there would be more understanding and passion…" (Aboriginal Educator)

A distinction was made between acceptance, tolerance and intolerance in referring to the teacher's relationship with the student:

R: I heard a good analogy: Acceptance—I have peas on my plate, these are not my first choice, but I will eat the peas. Tolerance or intolerance, yeah tolerance: I have peas on my plate, I do not like peas, I will leave them alone. Intolerance: I have peas on my late, I hate peas, I throw the peas on

> the floor and jump up and down. The whole 'Do you accept it? Do you tolerate it?' thing. (Aboriginal educator)

These perspectives demonstrate a nexus where experience, teacher empathy and relationship with students are described as forming an interconnected aspect of Aboriginal education.

Although not overtly expressed in science curricula, knowing in western science presupposes a set of cultural beliefs (Aikenhead, 2006, Chapter 7). One difficulty identified in establishing the connection between two belief systems occurs when one way of knowing rejects the other way of knowing, as in scientism. High school institutions, when supporting only the academic rigor of disciplined memorizing of detailed facts, ignore the experiential knowledge of Elders, who identify emotional content and respect relationship. The challenge in this case is not one of fusing or infusing knowledge as sets of detailed facts in the curriculum, but of accepting differing belief systems, each of which has its own methodology (epistemology) of determining the truth-value of knowledge. A traditional knowledge way of knowing is often not accepted in western scientific institutions. As a University Professor Emeritus challenged antithetically: "If they (Native Studies) have knowledge, let us see it and determine its legitimacy". When using only its own evaluation of legitimacy, western scientific methodology results in an inability to understand of how traditional knowledge arrived at an understanding of natural events, such as the Waswanipi Cree hunter's knowledge of locating moose (Feit, 1973; Suzuki, op. cit. Chapter 3)

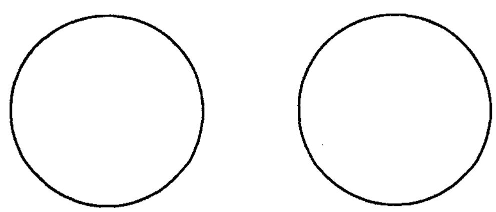
In one interview, the meaning of the term 'energy' was described from a Cree perspective, where energy meant more than the high school scientific definition of 'the ability to do work'. In educating a four-part person, energy was described as a life force coherently linking these four parts together:

I: Does western science understand nature?

M: To some level. In certain parts of the minerals and earth things and grandfather rock and its relatives, all these different minerals, and it shapes it into a car or train, it [western science] does understand. *What it doesn't understand is the residue, the spin off, today it's called pollution.* It enslaves the energy as opposed to being part of the life force. (Cree Elder)

In addressing the first research question (What connections exist between western science and traditional knowledge?), JM structured his reply in terms of three models of the relationship between the two knowledge systems represented by circles. First, JM drew two separate circles existing independently of each other and termed this a 'theandric' model (Figure 5.1):

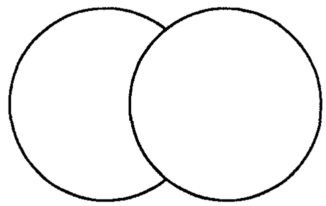
Figure 5.1.



This model (Figure 5.1) was described as two distinctive knowledge systems existing in relationship to each other by having no connection.

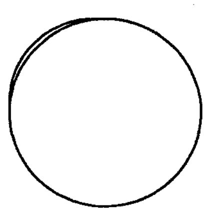
The next model (Figure 5.2) he labeled 'emperian' and resembles two intersecting circles where western science and traditional wisdom (knowledge) overlap:

Figure 5.2.



Here (Figure 5.2), the present role of western science is described to be that of a poor receiver, while today's role of traditional wisdom is that of sender. "They have to listen to us. I have been talking since 1953, and still they haven't heard me. It is now becoming more crucial to respect our traditional wisdom." JM suggested that an evolution of these two ways of knowing would eventually arrive at a third model, termed 'Tchonian', where the two circles entirely overlap or eclipse each other (Figure 5.3), and where processes of sender and receiver occur within one interconnected circle of understanding. JM explained this model as: "This is how dialogue should be happening."

Figure 5.3.



He described many factors presently preventing this dialogue from occurring, all given in relational terms of power and control issues, the need for healing, lateral violence, and the unconsciousness of individuals, especially those who have been "brainwashed by the western scientific system." Here, relationship is the "vehicle" through which dialogue occurs. JM described the art of listening with an empty mind, at which he said women were better than men; however, men were often the decision makers. In reference to relationship in dialogue, he asked: "What is the English word that describes, when hunting, how the rifle or shotgun leads the duck [gamebird] before firing? This is 'not-listening', but jumping ahead to conclusions and finishing off another person's thought before allowing them to complete it themselves."

Acknowledging the role of relationship in education has been described above as a central element in Aboriginal education. Relationship was defined here as extending beyond relationships with others to include relationship with all of nature. Some of the descriptors of relationship the participants gave here include respect, balance, and discipline as an ongoing process.

5.11.4 Relationship and protocol

Participants described the process of how humans go about dialogue or interview in order to gain mutual understanding. This process opens the door to mutual understanding and is referred to by Ermine (2006) as "ethical space". One of the purposes of protocol is to acknowledge of the importance of this process, demonstrating tacit recognition of a respectful relationship. JM describes the process as not only leading to knowledge: it is part of the knowledge itself. In using indigenous research methodology, I am able to approach another and ask critical linking questions, facilitating the emergence of concepts from other perspectives. In the example above, JM and I identified an expanded concept, namely that the process itself is part of the knowledge system. This process begins with proper protocol which initiates relationship as described by Cree Chief Smallboy (Botting, 2005):

> When someone desires to acquire certain knowledge then there is a specific way of doing this. With men tobacco or the sacred pipe was and is still used for asking for certain information. In the old days, and even now, the seeker of knowledge should be regarded as being of self worth by the one who possesses the desired knowledge. It should not be given to someone totally unknown of character by the one who possesses knowledge: that should not happen. Knowledge was valued, and considered sacred, something that should not be abused. People passed such knowledge only to such persons considered worthy and considered not likely to show disrespect. (p. 190)

The importance and meaning of relationship also extends to names in traditional knowledge. Aboriginal people, for example, were given names early and "If you heard a child's name, no matter how many years later, you were able to recall knowledge of him" (p. 103):

> Much has been lost in that we do not retain our Indian names anymore. Long ago, every Indian was named after certain things. Rarely would you hear of two persons having the same name—each name was different. From a name, you could tell something about a person and why he had received the name as a child. He could gain recognition from his name

anywhere he went. That is one thing we have lost. And now we have Whiteman's names and there are many who lose recognition. We cannot tell anything from the names of the young people, or anything about the young person's parents. It is that which we have lost: we have lost our names. (Botting, p. 103; recorded by Gordon Lee, London England, 1981)

Relationship is described here as an act of being in the world. Who a person is and where they fit in relationship to others is based on ancestral ties, in contrast to a Eurocentric model of basing relationship on what profession one assumes or what social status one has. This concept of relationship is described as an important aspect of Aboriginal education, where the process of establishing relationship and the emerging knowledge from dialogue are directly interconnected.

5.12 Community

When asked the question "In teaching science how could traditional knowledge be incorporated?" (Appendix 1), parental involvement was suggested as an important element to be included in children's community schools.

L: ...in an urban setting, incorporating more of the community, more of the parents. I notice that parents...there's not a lot of parents. Well, there are parents, but where are they? I don't know. Maybe if they took more of an active role in their children's education and communicated with the teachers how students will learn, or how they don't learn, or where they've been successful in life or haven't been successful. [It] might assist teachers even more in translating that knowledge. And if the teachers were to adopt a more balanced approach to teaching or educating students—(less) chalk and talk. That might be more successful.

This response reflects a shift in perspective from detailed concrete examples, as in product, towards a process of establishing community through relationship. Western science also approaches this process when a western scientific concept of community is expressed in the study of deep ecology (Naess, 1995): the word *oikos* comes from the Greek 'house'; community comprises a collection of homes. In viewing natural events wholistically, both traditional knowledge and deep ecology approach a way of knowing that encompasses both the event itself and its contextual setting. (This is also used in complexity science that includes the observer within the observation.) Previously examined examples of the Heisenberg uncertainty principle, Capra's dual nature of light explanation and Bohm's implicate order (chapter 3) have established a connection between the observer and the observed event. Western scientific deep ecology presents an event and its context as a whole. This ecological concept goes beyond, for example, a detailed list of species. It represents the biodiversity of a community, of organisms in the process of relationship. Relationship between human organisms wholistically involves a space occupied by elements such as ethics, mindfulness and understanding (Ermine, 2006; Davis, 2004). These factors are included as elements of a functioning community. A high school scientific definition of ecological community [49]omits these factors, which are not easily analysed using western scientific methodology. However, deep ecology does include these elements as community factors; traditional knowledge concepts of community wholistically also includes these elements.

An explanation of the relationship between education and community was given by participants who used the terms "life long learning", "wholistic", "whole being", "spirit", "nature based learning", "love based learning" and "life map". Residential schooling was described using the terms "fear based", "forced learning" and "force based laws"; it was presented as one cultural belief system imposing their worldview on another culture's community:

R: If I hadn't been kidnapped at a young age I would probably be by now in deeper knowing and [at] a higher discipline. But after the kidnapping another [way] was imposed on my life and, as I understand it today, that doesn't work. Wherever it's gone in the world, that hasn't worked—left a trail of tears, broken hearts, that was imposed by another and it's not geared toward love based learning. It's meant for make or break learning. It's more like fear based or objective based or forced based learning.

I: So we're still doing the same thing [in education]?

R: Absolutely. We're only providing knowledge for the mind; and (not) wisdom for the inner self. Looking back as a child I was set up already for

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[49] "Includes the populations of all organisms that occupy an area" (Ritter et. al., Nelson Biology, 1993, p. 612).

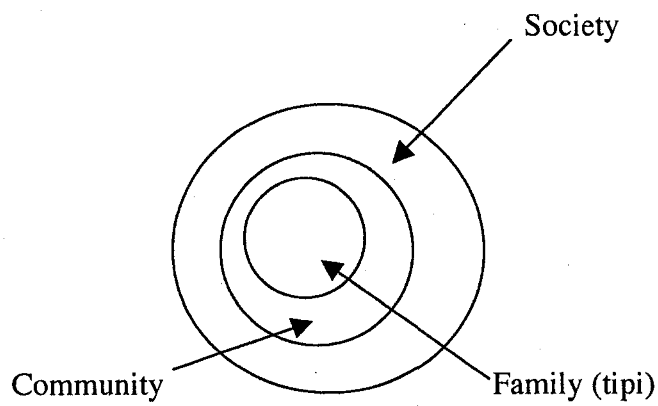
> that life map. Learning always came from nature, nature based learning, love based learning. And I also had role models. They themselves are strong and healthy at their level, but then when I was kidnapped, as I said earlier, you got yelled at and slapped around and it took years to recover from that abuse and then to go back and remember and to find a way—that [they] would later become my guides. So there's a lot of missed pages in between. But had it gone on the same way without interference... everything was forced based.... Like all the laws that we had. Another system that takes over and little by little *it chops down all those that would actually own that map, that life map.* (Cree Elder)

Community has been identified by Cajete (2002) as one thread in an interconnected weave of education, relationship and narrative. "Native community is the context in which the 'affective' dimension of traditional education unfolds, the place where one comes to know what it is to be related" (p. 86). He continues describing the connection between community and relationship: "Relationship is the cornerstone of tribal community, and the nature and expression of community is the foundation of tribal identity." Finally, he presents the interconnection between community and narrative: "Story enables individual and community life and the life process of the natural world to become primary vehicles for the transmission of native culture" (p.94).

The following field note data was obtained during an EDPS 601 class discussion group, Oct. 18, 2002, in which the further definition of community and its educational importance from an Aboriginal perspective emerged. Group dialogue focussed on the meaning of community. Community has been previously identified by Cajete, 2002, (above) and participants in this study as a factor in Aboriginal education as one element at the nexus of relationship, oral tradition, narrative, and Elders. Although each element above is identified separately, this data will be presented as an interconnected whole as it emerged during the discussion. Initially community was defined:

Community forms the second circle of relationship:

Figure 5.4.



A traditional community was defined as including the place, the land, rivers, tree and relationships based on recognizing harmony between these elements. Relationships are established on human values, which include patience and integrity. Being "Indian" on a reserve is a psychological element of community, giving members of that community a sense of self-identity.

In answer to Battiste's question, "What is a measure of success for Aboriginal education?" (CCL Conference, March, 2007) two levels of success were also identified in the above group discussion: credentialed (external) success and primary (internal) success. An educational meaning of credentialed success in public schools was correlated with individual marks given for examinations on subject material, and described as "superficial" or "exterior". This evaluation is given within the community by the larger society. Examples of indicators of this level of success include: success at school, passing diploma exams, obtaining educational degrees at university, getting a job or having a large house or car. Superficial here meant, "giving the appearance of success".

A meaning of primary or internal success included reciprocity: what can the student give back to the community? Community here was defined as a part of Aboriginal education that included not only where the student attends the community school but the relationships within that community. One aspect of relationship was described as reflecting self-knowledge: what the students have learned about themselves. From these definitions, one can achieve a high level of formal (certified or external) education and still "know nothing" about themselves (primary or internal). Knowing here included experiential learning. Informal education, such as that gained by listening to an Elder, was described in connection with self-knowledge using the words "patience" and "integrity". The relationships between people within the community were measured as "expressions of internal success". One definition of community focused on internal success with the word integrity. Integrity was used here to mean an internal state, matching what one believes with what one does. By focusing only on the intellect, academic language separates thoughts from actions, discounting integrity. “It is our heart which, through integrity, guides us” (B).

Participants cited urban Aboriginal education as differing from reserve Aboriginal education in terms of community. Some urban Aboriginal students, although apparently not connected to community through experience, have learned to “negotiate the white world” (L). Aikenhead (2006) identifies this as a successful cultural border crossing. These students were described here as achieving credentialed (external) success. Conversely, students living on the reserve have a different sense of community than those not living on reserve (identified as urban). Reserve students were described as deeply connected to others through relationship; they locate and associate their individuality in a particular land—space location— an ancestral community. “Being an ‘Indian’ though is psychological as well as belonging to a community” (J).

A question emerged (EDPS 601, October 18, 2002) regarding the connection between self-identity and community: “How can one be traditional in the modern world, the modern community?” and was answered from an Aboriginal perspective as follows: Living in a tipi and performing smudging ceremony describes being superficially traditional. However, an essence of living traditionally is demonstrated when enacting natural laws, for example by living in harmony within a community where the definition of community here also included the external environment: trees, rivers, and the whole living surroundings. Interconnections between self, others and the land cannot occur independently of internal success: as in being a good human being (S).

The relationship between western science and traditional knowledge was further addressed in this group discussion of community: the effect on Aboriginal communities of easy access to western culture by, for example, building roads, was discussed in terms of language, Elders, education and relationship. Culturally, bringing developed roads to communities metaphorically represented an incursion of western science on traditional knowledge. Communities were more isolated from western cultural influences before roads; with the result that children and Elders played together, spent time together, and lived more in each other's presence. The development of the physical road carried with it suspicion, envy and greed. Residential schooling could be more "effectively" enforced with the development of roads. Justice Berger's (1991) inquiry into the Mackenzie Valley pipeline documented first-hand accounts from the people affected in the communities describing the devastating effects on traditional communities of roads directly connecting rural communities to urban communities. One effect was loss of language (Cree, Dene, and Inuktitut) where meanings and identities were lost. "I see them/her/it differently" (L). The word assimilation was used here in connection with oppression (J). Using English as a community language rather than Cree changed the world of the community. For teachers new to rural communities, being with 'insiders' and participating in ceremony created a break in the "insularity outsiders create for themselves" (T). An interconnected web of language (oral and written), relationship and community was thus described in this discussion.

Finally, a connection with narratives was discussed in class: Community included not just people but an interconnection of language, stories, and narratives. "The story makes the community because it comes from the landscape".

5.13 Synthesis

Two worldviews have been presented.

Aboriginal participants indicated that in some cases western science may be coming-to-know traditional knowledge. For example, wholistic descriptions of nature in western science already occur in relativity theory, Bohm's implicate and explicate order, complexity science, the Gaia Hypothesis, and post normal science; examples which coincide with long held traditional knowledge concepts.

Rather than recounting a description of specific knowledge details, an approach to traditional knowledge in education was discussed by participants in terms of seven general elements: metaphoric meaning, language, narrative, oral tradition, elders, relationship and community. These elements were often presented as an interconnected whole rather than as separate strands. They form critical locations in the affective domain where western science and traditional knowledge can intersect. Each element does not act alone, rather the elements act wholistically in combination to comprise Aboriginal education. Although I am a researcher from a western scientific worldview, indigenous research methodology allowed me to begin the evolution necessary to come-to-know another worldview. From a western scientific perspective as researcher I expected response definitions in terms of specific detailed examples of traditional knowledge connections with western science. What emerged in dialogue was an interconnected web of the previous seven elements which were identified and described at the nexus of their crossing. Aboriginal participants identified affective spaces between these elements as important loci (e.g., the importance of the connection between community and relationship). This is in keeping with approaching mental physical, emotional and spiritual learning as a four-part human being–*Nehiyaw* (Cree).

Chapter 6

6. Conclusions and Recommendations

6.1. Meaning making

To claim that this thesis stands alone, apart from me, is to objectify this work. It does not exist apart from my own biases, worldview, and way of knowing. My input, conceptions and misconceptions in this work have been generated solely by me. In using myself as the instrument for this investigation I alone accept the responsibility for these conclusions and recommendations. The intent of this thesis has been to help make science education meaningful for Aboriginal students by examining existing connections between western science and traditional knowledge and by extrapolating educational implications. Examples have been included in emergent findings as a way of structuring my coming-to-know traditional knowledge. The interstices, spaces, and connections between concepts represent processes that hold detailed concrete knowledge together. As a teacher, when constructing science concepts for students, I was often unconscious of these interconnections and did not address them. This thesis gives my process of coming-to-know traditional knowledge more detailed scrutiny.

Seven interconnected theme words emerged in this study through interview/dialogue with participants: metaphoric meaning, language, narrative, oral tradition, Elders, relationship, and community. This thesis identifies loci or nexuses where these strands of the worldviews of western science and traditional knowledge coincide. Applying the above seven strands in response to the second thesis question (p. 4) indicates that each element is necessary but insufficient in itself for Aboriginal education; each strand element does not act alone but in concert with the others. In reweaving the separate strands into a coherent whole I use the following terms to describe the strands themselves and the connected spaces between each strand: complex, interconnected, interwoven, web, fusion, and whole; and where the strands or multiple strands intersect the terms loci or nexus are used.

6.2 Major Educational Implications

These implications are ones, which I, as an encultured Eurocentric science teacher for thirty years and researcher, have selected from many oral sessions using my evolving perspective and experience. As such, they are selective and may not necessarily represent what others may perceive as important. In addressing thesis question 2 (p. 3): What are the educational implications of this connection?) the discussion of educational implications emerged from oral sessions with many Aboriginal people over the last six years, and in many locations (e.g., Ahousat, British Columbia; Buffalo River, Saskatchewan). By engaging in this research, my worldview evolved and expanded beyond the boundaries of a narrowly defined Eurocentric educational view of mono-science.

Two major educational implications emerged from this study's interview responses, which will direct the following conclusions. First, different ways of knowing science originated from different epistemologies.[50] Diachronic knowledge originated from living in one location over long periods of time. Experience, intuition, emotional responses, spiritual understanding and metaphoric meaning are some methods used to acquire this knowledge. The participants of this study indicate that discussion, acknowledgement and acceptance of this way of knowing in science classes is an important first step for educational institutions to implement in science curriculum. Secondly, many of those who have been "colonized" may not be able to effectively question or recommend changes to the present education organizational system. Approaching Aboriginal science education from a Eurocentric mono-science perspective will predictably perpetrate the same educational reforms that have occurred in the past (such as residential schooling) where the dominant culture alone decides an answer to Spencer's question, 'What knowledge is of most worth?' This study suggests that those who understand traditional knowledge (i.e., Aboriginal people, Elders) be central to any attempt at 'infusing' traditional knowledge and ways of knowing in the science curriculum.

The following table emerged through dialogue as presented in Chapter 5 and references cited including Bronowski (1973), Durant (1939), Nandy (1988), Schaffer (1967), Smith et. al. (2002), Smith (2004), Stewart-Harawira (2005), and Wright (2004). It outlines conceptual shifts I experienced from a western

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[50] For the purposes of this study I do not distinguish between ways of knowing and ways of learning.

scientific perspective as *asokan* in coming-to-know traditional knowledge. Some elements in the white columns (Western Science, Resultant Paradigm) are adapted from Aikenhead (2006), p. 3; the shaded area summarizes emerging concepts in this thesis. These conceptual shifts occur in the spaces of Figure 5.1. Column 1 lists theme words around which the other columns are organized and, as previously referred to, are somewhat specific concepts derived from my interpretation of interconnected generalized concepts embedded within participant responses. Column 4 contains extensions of concepts I inferred from participant responses including those which are expansions of Aikenhead's (2006) Table 1.1: Possible Characteristics of Humanistic Perspective in School Science (p. 3).

Table 6.1 Asokan: Conceptual Shifts

	Western Science	Conceptual Shift	Resultant Paradigm
Wholeness	• prepare students for pre-professional science training • learning is a product • value decontextualized canonical abstract ideas	• science includes humanistic perspectives • process is as legitimate as product • western science describes, explains and predicts only a portion of natural events • traditional knowledge approaches lead to a wholistic construction of reality	• prepare students for egalitarian citizenship • learning is also a life process • includes contextualized and experiential ways of knowing
Community	• enculturation into a scientific community way of knowing • emphasis on content acquisition of community knowledge	• other ways of knowing exist in communities: western scientific is one way, traditional knowledge is another	• enculturation into a student's community which is shaped by science and technology • emphasis on content, context and ways of knowing • emphasis on how the community learns

	Western Science	Conceptual Shift	Resultant Paradigm
Hegemony	• western scientific methodology is a truth-confirming, mono-science approach • hierarchical, linear, dialectical conceptual structures • prescribed curriculum; rigid structure; discipline oriented	• scientific experimental and mathematical methodologies do not constitute ultimate proofs of the nature of reality; other epistemologies present other equally valid methodologies • an interdisciplinary research team approach is necessary to address complex questions	• science includes ways of knowing the natural/real world other than a purely western scientific one • use of other effective ways of structural thinking than only hierarchical or linear (e.g., intuitive, circular, spiral) • there are many ways to teach and learn science; i.e., a multi-science approach
Metaphoric Meaning/Narratives	• knowledge is canonical science • emphasis on external world and analytical, linear, left brain thinking	• knowledge can be obtained through metaphoric meaning/narratives • emotional development and intuition are needed to equally balance intellectual reasoning	• knowledge includes epistemology—how we know, includes knowledge about science and scientists • inner experience, intuition, narratives ('stories'), and metaphoric meaning are legitimate methodologies for learning about science
Relationship	• solely objective western scientific reasoning • isolated facts	• knowledge can be obtained through relationship • school communities structured by valuing relationship	• moral reasoning, values, human concerns, imagination are legitimate ways of knowing and learning • confluence and fusion

	Western Science	Conceptual Shift	Resultant Paradigm
Elders	• the world interpreted through the eyes of scientists • reductionist view does not include human experience	• other ways of knowing the world than through western scientific methodology and accreditation also truth confirming • qualifying life and living organisms results in expanded knowledge about them	• meaning is derived from other than scientists, includes students and Elders • experience is a valued quality
Educational Success Narratives	• performance driven based on achievement testing, lockstep progress, focus on norms • managerial	• teaching scientific knowledge takes many forms, including interpreting narratives told by Elders • learning is life-long	• self knowledge is an educational achievement • each individual performance is valued
Narrative, Metaphoric Meaning, and Elders	• external world is primary and separate from internal	• dichotomies are human-made, intellectual constructs reflecting only part of reality. • Elder's narratives reflect more wholistic reality	• inner experience is also a context for learning, including interpreting narratives' metaphoric meaning, listening to Elders, and acknowledging intuitive understandings

	Western Science	Conceptual Shift	Resultant Paradigm
Relationship	• classrooms and school structures designed for economic efficiency and cultural social sanctioning • scientific 'fixes' will save the world from immediate disasters such as global warming, overpopulation and unsustainable resource use • assessments designed for institutionally generated agendas such as economic and/or political convenience	• institutions (school systems) are not sustainable; those based on maintaining hegemonic power and on economic determinism are in the process of collapsing • humanistic science valued over scientism	• environment of learning is important, including supporting healthy relationships between students, teachers and community • other ways of knowing the world provides insight into creating sustainable ways of human living and learning
Community	• educational policies ensure institutional survival, resistant to individual community needs	• school institutions created to meet individual needs rather than individuals conforming to school structures	• encourages community input, community control, community designed curriculum
Education vs. Learning	• learning means acquiring scientific knowledge and developing scientific habits of mind, particularly theoretical abstract knowledge	• becoming conscious of that which we are unconscious of both in the physical world and within self • education includes balance of external and internal knowledge	• education includes self development and is a transforming process, includes experience (e.g., field trips, culture camps, fishing or canoeing camps) and intuition

	Western Science	**Conceptual Shift**	**Resultant Paradigm**
Education	• education is a social necessity, designed to create the good citizen and inculcate minimum skills	• education begins with individual students and specific communities	• education is a lifelong process • school structures maximize whole-student education
Humanistic Education	• increasing reliance on technology • education by technology (computers) replacing human interaction • dehumanizing methodologies • overloaded curricula	• humanistic education addresses the whole learner, values meeting human needs	• human relationships between teachers and students combined with appropriate technology

Table 6.1 is presented as a summary synthesis of my interpretation of participant discussions within the context of the mythic nature of western scientific progress, of which western science and science education are a significant part. The following conclusions emerge from Table 6.1 column 2: Western Science paradigms and are in keeping with Aikenhead (2006), Tarnas (2006), Wright (2004), Nandy (1988), and Bronowski (1973). 1) A western scientific perspective views civilization as a movement from savagery to civility. 2) This is supported through inductive logic where increasingly detailed accounts of natural events emerge from the use of scientific methodology. 3) Modern scientific knowledge represents an ascent in knowledge accumulation, as in Bronowski's (1973) ascent of man, Weinberg's conquest of nature, and Sagan's conquest of space. 4) Western scientific technologies increasingly allow mankind to alter natural events. 5) Western scientific knowledge represents the apex of human understanding of natural events.

Participants in this study often described their educational experience, including science, from an Aboriginal etic (outsider's) perspective. In contrast to the above Table 6.1 Western Science paradigm summary, their perspectives identified a lack of critical educational elements including: 1) Western science does not address (is unconscious of) its connection to previous examples of narratives such as Wesakojack (Cree) or Napi (Blackfoot). 2) Most participants did not experience any recognition in school of the contribution to scientific knowledge from their own culture or recognition of the operating cultural paradigms of the existing western scientific epistemological approach. 3) An unconscious emic (insiders) representation of western scientific knowledge as the only knowledge of value allows for the present degradation and exploitation of 'natural resources' and the genocide of indigenous cultures (Suzuki, 1997; L.T. Smith, 2004; Stewart-Harawira, 2005). 4) The absence of addressing the inclusion of emotion and spirit in learning values individualism and competition over developing relationship and community.

The shift from the existant Western Science paradigm column to the Resultant Paradigm column in Table 6.1 requires intermediary Conceptual Shifts. Arriving at these shifts has been described in Figure 5.1 as processes or spaces between Interview Segments, Metaphoric Meaning and developing an Emergent Theme. In order to arrive at Table 6.1 Conceptual Shift column I recursively refer to Figure 5.1 to include metaphoric meaning and the intervening spaces between the interview segments, and the emergent themes as part of my process of coming-to-know. The application of respect and reflection used in Indigenous research methodology applied to participant interview segments aided me in locating the Conceptual Shift column. Identification of these concepts is necessary in order to shift tacit unconscious worldviews to consciousness. My interpretation of Aboriginal participant dialogue included these spaces and metaphoric meaning to arrive at the identified Conceptual Shift column. Section 6.7.2 Polarity reconceptualization details an example of how I arrived at this column.

In acknowledging this process the following further questions emerged for me as researcher. I present these questions as part of my process of examining the connection between two worldviews: 'What are the consequences for humans of: 1) not being connected to the cycles of the natural world?; 2) of living in a synthetic technological world (e.g., city)?; 3) of separating self from the rest of life on the planet?; 4) of primarily educating intellect and ignoring emotion and spirit?; 5) of valuing individual competition over cooperative relationship and community?; 6) of structuring organizations hierarchically rather than other ways (e.g., circularly)?; 7) of valuing males over females?; 8) of structuring knowledge and belief in 'either-or' conflicting dialectics?' The following conclusions do not provide solutions to these questions or implications for education generally, but specifically address teaching (science). Table 6.1 identifies existing paradigms and indicates some paradigm shifts necessary to address questions such as the above. Although the following conclusions may not appear to be directed specifically towards the two thesis questions (p.4), they were often not separated by participants from the context of the thesis questions. A more wholistic approach suggested by participants would include the above types of questions and their implications as conclusions.

6.2.1. Redefining success

The concept of a non-hierarchical, non-linear, circular educational system initially based on developing community and relationship as suggested in this study does not appear to easily coexist within a hierarchically derived linear mono-science educational model. The structure of the school institution and the structuring of knowledge parallel each other in each conceptual model. Eurocentric educational institutions are hierarchically organized and the curriculum content is classified into specialties and subspecialties. In Alberta, high school science content is divided into general science, physics, chemistry and biology. Initial awareness of and subsequent reframing educational paradigms to fit the needs of Aboriginal learners have previously been suggested (Chapters 3, 5, Table 6.1) as one solution to aid the coexistence of these two educational models. Davis (2004) and Aikenhead (2006), by examining present science educational practices from a western scientific perspective, have suggested enactivist and multicultural approaches respectively; and Battiste (2005) and Kawagley (1995) have also presented suggestive transition solutions for science education by fostering the development of traditional knowledge models from an Aboriginal perspective. Participants in this study supported educational systems which include the concepts of metaphoric meaning (Cajete, 1999), relationship (Ermine, 2006), community (Battiste, 2005), language (Wilson, 2002), oral tradition, narrative, and Elders, as critical interconnected elements within a science curriculum. [51]

Battiste's (2007) question: "What is evidence of success for Aboriginal youth?" was addressed by participants in this study at a nexus of community and relationship (pp.162-173). Their suggestions are alternatives to a mechanistic

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[51] These are not exclusive to an Aboriginal context. They have been suggested by others for science education for moral, ethical and social reasons.

fragmented worldview, characterized in science classrooms by Cobern (2000) as presenting a "[s]cientific view roughly embracing classical realism, philosophical materialism, strict objectivity, and the hypothetical-deductive method" (p. 233). When this model fails, as in residential schools, in some present day reserve schools or in other schools which demonstrate low student achievement (as measured by such indicators as numbers of graduating science students), the participants (students or teachers) frequently are identified as deficient causal agents. The identifiers in these cases are often those within the hierarchy of the dominant educational institution, whose worldview reflects the existing dominant school culture described above (Aoki, 1991).

Another view suggested by participants here is that a failing lies with the concepts within this structural school model itself rather than with the participants. Although initially entering school as *Nehiyaw* (four part human beings), these same students develop apathy and a sense of powerlessness with repeated failures to succeed in the foreign culture of science, as exemplified by Aikenhead and Jegede's (1999) "I don't know", "outsider" and "other smart kids". Aikenhead (Nov.21/06, personal discussion) estimates these students comprise 90—95% of high school science classrooms. Aboriginal students can employ many strategies to succeed: they can abandon their Aboriginal identity and way of knowing and adopt a western science worldview (Jegede, 1995; MacIvor, 1995); play 'Fatima's rules' (Larson, 1995) by memorizing enough science to acquire a superficial knowledge without acquiescing their Aboriginal identity; or withdraw completely (Alberta Learning, 2002). Western science as a subject and western scientific classrooms are often too foreign for these students to engage in. In approaching this student reality, study respondents identified the presence of an underlying schema or belief structure found in schools that does not acknowledge the validity of Aboriginal ways of knowing; and suggest as an initial approach that this belief structure be discussed among teachers and in the (science) classroom. Cobern (2000) lends credence to their suggestions:

> Acknowledging in the science classroom that all knowledge systems are grounded in presuppositions would re-introduce a valuable discussion on the nature and meaning of science [tific] knowledge itself. It would force more instructional time on the nature of knowledge, reasoning, evidence, and commitments. This cannot be done, however, without acknowledging students' *other* beliefs and *other* beliefs held by scientists and science teachers. (p. 241)

Stanley and Brickhouse (1994) also support the contention that other ways of knowing be included in science classrooms:

> If students can also learn how the purposes of scientific activity have varied in different cultures and historical times, and how other cultures have developed sciences to meet these purposes, then they can also learn that the form of contemporary Western science is not universal, inevitable, or unchangeable. This kind of understanding is needed to encourage the critical thinking about the purposes western science has served, and how these could be changed to create future sciences that better meet the needs of the diverse societies that support them. (p. 396)

Suggestions from this study include alternatives to bracket fungus curriculum development such as focusing on developing school community through fostering supportive relationships as a necessary precondition for engendering student success. Participants described the process of initially establishing relationship by supporting the development of respect and trust between individuals. From a constructivist perspective Aboriginal students could be successful in school science if at first they received support for knowledge with which they are familiar and ways of knowing which are consistent with their culturally derived ways of knowing. Successful here means that students demonstrate knowledge about how nature works (Alberta Learning definition). These suggestions are also in keeping with the findings of Aikenhead (2006) and Kawagley (1995) and contrast with a western cultural model focusing on content such as building an external structure, equipped with classrooms and replaceable parts such as furniture, textbooks or teachers and using mark tokens as measures of success. Participants suggested that these foci are secondary to primary processes of establishment of community through focusing on relationship to create space for Aboriginal education.

Statistically, few public schools (or teacher training institutes) have successfully addressed this problem[52] [53]. Realigning a school system to engage

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[52] In Canada 8% of high school Aboriginal graduates go on to post secondary education where only 3% of these 8% graduate (S. Henderson, CCL Conference, March 8—9, 2007, Edmonton, Alberta).

Aboriginal students by working within their cultural ways of knowing may not easily occur through simple course restructuring from a western perspective. There is no evidence at present, which indicates that the simple addition of curricular directives in a Program of Studies for science without adequate teacher preparation will engender student success (Aikenhead, 2006). Because my past experiences were grounded in a western scientific approach, I defined and enacted science education from within this cultural paradigm. My interpretations of the research data in this thesis are still filtered through my cultural lens. Likewise many other non-Aboriginal members within educational institutions have offered suggestions for "helping Aboriginal students achieve success at school" (Alberta Learning Employee). One antithetical suggested solution from Flanagan (1999) is the overt adoption of western cultural assimilation and the concomitant traditional knowledge extinction for Aboriginal people.

Other more realistic educational programs have been developed within Alberta which, by definitions of success given by participants, do demonstrate

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[53] Initiatives are presently under way at the University of Alberta, Edmonton with two major directives:

(1) A framework of action related to teacher education, in collaboration with provincial faculties of education
(2) Strengthening measures that ensure relevant teacher education helps new teachers understand the needs of Aboriginal students, [helps]recruit and train more Aboriginal teachers, and offer[s] in-service education opportunities to teachers to provide current information and upgrading. (Dare to Discover document, 2006, Faculty of Education, University of Alberta)

educational success for Aboriginal students. For example, the Blue Quills School in St. Paul, Alberta, has demonstrated success by incorporating western scientific knowledge within an existing local Aboriginal community. As suggested by participants of this study, the threads of community and relationship appear here as a basis for Aboriginal education. Western scientific 'facts' are presented as adjunct knowledge under the aegis of cultural support. Additionally, the University of Lethbridge and Red Crow College have created joint courses which involve experiencing knowledge of place by actually visiting the locations.[54] A recent CCL Conference (March, 2007) addressing successful Aboriginal education included the topics of academic focus, cultural education, community and parental engagement supporting relationship, and developing school climate as interconnected examples of Aboriginal education focal points.

6.2.2. Other initiatives

Other initiatives have emerged during the course of this study. Alberta Learning has developed Programs of Study in Science from Grade 7-12 (2007), which have "infused" traditional knowledge into the curriculum content. This initiative acknowledges the existence and importance of traditional knowledge in

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[54] The importance of learning from spending time 'on the land' or 'in the woods' was suggested as an aspect of traditional learning methodology. "The land itself teaches us", "knowledge is on the land" (Narcisse Blood) requires that students spent time experiencing nature when studying nature. Traditionally in 'campfire learning', knowledge was transferred by talking around the campfire (John B. Zoe). Western scientific ecological courses offered by S. Barker at the Kananaskis Field Station, Alberta reflect this orientation.

the Alberta science curriculum. Additionally, Glen Aikenhead has detailed evidence-based practices in Science Education for Everyday Life (2006). Specifically, Chapter 7 entitled *Culture Studies: School Science as Culture Transmission*, identifies western science as a culture, and highlights the importance of student interest, self-esteem, achievement, and empowerment in teaching Indigenous sciences to both Aboriginal and non-Aboriginal students. He suggests incorporating a border-crossing model for Aboriginal science students as a potential methodology and has identified two areas for further research which are also in keeping with the results of this study. First the "enculturation of students into local, national and global communities" (p. 127) requires definition (see Battiste, 2007, below) by answering the question: What does it mean to maintain an Aboriginal identity and achieve success in science classes? Secondly, Aikenhead suggests that further research is needed because teacher curriculum materials are scarce and professional teacher development is often absent in this area. Aikenhead suggests that Barker (2004), Chinn (2004) and Sutherland & Dennick (2002) show promising action research studies in this second area. Battiste (2007), in indirectly addressing the thesis questions (p. 2), has begun research directed towards answering her questions: 'What is evidence of success?' and 'How do you provide learning from within our own culture?' Through her research First Nations, Métis and Inuit participants have developed educational models based on a Tree of Knowledge concept.[55] Participants in this thesis echoed

[55] CCL Conference, March 8-9, 2007.

her suggestion that a necessary condition for Aboriginal education is that it must centrally locate language, place and spirit. These concepts are "more important than the count"[56]. Here educational success means more than exam marks indicating achievement; it means developing a four-part person (J. Marie) within an Aboriginal cultural context which includes life long learning. In this thesis J. Marie defines success as "living a good life" or "successfully using all your available resources, including body, mind, spirit and emotion". The findings here further indicate a shift in perspective from quantative to qualitative, from product to process, from mass-producing graduates to valuing and fostering the development of individual knowledge.

The Canadian Council On Learning (CCL) is specifically conducting research into defining success for Aboriginal students, the results of which will be applicable in science classrooms. Sakej Henderson [57] is currently asking secondary education Aboriginal graduates the following questions: "How do you redefine success as measured for professions?; What learning conditions foster (professional) success among Aboriginal people [i.e., what constitutes success for Aboriginal learners]?; What has this generation of Eurocentric educated FNMI (First Nations, Metis & Inuit) achieved that can be handed down to the next generation? How did we [Aboriginal people] arise to overcome intractable

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[56] CCL Conference, March 8-9, 2007.
[57] CCL Conference, March 8-9, 2007.

challenges of cultural transformation?; and What do our children and grandchildren need to complete our legal, cultural and economic restoration?

In accordance with some his preliminary results the results of this study indicate that Aboriginal pedagogy is not a significant part of the educational or organizational mandate in public schools, institutes or professions (including teaching) that Aboriginal people belong to. Most curriculum developers view Aboriginal people as collaborators, without an understanding of cultural differences, and most teaching organizations have not addressed these cultural barriers (footnote 50). Participants in this thesis support individual learning as an educational goal. This is also in keeping with Henderson who, rather than describing statistics (footnote 56, below) as deficits, views them as individual successes because students are entering post secondary education (PSE) from first generation post-residential schooling where each individual graduate, each person gaining employment and each individual student maintaining employment in their field is seen as a success. Henderson cites 1991 Statistics Canada[58] data as

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[58] In education almost 5,000 Aboriginals were in teaching and related occupations in 1981; over 8,000 by 1991: where 16.6 % of Canadian health and medical services graduates are Aboriginal; in actual medical and health work force they comprise only 6.1%.

In education (1991) 15.5% of education related careers in Canada include Aboriginal women but they comprise only 6.1% of the actual teaching workforce; while Aboriginal men trained at 5.3% and comprise only 1.6% of actual teaching workforce (Henderson, 2007).

evidence of success for Aboriginals in an educational system which does not support the Aboriginal learner.

Some participants in this study describe their concept of the meaning of Aboriginal education to include the establishment of an environment in the educational community that reflects local cultural values. This concept requires a shift in focus from a purely external knowledge base or content to including an internal knowledge base or process (Table 6.1). Internal knowledge here is described as including the processes of respect and trust in developing relationship. Children initially learn how to relate with the external world within their family circle and expand this to a community circle (Figure 5.4). Initial relationships form a first circle around which a sense of community is developed in the second circle. Internal knowledge is described here as being developed through experience. Two Cree participants quoted in this study (J and L) specifically describe relationship as one critical educational aspect for developing a balanced four-part person. Alternatively, when the main focus of school is solely on the acquisition of external knowledge, as in mono-science, and success is solely measured through achievement testing, Aboriginal students whose worldview, sense of being or measure of success is obtained through using their own indigenous knowledge methodology will be marginalized because their way of knowing is marginalized.

6.3 Wholistic science

The concept of wholeness has been presented as a polarity in opposition to the concept of fragmentation (Chapter 3, Chapter 4). One belief of western science is the primacy of teaching discrete bits of physical content whose existence is observable and predictable through experimentation. In high school the description and explanation of relationships as found between particles as in holomovement (Bohm, 1980), the nature of quanta and electromagnetic waves such as light (Heisenberg in Herbert, 1993; Capra, 2003), or synergistic effects on individuals of pharmacological drugs (Pert, 1997) are secondary to studying models of concrete physical particles and predicting their interactions. Newtonian physics describes a relationship between mass and movement, but what occurs in the space between energy and mass (as in holomovement) is largely unexplained. A description of gravitational effects is addressed mathematically in Alberta high school physics, but not as an explanation of what gravity is or the difficulty of western science approaching a wholistic relationship between gravity, energy, mass and time in a unified field theory. From a mechanistic instrumentalist perspective, a mathematically represented relationship such as g = 9.1m/s/s. is a complete scientific answer to: How would a scientist describe acceleration due to gravity?. Although particulate matter has been described as existing in a state of flux by Heisenberg (in Herbert, 1993), Bohm, (1980) and Greene (2004), the dynamic spaces between physical particles is not a main focus in Alberta high school science. Western science has produced evidence for the existence of these spaces, as in quantum mechanics, theories of relativity (Einstein), inter- and intra-molecular bonding, and gravitational effects. The participants in this thesis repeatedly described a concept of nature seen as a whole (Chapter 5), inclusive of spaces between physical particles. Both worldviews are coincidental in that both present the existence of processes within these spaces; however, unlike science as presented in Alberta Education documents (2002, 2003, 2007), participants described the inclusion of these spaces as fundamental to their concept of the wholeness of nature. Just as in the model of research methodology for this thesis (Figure 2.1), the spaces between identified loci exist but are not an educational focal point from a western scientific perspective. A wholistic concept as described by participants here would not necessarily elevate one fragment of knowledge over another simply because it is better described or explained through western scientific experimentation. Traditional knowledge ontology includes all elements taken as a whole, including the effect of the observer. Thus a connection between both worldviews occurs in the acknowledgement of the existence of the above spaces; however, where western scientific approaches focus mainly on discrete measurable physical elements themselves, a wholistic approach of traditional knowledge does not elevate the importance of the physical elements, as in products, over the spaces between them, as in processes.

What would happen if we collapsed polar concepts, collapsed dichotomies such as found in Table 6.1, and regarded knowledge of natural events as an interconnected whole? One result indicated by this study's participants would necessitate an educational restructuring in science curriculum. Teaching science using 19th century, institutionally derived, linear, hierarchical, industrial educational models such as mono-science has been described (Chapter 5) and correlated with disillusioned youth who refuse to complete the cycle of schooling, refuse to participate in the culture of school science, and do not share the dominant western scientific worldview as an experiment in modernity of economic determinism (Aikenhead, 2006; Battiste, 2000; Chapter 6, footnote 56). Engendering a change in how science is presented in classrooms (including curriculum) would require an educational approach to the question: What statements can we make which highlight, bring into relief or question the beliefs which sustain a continual promotion of the superiority of the western scientific worldview in science classrooms? Table 6.1, Conceptual Shift column, demonstrates some summary participant response implications of this question.

The shift in cognition from fragmenting concepts of polar opposites to regarding wholistic processes, as suggested by this study's participants in Chapter 5, is addressed by Urion (1999) who "supposes a primary legitimacy to academic discourse over a First Nations discourse in [sic. through?] the definition of the difference" (p. 3). He argues against setting up a discourse of "opposing dialectic" which exacerbates the valuation and devaluation of one approach over another. He gives Hedley's (1970) model of the relationship between Aboriginals and the dominant society as an example given of theoretical cultural determinism not applicable to real life. Because humans are not static entities as described by Hedley, a social dynamic can never be "objectively and empirically describable" (p. 8). In first nations discourse, the observer is part of the observation, not disembodied from it. Discourse becomes more of an interplay of presenting knowledge between people, as in JM's Tchonian model (Figure 5.3), rather than a pedantic model of giving and receiving information as in the discourse outlined as Theandric by JM (Figure 5.1). Table 6.1 (above) demonstrates conceptual shifts necessary to encapsulate such wholistic descriptions as JM's and Urion's, as they apply to Aboriginal education. Although this table may imply polarities in worldviews, it is intended to be a continuum rather than presented as separate polarities such as found in Table 1.1; it presents intermediary concepts necessary to enact a conceptual shift towards what the participants in this study termed Aboriginal education.

6.4 Paradigm shift of western scientific worldview (Table 6.1)

Participants described further attempts by school systems to use a western scientific approach of combining traditional knowledge and western scientific worldviews as supporting a cycle of developing a sense of inadequacy and failure among Aboriginal students who do not succeed. Adelard Blackman (Dene) asks, "What is the solution?" These thesis results support the contention that further suggestions that come solely from a western scientific perspective (including mine) may only exacerbate the problem. In the Alberta FNMI Progress Report (2003), while there is a clear indication that traditional knowledge exists, is included in the Program of Studies in science and is beginning to be recognized in science classrooms, the context of how this is to be presented (e.g., 'infused') and its relative importance in science curriculum is not well documented. It is unknown at present whether these initiatives will result in a solution, or if, for reasons outlined by Aikenhead (2006), this approach is met with continual declining Aboriginal student enrolment, discrimination and cultural alienation, perpetration of dishonest and mythical images, exacerbating learning difficulties and the continuance of playing Fatima's rules (pp. 25-29). The participants of this study suggest an initial reframing of Aboriginal science education within a larger context than the existing mono-science context. Aoki (1991)[59] asked over 25 years ago "Whose culture, whose curriculum?" This same question is still asked for Aboriginal students throughout Alberta science classrooms when Aikenhead (2006) reframes Spencer's question by again asking, "Who decides what is relevant?" (p. 24), and Battiste asks an axiomatic question: "How do we describe or provide learning from within our own culture and traditions? (CCL Conference, March 8-9, 2007). These questions resonate with my two thesis questions (p. 4) in response to which I have described some epistemological overlap and presented my interpreted educational implications from selected participant dialogue.

6.5 Connections between Worldviews: Common Ground

In Chapter 5, I described the congruence between models and metaphors. The western scientific model of the Gaia hypothesis (Lovelock, 1991) and the traditional knowledge metaphor of mother earth use a similar wholistic concept to describe natural phenomena. Cree ancestors have enacted sustainability with animal and plant populations for thousands of years before its appearance as a western scientific concept and concern. Experiential knowledge (e.g., through field trip) is a currently accepted educational scientific pedagogy in both worldviews. Another specific area of intersection between these worldviews

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[59] 1991 publication of a 1979 article: Toward curriculum inquiry in a new key.

found in this study is the ontological connection between theoretical physics and traditional ways of knowing (Chapter 5), which have educational implications for models and metaphors.

6.5.1 Models and metaphors

A western scientific approach often uses models to describe or explain scientific concepts of natural phenomena. For example, in scientific papers and texts, models can be displayed as two-dimensional diagrams or given as three dimensional visuals. These models when used in research can be instrumental in clarifying structures or functions, as in DNA, or in identifying mechanisms, as in the haemoglobin molecule or enzyme release and activity. Models can be based on evidence obtained experimentally or on mathematically derived predictive ideas of how events function, as in the difference between using Cartesian geometry or Euclidian geometry and in relativity. In theoretical physics a model can be used to give visual meaning to a theoretical construct. A visual model of the relationship between education, western scientific knowledge, and traditional knowledge has been given diagrammatically as three intersecting circles in Chapter 2, Figure 2.1.

In traditional knowledge, a narrative is often told where metaphor is used to give meaning. In interpreting and understanding Little Bear's (1994) metaphor below, the listener/reader constructs a meaningful concept using personal intuition and experience. Often the concept can be actively tested in real life experience where experiential meaning is given to a concept by enacting it in the world. Likewise, in praxis, student teachers, when working with students to determine what students might need to help understand either a western or traditional knowledge scientific concept, are experientially testing educational theory in order to give their model meaning. In coming-to-know the metaphoric meaning of narratives told by Elders the listener constructs a concept that can then be used to guide actions in the world, such as respect for nature. This can be compared with models created from western scientific experimentation which similarly act as metaphors for representing events in the natural world, such as happens when overpopulation in a closed system results in extinction.

Ontologically, an example of fusion between worldviews occurs in Leroy Little Bear's (2004) metaphor[60] and in Bohm's (1980) model. Little Bear's metaphoric description of time from an Aboriginal perspective can be interpreted by applying Bohm's model, in which matter and space are enfolded interactively with one another. In both cases, time is not described as a linear static measured event, but a dynamic space between past events and future events. Past events two days ago (e.g., relationships) affect future events two days from the present; past and future are interrelated. Little Bear uses the term synchronicity to describe the timing of an event where people meet to determine a course of action when the 'time is right'. For him, events do not happen in the future, actions are not planned until affective domain elements such as emotion and intuition are

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[60] Blackfoot and Cree worldviews differ. The 'story' used here applies to Anishnaabe, Haudenosaunee and *Netitapee* and may not be representative of all First Nations (L. Little Bear, p. 12).

synchronous within individuals and between individuals. I interpret this meaning of time to include the affective elements of human emotion and spirit in connecting past events to probable future events. The term synchronicity used here includes these elements in the phrase 'the time is right'. This is in agreement with Jung and Pauli (1955) for whom synchronicity determines the manifestation of an event.

In extending his metaphoric meaning, Little Bear uses the term constant flux where beliefs emerge from a flux of relationship. Similarly, Bohm applies the term constant flux to the connection between implicate and explicate order, where matter is manifested through holomovement. Bohm's model uses matter; Little Bear's metaphor uses belief where model and metaphor are an instance of co-incidental conceptual connection.

Little Bear's conclusions are in keeping with those of this study's participants and do not necessarily give an implication of applied negativity:

1. Linearity results in a singularity worldview; singularity results in a product mentality;
2. Circularity results in generalist worldview; generalist results in a process mentality.

In both above instances, time is not conceptualized as a linear event but as a circular event. From a traditional knowledge perspective, Little Bear describes time as a two-day separation of a point on the circumference of a circle, or medicine wheel. In theoretical physics, Einstein's relativity theory describes time as a nonlinear event where time is relative to the observer. Both worldviews approach time as nonlinear and relative, where past and future are interconnected. Both western science and traditional knowledge also present similar conceptual models of enfolded space and time arrived at through differing epistemologies (Peat, 2002). The similar endpoint through using either a model or a metaphoric understanding reveals the distinct connection of conceptual knowledge between these two worldviews.

Little Bear (2004) extends a metaphor to give meaning to the term constant flux:

> … if I just made scratch marks all over and so on, here and you apply this –these scratch marks, this constant flux picture to the cosmos if you want to, or you can apply it to, our earth, you know, our immediate surroundings……this as a kind of spider web network, a three dimensional kind of spiral-geodesic type of a spider web network, that's forever moving, combining, recombining, changing, transforming and so forth. You know, just continuing to mix all the time and so on, that's the **picture** of constant flux (emphasis mine).

A distinction between two worldviews emerges here: one in which specific points, scratch marks, are identified (e.g., detailed facts) as content; and one in which the relationships between the points are identified as process (as in the synthesis of detailed facts). A language that is linear, noun based, and product oriented is used for the first approach, whereas the second is associated with a verb-based language, circularity—a process approach. The inclusion of process is used in quantum mechanics (Bohm, 1980), deep ecology (Naess, 1995), complexity science and post normal science (Funtowicz and Ravetz, 1992). When a school science orientation elevates the importance of discrete bits of knowledge, as in mono-science, the first description applies; when school science is approached with a focus on the interconnection between bits of factual knowledge, as during a science field trip or creating school community, the second approach is enacted. If Aboriginal students are given support for this wholistic worldview with western science where the interconnection between objects in space and time (i.e., how they are related) forms an integral part of their cognitive schema; then a science curriculum which reflects this would be more meaningful to them because it might be more easily understood. This comprises one element of the expression—making school science relevant to Aboriginal students (Aikenhead, 2006, p.31).

6.6 Relevant Curriculum

JM's previous statement, "We are part of the all" in response to the two thesis questions can be further examined with reference to relevancy. A specific educational implication of relevancy occurs in the presentation of atomic structure. In science class atoms can be presented as discrete structures, each with analyzed static characteristics, or as dynamic interconvertable mass-energy events, each interconnected to the other. A second approach would demand a shift in concept between fragmented points on a linear plane to continuous energy movements in a hyperbolic plane resulting in atoms (singularities). The second description is supported by physicists Bohm (1987), Peat (2002) and B. Greene (2004) as an accurate portrayal of reality.[61] This second approach represents a western scientific description of a traditional knowledge concept as expressed by Black Elk (1959), where everything is connected to everything else, and additionally described by Chief Smallboy (Botting, 2005), where our actions today reverberate through future generations.

A further ontological connection appears where Bohm's theoretical construct of matter as an emergent singularity from an implicate order coincides with a metaphoric understanding given by Little Bear (2004):

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[61] According to Bohm order and measure of time are no longer regarded as absolute, but are relative to the observer. Bohm describes a structure of reality as a "world tube" in which a "pattern of movement" exists (p. 157). The Einstein—unified field theory begins with the total field of the universe. Particles are regarded as an abstraction from the total field corresponding to intense field regions called singularities. This results in an undivided whole universe with singularities in it related to each other through the field. The order is one of undivided wholeness. Einstein's use of non-linear equations relating gravitational field with curvilinear order supports this concept of distinct but interrelated components (p.159).

Bohm further articulates the concept of wholeness. In classical physics the world is analyzed into constituent parts that are conceptually reassembled to create a total system. His meaning of "to analyze" here is a special kind of description that uses the separate parts having an existence independent of each other. To describe here means to "write down". But a description of the parts of field theory does not mean that they have a separate existence just because they are written down, they have meaning only when the terms are related to each other by reason (or ratio). Used here it is this ratio (i.e., what calls attention to the whole) which is meant by the term description. Analysis using a description of parts was adequate for Newton and Galileo but not for Einstein. Analysis in field theory cannot occur in terms of spatially separate objects.

> ...this notion about flux, what it is, is that this flux consists of energy waves.... It is the energy waves that know, talking about knowledge. You and I are simply a particular combination of energy waves. Once the energy waves kind of dissipate, in other words, if they start to break up and dissipate, well, I guess that's when we pass away, you know, we are no more because that particular combination is not there. (p. 19)

Some participants in this study stated that by ignoring traditional knowledge as a way of knowing the acknowledgement of Aboriginal culture was absent and, by implication, devalued in school science curriculum. This is described by L's charge "school science is not relevant". To address this, participants suggested that school education include community, Elders and their teachings, that science be experientially meaningful (as in L's experiencing a father's fishing trip), and that science include cultural components.

As previously mentioned Aikenhead (2006) addresses the relevancy of school science where relevancy questions usually take the form of 'relevant to whom?' or 'relevant to what?' (pp. 31-48). He hegemonically suggests that reframing these questions to include 'who decides what is relevant?' would redirect attention toward the political educational realm rather than concentrating on students or subject matter, because politically driven curriculum reform takes precedence over educationally driven curriculum development. Aikenhead defines science relevancy to mean that it must be practical (e.g., citizen science), functional (e.g., veterinarians), on a have-to-know basis (e.g., emergency room doctor), include personal curiosity science, or science as culture (including common sense) from a student's point of view. Participants in this study identified a definition of relevancy where science has meaning culturally and is supportive of a student's way of knowing, such as is found in the practice of traditional knowledge: students need to learn how to learn science, not just what to learn as memorized content (Aikenhead, 2006). This study's results are in keeping with Aikenhead's suggestion of a humanistic[62] cultural approach to teaching science. He cites research which indicates that on standard achievement tests, humanistically taught students' achievement scores are equal to or better than regular science classes, and contends that assessments such as provincial achievement exams are driven by a political agenda, not necessarily an educationally evidence-based one. In addition to supporting this type of humanistic science concept, the findings of this study also suggest the inclusion of the interconnected educational elements of: metaphoric meaning, language, narrative, oral tradition, community, relationship and Elders; and support a process orientation in Aboriginal education. This research also supports Aikenhead's evidence-based notion that science be encultured into local communities rather than incorporated by a process of assimilation or acculturation.

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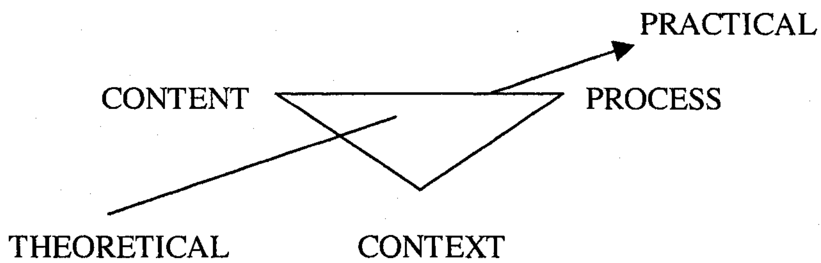
[62] "[I]t does not make sense to delineate an iron—clad definition of humanistic school science based on this rich array of research programs. However, central to humanistic school science is its relevance to students, usually determined by student's cultural self identities, student's future contributions to society as citizens, and student's interest in making personal utilitarian meaning out of various kinds of sciences—Western, citizen or indigenous." (Aikenhead, 2006, p. 23)

6.7 Polarities: Process-Content-Context Triad

One barrier to incorporating the above approach educationally is the concept of process-product dialectic. One Aboriginal educator (L) described the school focus of memorizing detailed facts in science as "a problem". Another Cree Elder (JM) stated that educators could obtain teaching degrees and still "know nothing". As suggested in Table 6.1, an alternative orientation requires a paradigm shift. If everything is interconnected to everything else (Capra, 2003) including polarities, then the inclusion of context would result in the collapse of content-process polarity. The view of a dichotomous process-product polarity from an educator's perspective can thus be reoriented through the inclusion of context. Context here may be included in this linear dialectic to form a triad connected through two loci: theoretical and practical (Figure 6.1). Practically, in the classroom, one barrier to an Aboriginal student learning science may be the student's difficulty in entering the foreign culture of science coupled with the science teacher's ignorance of that student's culture. Within this classroom reality context, a science teacher's orientation towards enacting a humanistic/cultural model such as Aikenhead's would allow for the replacement of a barrier by a bridge *(asokan)* through developing the teacher's understanding and acceptance of the student's dilemma. Within a practical classroom context, a science teacher's adoption of this approach coupled with enhancing student's trust would allow for the development of a bridging process. The process-product polarity orientation is thus reoriented by the inclusion of the context concept, dynamically altering the polarity within the lived-in reality of the classroom. This dynamic triad, derived from STS curriculum, is modeled in Figure 6.1:

Figure 6.1 Dynamic Triad[63]



The theory of content-process orientation of western science is described in Aokian (1991) terms by an etic or emic approach. The etic (outsiders) approach in which the teacher/student gains understanding by internalizing concepts and then enacting them in the world, suggests a process orientation where, in the case of Aboriginal education, the processes of individual relationships (radical constructivism) and community interrelationships (social constructivism) have primacy. An emic (insiders) approach addresses content, the external physical world, where the details of material things-in-the-world (Aoki) are a primary focus. Seen from an emic perspective, the content of the science curriculum is valued as all encompassing; seen from an etic perspective, the practical pedagogic process of the science teacher in classroom praxis becomes a focal point. A contextual humanistic-living-real-life dynamic interface of internal knowledge and external knowledge in praxis shifts the barrier created by, and gives another

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[63] Derived from discussion with Aikenhead, November, 2005

dimension to, an external linear content-process dialectic. A teacher enacting wholistic internally constructed dynamic models in the external science classroom is part of what participants here described as the context of Aboriginal education.

6.7.1 Collapsing polarities

Collapsing polarities through the inclusion of context has an educational implication. The context (e.g., the classroom as community) and perceived way of knowing can determine an orientation towards either process or product. Context can determine the dominant polarity (process or product). From either orientation, it is only the way of perceiving or categorizing within a specific context that determines which polarity is dominant. In the example of marks, which act as a time-frozen product, teachers are acculturated to believe that these exist outside of an educational perspective in an external reality and that marks have direct correspondence to a student's understanding of a subject such as science; even though evidence indicates that a majority of science students (90-95%) fall into the "I don't know", "other smart kids" or "outsider" category (Aikenhead, personal discussion, November, 2005). Marks as a product only have meaning in an educational context where they are thought to measure the success of the process of cognition.

6.7.2 Polarity reconceptualization

Both western scientific and traditional knowledge worldviews exist within a larger whole. What would happen if their polarities were collapsed and the dichotomies eliminated as in the above example? What is left when both sides of a polarity are collapsed? Viewed wholistically, the polarities do not exist only as separate entities but are part of an interconnected whole, as in traditional knowledge where the known and unknown do not exist independently from the knower (e.g., Elder). This part of traditional knowledge includes a process where the way in which understanding knowledge occurs begins with protocol in approaching a 'teacher' or Elder and is included in the ensuing dialogue; the process becomes embedded with the emerging information. From a western scientific approach, the act of teaching (pedagogical process) the Alberta science curriculum is separate from the knowledge to be transmitted (science content). The acquisition of this latter knowledge by learners is tested in terms of quantitative factual evidence (i.e., written tests) and used as a measure of success. In traditional knowledge the process of acquiring is itself considered part of the knowledge; the knowledge and the process are an inseparable whole, not a dichotomy. While western scientists operate within a paradigm of objectivity separating themselves as learners from what they are learning, many of the Elders in this study did not separate themselves from what they knew.

This concept has not been directly addressed in Alberta Education's 'infusion' model. The above approach of giving educational meaning to the term traditional knowledge implies that the meaning of teaching science shifts from teaching the subject science *to students*, to one of *teaching students* who are learning the subject science (Table 6.1). This represents a paradigm shift from viewing scientific knowledge as an object to giving this knowledge subjective meaning. As previously suggested (chapter 3) this is represented within western science by the conceptual shift from classical Newtonian physics to quantum mechanics. For example this approach would demand a shift in perspective from subject based teaching/learning to student based teaching/learning, where the focus includes the student's ability to 'make sense' of their school experience.[64] This conceptual shift would require the intermediary stage of acceptance that dichotomies are man-made constructs and that humans are wholistically part of nature, not separate from nature (Table 6.1).

In education, this would require a paradigm shift and a resultant structural change. Present institutional cognition in linear, hierarchical structures would (d)evolve. Table 6.1 suggests the questions: What long held Eurocentric assumptions and strategies are being deconstructed by these statements? What statements can we make which bring into question the beliefs that sustain the promotion of the superiority of the western scientific worldview over other ways of thinking?. Addressing the Conceptual Shift column in Table 6.1 implies answers to these questions.

6.7.3 Healing and curing

One example of the traditional knowledge concept of wholeness occurs in medicine. Western science generally regards medical illness from a single physiological perspective, often treatable through surgery and/or biochemical pharmacopeias (drugs); however, Navaho healing ceremonies involve two distinct orientations. According to Weatherford (1991) Navaho shamans (medicine men)

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[64] See Aikenhead's (2006) humanistic science definition (p. 3) and seven identified heuristic categories of relevance (p.32).

perform ritualistic healing, often involving sand paintings addressing four quadrants (corresponding to Cree *Nehiyaw*: four-part person). The healing ceremony addresses the harmony of the patient while a second orientation involves curing, which is regarded as a physical treatment for specific symptoms, as distinct from the healing ceremony. Thus a patient with, for example, type 3 systemic malignant metastasizing carcinomas (terminal cancer) can still be treated for internal harmony. This distinction between healing and curing represents a shift from a western scientific worldview which addresses physical curing, whereas a traditional knowledge curing/healing approach to human disease includes all aspects of what it means to be human. An implication for education is found in Jean Marie's (Cree Elder) quote: "Education isn't about just teaching the facts. It's about teaching children to be human", and in Leonard Cardinal's statement on leaving an urban school to return to his rural community: "I go home to be human." If schools are to reflect a humanistic perspective in school science (Aikenhead, 2006) by incorporating traditional knowledge, then a pedagogical understanding of traditional knowledge by teaching professionals is required. Table 6.1 outlines some conceptual shifts in western scientific belief structures necessary for this to occur.

6.8 Metaphoric Meaning, Narrative and Experience

Understanding traditional knowledge can occur through interpreting the metaphoric meaning of a narrative; using dialogic exemplification of life experiences as when an Elder orally tells "stories". "[A]n apt metaphor can carry a huge information load with it because it can be interpreted at many different levels and in many different contexts" (Urion, 1999, p. 9). This is in keeping with constructivist approaches of Geelan (2003), where students use preconceived constructs or experientially based organizing principles, including scaffolding, to derive constructs which give meaning to new concepts. Here the learning/teaching event values meaning-making by the listener over memorized accumulation of detailed facts. This contrasts with my experiential knowledge of many public school science classrooms in which I have taught, where the accumulation of factual knowledge supersedes an understanding of the connection between the facts. One Aboriginal educator (J) stated: "They [schools] don't teach us how to live." This study indicates the importance of the larger contextual inclusion of metaphoric meaning within Aboriginal education.

Two implications for teaching science would emerge from this inclusion. By acknowledging an Aboriginal way of knowing that includes metaphoric meaning the science teacher can act as a "culture broker". Aikenhead (2006) is one proponent of this pedagogical methodology, where students enact a "border crossing" model in coming from their worldview into the worldview of western science. "[Schooling] satisfied my need to know and understand the world beyond myself and my cultural group. I had to be willing to immerse myself into that culture in order to understand it" (Weber-Pillwax, 1992, p.43).

Another implication is that teachers not only include a methodology (process) from an Aboriginal worldview but also include information (product) from an Aboriginal worldview in presenting a scientific concept, as in sustainable hunting examples. Using another specific example, a talking circle methodology brings students together face to face, supports an emotional context, and values individual knowledge. Aboriginal methodologies such as this example, excluded in most science classrooms I have experienced, could be incorporated in science teaching and is in keeping with a traditional knowledge approach to learning in a larger context, where "learning is a transcendent experience"(Urion, 1999, p. 10). As participants referred to in Chapter 5, the use of Elders presenting narratives in their own languages can convey many layered cultural meanings. One participant's statement, "They don't teach us in our own language" (Aboriginal educator) is a plea for implementing this cultural context which includes metaphoric meaning, narrative and experience.

6.9 Language, Elders

"Cree culture and language reflect a natural interconnection where nature is whole, interconnected, and the parts are related to each other" (Webber-Pillwax, 1992, p. 15); western scientific objectification and fragmentation does not. This study supports the notion that Cree language is more representative of nature as a whole than the fragmented language of western science.

One consistent participant recommendation focuses on educational language. Cultural borders are less difficult to cross when students use or are taught in their own language. The present worldwide rate of loss of languages (over 5,000 from 1950 to 2000 at present)[65] has been reflected in Canada: since

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[65] Wade Davis lecture, 2005, University of Alberta, Edmonton, Alberta.

the time of the death of the last living Boethuk on Newfoundland (1829) to present, 72 Aboriginal languages exist in Canada (Battiste, CCL Conference, March 2007). Throughout my elementary and secondary education during this time I received no instruction in one word of any of these languages. The loss of a culture's language parallels the loss of the culture itself. If each culture—sustained by interwoven strands of oral tradition, spirituality, common narratives, and language—is able to maintain its language, then the culture maintains the meanings embedded within words: a way of knowing the world. A (synchronic) western scientific approach to knowing the natural world by definition and explanation through fragmentation and separation is often accompanied by the exclusion of making meaning of how the world is constructed through other ways of knowing (e.g., diachronic). The concept that words exist as externalities that describe or explain objects in the world external to the user, apart from the user and distinct from the user, is a foreign concept for Cree language users (Weber-Pillwax, 1992, p. 14). In Cree, animate words are used to imply a wholistic connection to living processes where "principles of a world view are based on a planetary vision wherein every living thing is interconnected." (p. 18). The use of the written word begins the process of objectifying. To reiterate, although Norris (2003) claims that scientific concepts cannot exist without the written word (i.e., science cannot occur without written words), much of early science did occur through orality alone (Bronowski, 1973).

Aboriginal ways of knowing, specifically the Cree examples here, describe and explain natural events. One initial implication of this is valuing this knowledge as a way of making meaning of the natural world in the science classroom. The Beaver River Dene Nation in Saskatchewan, has charged the Canadian government with cultural genocide for ignoring precisely this (Dene) way of knowing (Adelard Blackman, 2007, personal correspondence). In Alberta, the inclusion of Cree language in Hobbema classrooms, at Blue Quill in St. Paul, and Native language studies at the University of Alberta (e.g., CILLDI) Edmonton are a few present indications of political support for including and legitimizing traditional knowledge in Alberta Learning institutions through language inclusion. In keeping with Marie Smallface Marule (CCL Conference, 2007), one recommendation from this thesis is the use of Aboriginal language and its concomitant deeply layered word meanings (Chapter 5) in the science classroom.

Another reference to language relevance in Aboriginal education emerged in this study. "[E]ssentially, I realized that the Cree respect for the power of words and the recognition of personal responsibility for their use also applied to the use of English words" (Weber-Pillwax, 1992, p.40). Several participant key words and phrases in English addressed the absence of elements necessary in Aboriginal education (Chapter 5 and below). As previously referenced (footnote 56), when 8% of Aboriginal high school students in Canada graduate and of those, only 3% graduate from post secondary schools (Henderson, CCL Conference, 2007), then the school systems themselves bear examination. This conflicts with the predominant Eurocentric view that "the source of inadequacy lay" with the student (Weber-Pillwax, p. 45). Weber-Pillwax's thesis describes the educational experience of an Aboriginal student in a Eurocentric school system: "The 'schooling' experience had led me to the conclusion that my Indian reality had to be separated from the white man's reality (p. 21)". In making meaning of her education (including a mono-science classroom) her thesis represents an impassioned plea concerning the absence of wholistic understandings, first language usage, metaphoric meaning, and meaningful relationship and community support in education. The English words–imbalance, disharmony, dis integration, and spiritual brutality—were used to describe her educational experience. She also used the following English words to describe necessary components of Aboriginal education: interconnected (vs. disconnected); shared meanings; a "network of existence" (Maturana &Valera, 1989, p.131); coexistence; different "ways to see and discourse" (Urion, 1992); relationship; state of being (vs. disciplined mind); process (vs. product); relationship to self (vs. relationship to information, as in product orientation); processes of relationship and interrelationship; intellectual, emotional and spiritual whole human being; and large physical space (vs. confined classroom with no contact with nature). This study supports the conclusion that these English words and phrases accurately address the absence of Aboriginal cultural relevance within the public school's structure. If the educational importance of these words cannot be perceived by individuals from a western scientific perspective, then one curricular implication of this is to centrally locate those who have had the experience of being Aboriginal in western scientifically oriented schools to redesigning school structure and curriculum.

6.10 Oral Tradition

Urion (1999) argues that literacy alone does not approach "First Nations discourse"; orality is needed. This coincides directly with teaching pedagogy in many science classrooms where the teacher orally presents science curriculum. This use of oral presentation in science classrooms allows for government (Alberta Education) mandated science Program of Studies to be enacted by teachers. By providing Aboriginal content in the program of studies and contextualizing science within a traditional knowledge framework, which includes orality and Elder participation, science classes begin to approach traditional knowledge inclusion. These educational inclusions of language and orality, necessary but insufficient in themselves without five other elements (metaphoric meaning, narrative, wholistic, community, relationship) described in this study, would thus begin to meet the constructivist charge made by one participant (L.) that "They [schools] don't acknowledge what I already know".

6.11 Culture, Community and Relationship

Although these elements were discussed independently in chapter 5, their interrelationship will be addressed in these conclusions. Culture, community and relationship interact wholistically when viewed as students' interrelationship with their teachers, science, school culture, and their community. In addressing thesis question 2, (i.e., What are the implications of these connections for teaching science?) one aspect of a mono-science subject focused approach to the teaching/learning complex values curriculum fact retention over personal understanding. However, teachers in praxis with their students, when navigating through a prescribed science course, encounter situations which contradict or conflict with a subject focus. These situations, when addressed, can lead to a clarification of this aspect of the relationship between Aboriginal and western scientific belief systems.

A students' relationship with a teacher in a science course is not the same as his or her relationship with a computer program or a textbook; rather it is a relationship with another *human* being (Aoki, 1991). In Alberta, curriculum is constructed in the Program of Studies to allow for teacher interpretation through lesson planning and unit planning; although it does not mandate day-by-day, step-by-step, factual presentation, it does mandate increasingly detailed factual content. As found in this study, research (Aikenhead, 2006) supports the notion that the human relationship between students and teachers is an integral part of praxis. Science classes in which the student/teacher relationship is devalued can become difficult for students, especially those Aboriginal students for whom relationship plays an integral part of their learning process. The identification of this relationship may be one context in which western scientific and Aboriginal education coincides; as found by Marker (1997) who suggests identifying the cultural relationship between cultures in schools. As previously suggested, when cultural contexts in science classrooms are not addressed, identifying meaning-making possibilities for students are ignored and science often continues to be taught using a mono-scientific approach.

Often because no previous model has been identified for them, Aboriginal students are left to themselves to form their own *asokan* (bridge) between presented western scientific and internalized traditional knowledge approaches in school science classes. Weber-Pillwax (1992) echoes many of the statements made by this study's participants: her childhood held wholeness, although there was a superficial lack of food, clothing and shelter, there existed a childhood sense of completeness; the absence of modern technology did not create a feeling of a lack to be fulfilled with the latest material possession. As a child growing up, this concept of completeness gave a foundational worldview or schema on which to layer her other experiences. An opposite concept that Aboriginal children can internalize is that they "lack" acceptance in the dominant society, and develop a cognitive pattern and behaviour of attempting to achieve that acceptance. This can result in a disjointed worldview in which their cultural traditional knowledge and way of knowing are devalued. Various methods by parents to adjust to new western scientific cultural thinking were described to me in this study. One was the absence of the use of Cree language at home, mirroring a residential school approach. Another was to simply let their children find their own way, while the parents coped with their own cultural turmoil. Others adjusted by accepting the new culture and embracing the new approach into their lives through acquiring new technologies (i.e., television, skidoos, modern housing, cars, fast-food, computer games), which were regarded as useful or critical tools for survival in a new culture. These approaches provided a new definition of self for both parents and children (Weber-Pillwax, 1992). Some participants specifically described Aboriginal youth dropping out of school because of the conflict this assimilation engendered. In response, Aikenhead (2006, p.18) suggests incorporating an enculturation approach where "the culture of science supports a student's worldview" as a promising science educational practice.

6.11.1 Community/relationship

Western scientific methodologies and knowledge bases are grounded in the physical world. Traditional knowledge, in incorporating a wholistic perspective, encompasses more than the physical material world: it includes relationship and community as essential parts of a knowledge system. Although in western science, the separation between matter and energy becomes indistinct (e.g., in quantum physics, in chemical bonding, and in synergistic effects in biology), participants identified that the two knowledge systems are generally regarded in school curriculum as separate and distinct. In approaching nature from different perspectives or in approaching reality from different ontological bases, different methodologies highlight different aspects of what we experience as reality. As previously mentioned (Chapter 2) the western scientific approach to knowing the world has resulted in immense technological advances and, for some, relief from human suffering. From a western scientific perspective traditional knowledge, by including relationship and community as elements in its epistemology, has exposed more intangible (but existent) factors. Intangible here means that it is not easily accessible knowledge using a western scientific methodology of experimentation. Western scientific methodology, although acknowledging the existence of relationship and the effects of a human observer and interpreter of experimental results, has not yet proved a useful methodology[66] to answer questions about human relationship to self, to other humans, or to the natural world (see below). These factors are often regarded as "externalities" in addressing questions such as: 'How do we come to understand the importance of the "desire to know" of a scientist?' or 'Does a scientific analysis of the factors of motivation completely, fully and clearly explain motivation?' Relationship is not easily quantifiable or reducible to analytical discourse or constructs. Emotion, individual relationship, and interpersonal relationships within communities are translucent subjects of investigation for western science, although it acknowledges their existence. From a traditional knowledge perspective, "[t]hese realizations don't come as thoughts, in a sequence which gives time to internalize and accept. We simply accept them because they happen and they are real. Trying to explain or talk about them is a totally different experience" (Weber-Pillwax, 1992, p. 27). By reducing the teaching of Aboriginal students to a chart of Aboriginal learner characteristics (Chapter 3), logically interpreting the results, and assigning to each factor a corresponding teaching methodology; we miss an essential element of Aboriginal education: the importance of a wholistic understanding of relationship and community. When science classroom teachers by choice or circumstance focus on content and product (student achievement)

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[66] Human relationship on a large scale relates to present-day wars, human suffering and ecological destruction. Because western scientific approaches have not yet provided solutions to these problems, examining other ways of knowing the natural world is indicated.

and ignore the importance of relationship and community processes, they are missing what participants in this study have identified as two essential elements of education—part of the interconnected knowledge system of traditional knowledge. Curriculum from a western scientific perspective has often meant a Program of Studies, a unit plan or an individual lesson plan. When written, the substantive content of these physically tangible pages contain factual material. The teacher's role becomes one of delivering the mail (Pinar, 2004) where the teacher delivers the facts, the students receive the facts and the student's retention of these facts is assessed through testing procedures. Some students are successful; those who do not succeed in these testing procedures are considered failures. As mentioned above, one element addressed by participants in this process as missing is relationship—including interrelationships between student and student; student and teacher; teacher and teacher, class and the school community; and with content. Interrelationship encompasses a meaning of these example multiple relationships where community often identifies multiple relationships in one location. In science, the biological definition of community is "populations of all organisms that occupy an area" (Ritter et al, 1993, p. 612). This scientific definition demonstrates reductionism, where a natural phenomenon/concept is reduced to its elemental parts, allowing analysis of each part; but it fails to reassemble the parts into a cohesive whole to include the meaning of relationship and interrelationship as identified by this study's participants. High school science classrooms often generate detailed concepts such as this scientific biological definition, but often fail to provide a location for students to construct the concept into their own cohesive whole, including their culture, or their community.

Aikenhead (2006) describes the worldview of Aboriginal students as a culture and the science classroom as a separate culture of science. He identifies those science teachers who approach science as "the truth" as exemplifying scientism: the belief in science and scientific explanation/description of our world as the only true explanation/description of the world. Participants in this study suggested that by including such elements as community and relationship as a classroom teacher focus, Aboriginal students might more easily bridge the culture of western science, and achieve success.

In addressing thesis question 2 (What are the implication of these connections for teaching science?) with specific application to the classroom, Aboriginal educator L described "teacher empathy" as indicating an intricate relationship between student and teacher composed of multiple factors, including the teacher's awareness of their own interpretation of the relevance of science, and an awareness of their own belief system. Demonstrating empathy requires an awareness of 'other', a consciousness of the basic belief system of students used to construct knowledge into an epistemological structure; an awareness of how students construct their world. A teacher awareness of how students connect the written word and human experience is difficult when literacy is based on experiences rooted in another culture. This unconscious residual scientism is expressed by Weber-Pillwax (1992) when "[e]ducators treated us as if we were in school to learn a better and higher way of life" (p.44).

From the above discussion one implication emerges for science educators. The model used in Figure 6.1 suggests that relationship and community could be used in context to structure theoretical science educational practice in praxis.

6.12 Wholistic/Relationship/Hegemony

With reference to thesis question 1 (What connections exist between western science and traditional knowledge?), Ermine (2006) has identified four approaches that have been taken historically when entering the space between these two knowledge systems[67]. In focusing on the process *wakomakanak* (relations) by acknowledging and identifying ideological differences from a traditional knowledge perspective, Ermine identifies an ethical space (term used by Roger Poole) existing between two cultures, where ethics is a moral arena between societies, containing the unseen and the unspoken. Metaphorically like a river, it is a relationship with undercurrents. In examining why breaches or ruptures occur in this relationship, Ermine articulates six elements of this undercurrent: (1) an enfolded consciousness; (2) a western mind (through history, thought, values) which seeks universality, hegemony, and monoculture; (3) displays of a model of society presented as the norm; (4) a society advanced by its centers of authority and state apparatus (e.g., education); (5) a society which contains an Indigenous peoples' image which marginalizes and is non-inclusive of Indigenous (traditional) knowledge; (6) and a re-creation of this model by its

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[67] These include a monoculture model, a colonial model, appropriation model, and an Indigenous framework.

systems, institutions and processes containing prewritten, prescribed knowledge. The elements described by Ermine reflect dialogue by participants of this study who specifically differentiated between collective organisms and fragmentation; natural contexts and artificial contexts; acknowledging other ways of knowing the world; and identified hegemonic stances. In applying the English word interconnectedness to Ermines' *wakomakanak* thesis: if all things are in relationship–interconnected–in nature, then the western scientific approach is in direct divergence with an Indigenous approach to knowledge, except in the science areas previously outlined (Chapter 5 and 6). Traditional knowledge articulates a collective wholistic worldview (*misiwe*), whereas western science presents knowledge as discrete elements of informational text. Echoing the dialogue presented in this thesis and conclusions presented in Table 6.1, Ermine, in examining process from an Aboriginal perspective of the dynamic interplay between these two knowledge systems, identifies a nexus between relationship, wholism and hegemony: "Eurocentrism… is the undercurrent which undermines and engulfs any attempt to build bridges for the effect of cross cultural understanding and ethical relations between Indigenous peoples and the West." (Discussion paper: Ethical Space, University of Alberta, 2006).

Like Ermine, an assimilation model is also given by Smith (2004) who articulates her position with a description of a western Eurocentric or dominant approach, where the ingestion of all forms of knowledge are, as in a Procrustean bed, adjusted to fit an existing Eurocentric conceptual framework. The existence of conflict itself indicates and supports dialectic with two sides in opposition—

two divergent ways of knowing. In Smith's version, western ideology is seen by one side as a carcinogenic growth: ignoring protocol, people, and cultural values and defending the legitimacy of a mono-cultural mono-scientific approach to human (scientific) knowledge. This side of the dialectic views traditional knowledge as perhaps nonexistent or at least non-scientific, inaccurate, not provable and therefore not legitimate. One potentially productive way towards synthesis through the hegemonic disparity presented here is to include the third element—context (Figure 6.1).

6.13 Hegemony

The inclusion of traditional knowledge in science curriculum raises many educational hegemonic questions, which emerged in the interviews such as: 'Why this inclusion now? Is it to further knowledge? Is it scientific interest or is it because of emerging cultural issues of power? Why should the dominant culture acknowledge our (i.e., another culture's) knowledge?'(Aboriginal Educator). Addressing these questions directly is beyond the scope of this study. However, the following three summations from interview responses to the two thesis questions do indirectly address the above hegemonic questions directed towards power and privilege of western scientific paradigms:

- Education is the place for this inclusion to occur;
- Reservations on the part of Elders to participate in knowledge transfer are due to previous negative experience with *belagatto-wapastimata* (whiteman);

- The process of how knowledge is received is important. It connects relationship to experience and is a determinant in how students structure their world.

Dwayne Donald (personal correspondence) approaches similar hegemonic issues using the term metissage—where the metaphorical map reading of knowledge differs between cultures but where there exists a distinct interrelationship between worldviews. Table 6.1 suggests a necessary shift in consciousness (paradigm shift): from one of 'I do not question the western scientific (dominant culture) worldview' to 'I acknowledge that there are other ways of legitimately knowing the world: traditional knowledge (native science) is one of these ways.' Traditional knowledge exists as product—how to predict herd movement or individual animal movement in hunting caribou, seals or fish; and as process—a way of knowing a wholistic interconnected natural world (Chapter 3; Chapter 5). Human survival has been associated with reconciling these divergent viewpoints (Suzuki, 1997; Jardine, 2000; Peat, 2002).

6.13.1 Relationship, western scientific approach, and survival

Participants described relationships between people within a school culture and within a community as an interconnected whole (Chapter 5). Western science presents a culturally influenced perspective on "natural events" when it only contains elements of western ideology (Aikenhead, 2006); traditional knowledge emerged from within another cultural perspective. A realist Eurocentric perspective posits that both perspectives are describing, explaining and predicting the same thing: 'nature'. However, Aikenhead (personal correspondence) has pointed out a crucial distinction between a western scientist looking at 'nature' and "when an Elder inhabits what is taken by English speakers as 'a natural event' ". Inadvertent Eurocentrism conflates this distinction.

The potentially lethal environmental effects of humankind's present approach to nature has brought a wholistic view of knowledge to the attention of the western scientific community (Wilson, 1994; Suzuki, 1997; Gore, 2006), which now seeks to become informed by other approaches to knowledge. In the process of understanding another way of knowing, the conceptual framework of western scientific approach to knowledge—including Midgley's (1992) four axioms and a fragmented, artificial (synthetic) experimentally derived context—becomes transformed (Table 6.1). This transformative process is encoded in the verb coming-to-know.

A western scientific approach to including Aboriginal perspectives in science curriculum has been used in Alberta by adding bits of traditional knowledge to the main core categories of secondary science (e.g., chemistry, physics and biology). This retains the central theme that true scientific knowledge is empirically testable and falsifiable (Popper, 1968) and has been a main curriculum development methodology used by educational institutions such as Alberta Education. This methodology is described here as the 'bracket fungus' approach; where bits of knowledge from other worldviews are attached to the main trunk of an existing knowledge structure. Using this concept, the 'infusion' of traditional knowledge is metaphorically represented by the bracket fungus growing on the trunks of white poplar trees of the boreal forest (see p. 113).

In education, Alberta Education is approaching traditional knowledge from a Eurocentric perspective; in viewing it as a 'product', it is 'infusing' Aboriginal knowledge into the present science Program of Studies. The basis of this approach corresponds to Ermine's (2006) appropriation model in which a western scientific approach to indigenous (i.e., traditional) knowledge is taken as scientism and directly transferred through education into western society. I have termed this specific educational methodology the bracket fungus approach. It represents a hegemonic stance of the dominant western scientific paradigm as described by Aboriginal participants in chapter 5 whose etic views are outside of this paradigm (Table 6.1).

6.13.2 Cultural epistemological borders

In Chapter 3, three perspectives of western science were described: scientists (doing research resulting in new knowledge), scientific philosophers (analyzing the research and the paradigms under which it occurs), and science teachers (presenting the knowledge obtained from the above two perspectives). These groups operate within an existing structure, which sets boundaries on the definition of the truth of knowledge claims by demarcating the border of what represents true knowledge. An example in science of questioning the results of cold fusion experimentation by Pons and Fleischmann (1996)[68] demonstrates the self-correcting effectiveness of this system. Within these borders other ways of

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[68] Pons and Fleischmann claimed to have generated cold fusion as an energy source. Their experiment was not reproducible.

knowing must either fit the existing criteria for determining the truth of knowledge claims or be excluded from this dominant epistemology. Knowledge derived outside of the borders of these prescribed rules for legitimization (by using the scientific method) is rejected. However, the dissection of scientific thought from non-scientific thought itself operates within a larger paradigm (Table 6.1). Participants in this study described other ways of knowing and, seen from their perspective, these ways are equally legitimate. This thesis presents participants' questioning of exclusive truth claims by western scientific ideology and suggests a re-evaluation of what Aikenhead (2006) terms the "pipeline ideology" of present science education whose "purpose has been to funnel capable students into science and engineering degree programs" (p. 1). I argue that a teaching/learning complex occurs within a cultural context, and cultural transmission becomes embedded in praxis. When western science is presented from one western cultural perspective, the teaching of science requires students to accept that culture's epistemology: they can accept the "pipeline" ideology (above) or play Fatima's rules (Redefining success 2.6.1) to succeed. For Aboriginal students Battiste (2003) presents it this way: "[we are] imposing one worldview on a people who have an alternative worldview, with the implication that the imposed worldview is superior to the alternative worldview" (p. 193). This study confirms that a central educational issue is not the identification of a different student's "styles of learning" (Chapter 3), or linguistic confusion resulting in sociolinguistic interference. Cognitive imperialism or cognitive assimilation is, however, described as a central cultural issue by participants

(Table 6.1). JM (Cree Elder) describes this metaphorically: "They can't see the trees for the forest."

6.13.3 Language, culture, identity

By valuing one worldview over another, promoted either by force (residential schooling) or by transitory economic or technological advantage, the history of the Canadian educational system has been to reject an Aboriginal way of knowing the world as non-scientific and thus an educationally illegitimate form of knowledge (Willinsky, 1998). Within some participant questions (above) lie directions towards inclusivity of this way of knowing. Aboriginal language, culture and identity form a key focal nexus not previously addressed in science education, but have become of present interest in science education institutions and texts (Alberta Learning, 2003; Jenkins et al., 2007). In regarding these three elements metaphorically, like the many sinew strands in a caribou tendon, each strand can be separated out, but does not function without support from the other strands connected to the whole animal.

One strand is that until the epistemology of Aboriginal thought is known (as a way of knowing) and valued by teachers in the classroom, 'infusing' traditional knowledge into the existing curriculum has little evidence-base as a solution (Aikenhead, 2006). Infusion is an example of previously identified "bracket fungus" model of curricular change where Aboriginal knowledge is supplied as add-on material, often found in text marginations (Jenkins et al., 2007). The approach of providing detailed western scientific knowledge as the main component of scientific cognition and literacy in the curriculum allows little space for the more affective traditional knowledge concepts of listening, approaching wise people (Elders), and developing intuitive metaphorical understandings of the relationship between humans and of the relationship of humans to the cosmos. Participants indicated that these concepts are embedded in Aboriginal language, culture and identity. The structure of western scientific knowledge and the structure of the school systems presently allow for the inclusion of Aboriginal knowledge through assimilation and acculturation where Aboriginal language, culture and identity are subsumed. Many participants of this study expressed a need for the equal inclusion of language, culture and support for identity in Aboriginal education.

6. 14 Summary Conclusions and Recommendations

6.14.1 Conclusions

My position as researcher is that of an *asokan* (bridge) between knowledge systems (Figure 2.1). Indigenous research methodology (Weber-Pillwax, 1999) allowed in-depth participant responses to emerge as my process of coming-to-know traditional knowledge concepts evolved during this thesis study. In using an initial western scientific approach to understanding traditional knowledge, I expected specific details to emerge which could then be 'fit into' the existing science educational structure without addressing epistemological or ontological constructs of western science. However, the open-ended and open-entry questioning/interview technique and the use of indigenous research methodology allowed for unexpected results to emerge. In my process of coming-to-know traditional knowledge, I realized that responses to the two thesis questions could not be formulated without addressing a western mono-science educational approach. Some conceptual shifts arising for me in this conceptual evolution are outlined in Table 6.1. One initial key premise is that western scientific knowledge is culturally derived, a view supported by thesis participants from the etic stance of Aboriginal people who have been colonized.

Specific examples of connections between western science and traditional knowledge have been given in Chapters 3 to 6. Insightful openings into traditional knowledge epistemology and ontology from a western science perspective include indeterminacy (uncertainty) in quantum physics, wholistic ecological concepts such as the Gaia hypothesis, synergy and healing in living organisms, and Prigogne's dissipative systems in chemistry. Rather than outlining specific details of educational implications of these connections for the science classroom, most thesis participants did not suggest specific conclusions or recommendations, but asked me to pay attention to my process of coming-to-know. I was the learner, they acted as advisors to me, not to my study. Some participants identified a lack of essential elements in education systems. These elements I described under the general categories of language, metaphoric meaning, narratives, oral tradition, Elders, community and relationship. My summary conclusions are based on this categorization, however participants indicated that my process of coming-to-know individually superseded specific summary conclusions.

Educationally applying a universal methodology for incorporating traditional knowledge into the western scientific model of knowledge has not been successful in the past and predictably this approach will not work in the future. The expressions “assimilating”, “acculturating”, “incorporating” or “infusing” imply a limiting conceptual understanding of this complex process.

Coming-to-know traditional knowledge is a process that cannot be fully understood using only western scientific methodological approaches. Traditional knowledge as a way of knowing includes such processes as way of living in the world, and incorporates not only the rational, logical mind but includes emotional, intuitive, spiritual knowledge as found in Cree *Nehiyaw* (four part person).

Just as occurs in translating scientific research to school science, some words and their attendant concepts don’t easily translate between cultures: “Translations lose epistemological, ontological and axiological nuances, and hence cause misunderstandings” (Aikenhead, 2006, p. 110).

Aboriginal scientific knowledge is often related to experiential knowledge obtained by generations living in close association with the land and natural cycles (e.g., diachronic knowledge). Thus for many Aboriginal students, “a sense of place is also endemic to urban science education” (Aikenhead, 2006, p. 111).

Both worldviews share a similar approach to *kisteyittamowin*, (knowledge/respect, p. 131). Teaching traditional knowledge in the science classroom demands inclusion of this element. Although Alberta Education has legislated science curriculum, individual teachers each approach praxis differently; there is a tacit understanding that individual teachers respect other ways of knowing. However, from a western ideological stance although the word respect is conceptually understood, it does not necessarily imply a lived application. In traditional knowledge, Elders as knowledge keepers are regarded as those who do enact this concept of respect (JM). Teaching traditional knowledge in the science classroom includes this definition of respect for Aboriginal epistemology and western science.

In agreement with O'Loughlin (1992, p. 791), sociocultural constructivist concepts can pragmatically apply to those Aboriginal students who are enculturated into a western scientific worldview by supporting the retention of their personal belief systems.

6.12.2 Recommendations

As previously mentioned, many participants of this study did not suggest specific recommendations or conclusions as outcomes of an interview. I make the following recommendations from my summary of participant responses to thesis question 2 (What are the implications of these connections for teaching science?) with an awareness that other readers and researchers may make other recommendations.

There is no one best remedy or solution. Many different approaches can be taken to include traditional knowledge in science education and research needs to be done to determine the effect of each approach.

Identifying elements of cultural transmission in science curriculum is not easily conceptualized by science teachers or easily integrated into science lessons. This process implies a complex approach which in this thesis requires the inclusion of metaphoric meaning, language, narrative, Elders, oral tradition, relationship and community. Input by Aboriginal people themselves is needed to foster the inclusion of traditional knowledge in curriculum creation.

Aboriginal language (e.g., Cree) needs to be a part of science education and used in science classrooms. When educators are aware that in teaching science, they are teaching a western cultural perspective (Aikenhead, 2006), then this recognition would allow a questioning space to be created where other ways of knowing can be addressed. Educational institutions need to include epistemology as part of science education. Educator training facilities need to teach that science is culturally derived and that teaching science is a cultural activity which can also include knowledge from Aboriginal sources. Definitions of words within a cultural context need to be part of Aboriginal education and science education for all students.

Humanistic science education needs to be implemented, where honesty, kindness, strength and wisdom are a part of every science class. Teaching students as *Nehiyaw* means addressing all four parts of a person (Cree).

Elders need to be included in science education classes. The wisdom of the Elders needs to be passed on to all students.

The assumption that western scientific thought is an accurate description of reality is central in western scientific curriculum. Questioning this assumption in science classes can lead to a greater understanding of scientific knowledge (Table 6.1) about the whole of nature for all students.

Viewing education and curriculum as a product maintains the hegemonic concept that the existing social order that grants power and privilege to a select few is the sole determinant of legitimate knowledge. Although this unconscious educational practice maintains the *status quo,* some curricular theorists have suggested a reorientation of educational practices (Aikenhead, 1999, 2000a, 2000b, 2006; Aoki, 1991; Battiste, 2005; Eisner, 1998, 2002; Hampton, 1995; Jegede, 1995; Kawagley, 1995; D. Smith, 2002; Urion, 1999; Weber-Pillwax, 2003; Wilson, 2003) based on an interpretation of curriculum which takes into account such factors as the student, teacher, school, community *and* culture; and places an acknowledgement and value of an identified cultural orientation over maintaining an established social structure of accountability (such as is used by achievement on test results solely as measured success). Aboriginal participants have described this reorientation of educational practice as the decolonization of education and suggested identifying other measures of success such as viewing education as life-long learning.

Three areas indicate promising directions for further research. First, Aikenhead (2000b) has shown a methodology for developing curriculum in Aboriginal education with the Rekindling Traditions Project. However, the inclusion of this type of material in present science classrooms may be limited when solely applying a multicultural border-crossing model to enact it (2000a). Second, the inclusion of Aboriginal educators at every level of educational program development allows for potentially new science educational initiatives to emerge (Table 6.1) This is suggested by Battiste (2005) who is presently developing guidelines for defining success in Aboriginal learners. Her methodology of including Aboriginal people in developing these guidelines may ensure that the meaning of traditional knowledge is encoded in praxis—the act of teaching science. Finally Ravetz (1999) has presented the concept of post-normal science that uses concepts from reflective social systems in application to complexity science using the properties of 'radical uncertainty' and 'plurality of legitimate perspectives' in environmental policy which could also apply to the inclusion of traditional knowledge in western science education.

6.15 Concluding Remarks

This thesis is a reflection solely of my own construction. I am responsible for its contents. Hopefully it may be of some use to others.

I know that some Aboriginal readers may be skeptical of its contents. Many of them have experienced misrepresentation, misinterpretation and unconscious exploitation by white scholars (L. Smith, 2004; Weber-Pillwax, 1992).

For them I hope that I could discuss these judgments and move to mutual benefit, that we could cojointly construct Willie Ermine's *asokan* (bridge). My intention is not that of a white anthropologist who dissects cultures under a microscope, or one who is a 'wannabe Indian', or one who amasses the wisdom of native Elders for presentation and personal accolades.

If this thesis presents anything, I hope that it moves some forward from ignorance about science and scientism, and brings to light some Aboriginal ontological views of the natural world, Aboriginal views of education, and Aboriginal views of science.

I have been asked not to disclose some sources and not to directly quote others in this thesis research. I have honoured these requests.

I believe, more firmly now than when I started, in the great role that Aboriginal ways of knowing and knowledge have to play in the future of humankind, that Aboriginal people will help determine if educational institutions continue to view nature as a threat to be controlled by humans or if we will be able to direct our attention to find a sustainable relationship with nature.

Hopefully, I have not added to the dehumanizing effects of packaging Aboriginal thought neatly for white scholarly consumption. In a desire to understand Aboriginal thought, thoughtless action can destroy the very essence of it. I hope I have not done so here. Aboriginal thought and knowledge in many ways is similar to thought and knowledge found in western science: it is done by real people existing in real time who live in and try to understand the same real world. I believe that common human experiences, thoughts and knowledge form the essence of education, where knowledgeable and wise people can pass on that knowledge and wisdom to our children.

I offer this work as tobacco is offered, to honour those who have helped me and informed me in the hope that it may help and inform others.

Thank you.

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APPENDIX 1

Faculties of Education and Extension

Research Ethics Board

(EE REB)

I. Application for Ethics Review of Proposed Research

(revised June 23/03)

Purpose

The purpose of this research is to investigate the common ground occupied by western science and traditional knowledge. By delineating the area where these two worldviews intersect (and subsequently do not intersect), these combined views could add to the understanding of the natural world, one of the aims of science. Some of the questions guiding this study are: What do both views have in common? What basic underlying philosophies of science allow for (or prevent) a combination of both descriptions or explanations of the natural world?

One of the practical results of this discourse will be in locating areas where traditional knowledge could be included in today's school science curriculum. A conceptual framework unifying both knowledge systems would help to facilitate this. How can traditional knowledge be taught or incorporated into actual science lessons within the classroom becomes a third resultant question.

Significance:

Generally, this study is significant to two ways:

1. It generates an answer to the following question: How are western science Aboriginal ways of knowing related?
2. It informs educational institutions about the importance and relevance of and the relationship between these two knowledge systems.

Aboriginal youth have had only measured success within the present day educational system (Census, 2002). Various reports have outlined the importance of focusing on the success of Aboriginal youth within the extant educational system (Alberta Learning Recommendations, 2003; Aikenhead and Jedge, 1999). Some have suggested incorporating Aboriginal knowledge (e.g. exploring the meaning of the medicine wheel) into today's educational curriculum with the intent of fostering student attendance and increasing high school participation and completion rate (SSHRC—draft summary paper, 2003; Alberta Learning, 2002). Also, some studies have focused on the importance of 'border—crossings', which occur when students attempt to navigate between two worldviews. (Aikenhead & Jedge, 1999). The suggestion is that an increased educational awareness of the difficulties facing students negotiating these border—crossings may result in the development of pedagogic strategies (for example the use of the sharing circle), which in turn may affect success at school. This can only be done if there is an awareness of the underlying structures that exist, the intersecting and parallel paradigms under which both these knowledge systems operate.

Although Alberta's science curriculum focus includes the elements of knowledge, skills and attitudes, the latter two are inadequately represented on diploma exams. Exploring western scientific attitudes towards traditional knowledge might address the absence of information about traditional knowledge in science classrooms. If traditional knowledge is to be included in the existing science curriculum, then educators initially need to be aware of the relevance of this way of knowing. Western scientists have demonstrated support for this way of knowing science. Science educators such as David Suzuki and Glen Aikenhead have outlined the importance of recognizing and including traditional knowledge systems within today's educational system (Suzuki, Aikenhead). Additionally, E.O. Wilson (1994) coined the term biodiversity, which emphasizes the importance of maintaining the relationships among living organisms, an example of long—held traditional knowledge by Northern Alberta Cree. This common understanding, recently elucidated by western science, is particularly relevant in light of present day worldwide environmental loss of diversity. Displaying the importance of Aboriginal knowledge systems could thus have an impact not only on the success of Aboriginal education but also on supporting universal concepts of science for the benefit (and possibly survival) of all humanity. This small discourse would add to the growing discussion concerning the relationship between globalization and environmental degradation (Smith, 2002).

Institutions aimed at the inclusion of native students in societies' educational systems are facing such questions as: What needs to be incorporated into the curriculum and instruction, which would help to engender success for Aboriginal students? What does coming-to-know mean pedagogically for science educators of native youth? How can the present educational institutional models adapt (change) to allow for the inclusion of traditional knowledge as a product of a valid way of knowing the world? What role can knowledgeable Elders play in developing curriculum and instruction in science?

With a basic epistemological understanding and acceptance of traditional knowledge and a traditional way of knowing the world, educators could begin the pedagogical inclusion of this knowledge in educational curriculum. Specifically, in science, teachers using an approach that supports an Aboriginal way of knowing the natural world would nourish the success of native youth taking science courses. Facilitating the inclusion of this knowledge in the present science curriculums of educational institutions would thus be an important first step towards successfully educating Aboriginal youth. By demonstrating epistemological congruity between western science and traditional knowledge in the embryonic stage of western science coming-to-know traditional knowledge as a scientific explanation/description of the world, students would, at the very least, experience less conflict in negotiating cultural border crossings. It is hoped, however, that more than this would emerge from studies of this type. Although it is not possible to predict the outcome of this study, there is strong evidence (Suzuki, Aikenhead) to suggest the existence of scientific knowledge and a scientific knowledge system which, until recently, has been largely ignored in western scientific thought.

Method

This study will adhere to the principles of indigenous research methodology. Its focus is on gathering contextualized understandings of the relationship between western science and traditional knowledge from people directly involved in Northern Alberta Cree communities.

One of the focal points of indigenous research revolves around the word respect. It is my understanding that this includes at least four elements. Integral to any research of this type is (1) respect for the participants as individuals and (2) respect for the community in which the research is located. Other equally important preconditions for an indigenous researcher is (3) a conscious awareness of the interconnectedness of life, by expanding personal respect to include the respect for all forms of life. (4)The research must also be of benefit to the community; which, in this case, would require the researcher to have an understanding of indigenous ways of knowing. Directing the element of respect towards indigenous ways of knowing would specifically imply, for example, that no material would be presented as referenced to an individual or community without the individual's and/or the communities' consent. The communities referred to consist mainly of Northern Alberta Cree people.

Design

A pilot study will be conducted through interviewing University of Alberta colleagues. They will be presented with a hard copy of the study and then interviewed directly to discuss their reactions. These reactions will be incorporated into the study before proceeding to the second stage.

The research involving case study information will adhere to the principles of indigenous research methodology. Protocol and respect play an integral role in the research design. Participants will be selected from among those identified by other indigenous researchers and community members known to the author as having an understanding of traditional knowledge and how it might relate to western science. My advisor Cora Weber—Pillwax, or someone known by myself to be a respected member of the community, will initially approach the potential participants. The intent of the study will be presented to them and they will be asked if they would agree to participate. Thereafter I will maintain and foster this initially established trust. At present, we have identified two possible locations near large towns, two possible more remote locations and one location intermediate to the others.

Sampling and selection

Cora Weber-Pillwax will be my main advisor in both directing me towards communities and specific people within those communities, and advising me as I proceed through the interview process. She has agreed to act as my advisor and guide as I gather and interpret data. Dougal McDonald has also identified some communities as having a rich resource of people with a detailed understanding of traditional knowledge and how it might relate to western science. Cora will recommend me to community residents whom she knows would be willing to be involved in this research. These residents will include Elders, the carriers of traditional knowledge. Other community members may be included who have been previously known to me or known to my colleague Bertha Laboucan. I will then approach these individuals in order to demonstrate that I have no "hidden agendas" and that my intent is pure. I will then begin to develop a level of trust. If this can be established, then I will proceed with a request for dialogue dealing more directly with research on traditional knowledge. Because my role is that of a visitor or visiting teacher/professor in a community, I will establish contacts within that context. Other community residents who have a stake in education (e.g., sit on various community organizations or act as advisors to the educational authority) or have a knowledgeable interest in this subject will also be approached as contacts. These community members can provide invaluable direction in addressing the last research question concerning the inclusion of traditional knowledge in each community educational institution[69]. This could lead to a future development where I might be of use to the community in supporting the development of the inclusion of traditional knowledge in the existing science curriculum. No persons under 18 years of age will be part of this study.

Once contact with community residents has been made I will be continually monitoring to make sure the "fit' is good, and that my use of any data is transparent to all the participants.

Pilot study

The pilot study will consist of interviewing fellow Aboriginal colleagues, including Bertha Laboucan from White Fish Lake First Nation who has agreed to translate interviews conducted in Cree. She has completed her M.Ed. in First Nations Education, has taught in Wabasca and Drift Pile First Nation and is presently working with Alberta Learning as resource manager, Aboriginal studies, developing First Nations curriculum. She can provide constructive

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[69] Once an initial level of personal trust has been established, interested stakeholders including educational directors, teachers and parents will also be approached.

criticism of the initial structured interview questions and suggestions for the ensuing semi—structured questions as well as honest, insightful feedback on my methodology. I will also interview Dwayne Donald who has completed a M.Ed. from University of Lethbridge and is presently in the Ph.D. program in Secondary Education, University of Alberta. He has taught for a decade at Kainai First Nation, and can provide similar constructive criticism of specific interview questions and methodology from his perspective.

Data collection

In order to locate the areas of intersection between the traditional knowledge presented by individuals in each community and the western science knowledge presented in the present science curriculum, the initial step is to develop rapport and trust with the individual participants. The depth of knowledge exchanged will depend both on my receptiveness and the participants' willingness to talk. I will attempt to create an arena of mutual respect where this meaningful dialogue can occur. Although my intent is to gather data concerning the intersection of these two bodies of knowledge, the individuals within the community may have other intents; the communities may have other needs. For this discussion to proceed (although it will not be part of the data collection), I will keep the following questions in mind: What can I offer to the community? If the need emerges, how can I support the process of including traditional knowledge in the community's school science curriculum? Other questions I will be asking myself include: What are the wishes of the community? How can I best respect the wishes of the participant individuals in the community? How can I best facilitate the community's needs within the intent of my research? How will my evolving understanding of this project be of use in each community?

Besides interviews, Aboriginal ceremonies will also play a part in the data collection. Information and understandings of the contextual meaning of the words used in conversation and interviews must be interpreted against the surrounding community milieu in which each individual exists. Sharing circles, feasts, meditation, prayer, sweats and participation in other community ceremonies all play a role in facilitating my contextual interpretation of data and developing within the community an understanding about how I am seen as going about collecting data. "The method of interviewing key people is used to best advantage when it is closely integrated with participant observation." (Pelto and Pelto, 1978).

Once the participants have been identified and have agreed to a discussion of the topic, interviews will be conducted. If acceptable to the participant, the interviews will be taped. The interviews will last one to two hours, depending on how long each participant wishes to talk. In responding to interview questions, it is understood that, in many cases, the speaker may use narratives which contain the meaning of the intent of their response. Eber Hampton (1995) has reported that elders 'talk in circles' and Suzuki (1997) has shown that narratives contain deep ecological understandings, which are often later supported by western science. Van Kessel (2002) has identified the importance of diachronic data[70]. Interruption with questions at those times would be inappropriate and disruptive to the speaker's flow of thought (Hampton, 1995).

Only one interview will be conducted with each participant, unless the participant requests another for further elaboration, or if statements need to be reconfirmed. Interviews will be conducted in locations where the participant feels most comfortable, usually, but not necessarily, in a home.

During my initial introduction to participants, it is important to clearly state the intent of the research project; what my purpose is in asking questions about traditional knowledge. Many participants, acting from previous experience, may wish to determine if my intentions as a researcher are pure. If there is any hesitancy or caution on the participants' part in relation to my use of their words, or my interpretation of what they are specifically saying, I will address this directly and immediately and will respect their wishes in my recording of any information. My intent here is to bring the element of respect to communication with each participant as we proceed through the data collection process.

Using the findings

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[70] Information that has been collected in a small region over a long period of time

Depending on the wishes of the participants, I will give them copies of how their input has added to a knowledge base, which in turn generates a unifying conceptual framework for science curriculum. Ancillary to the study, if I locate any pedagogical examples of the incorporation of both knowledge systems in the science classroom I will, with the author's permission, make copies and distribute them to all participants. The dissemination of this information may take the form of a public information sharing session, website update or the distribution of hard copies. It is my hope that this initial research will begin the process of uncovering ways in which traditional knowledge can be pedagogically incorporated and embedded within each communities' science curriculum.

In a semi-structured format I will be carrying the following questions into the interview. These specific questions may or may not emerge, depending on the individual situation. They reflect the intent of this research.

Questions for the Elders

Who are you and where are you from?

Tell me what you know about traditional knowledge?

Tell me what you know about western science?

Should traditional knowledge be taught in schools?

What is the Cree way of life?

What are the beliefs, values or traditions of the Cree people?

How do Cree children gain an Aboriginal worldview?

What is the Cree way of knowing?

Tell me about the way life used to be a long time ago.

Tell me what you know about:

—what times were like a long time ago?

—being Cree was like for you

—school is like now

—what are the belief systems of the Cree people?

Questions for Other Community Members

This study is about the relationship between western science and traditional knowledge.

Western science means many things, what does it mean to you?

What about traditional knowledge, what does it mean?

Can you give me any examples of what you mean by traditional knowledge?

What traditional knowledge do you consider to be scientific?

Are there any examples of where traditional knowledge is the same as western science?

What would be the difference between the two?

Is there a connection between western science and traditional knowledge?

Do only elders know traditional knowledge?

How is traditional knowledge gained? Taught?

Are all things interconnected? In what sense are all things living?

Specific questions for educators

When teaching, should we include these cultural teachings at school?

What cultural teachings or traditional knowledge should we include?

If they were to be presented in school, how can they best be presented?

In teaching (western) science, how could this traditional knowledge be incorporated?

If traditional knowledge were taught like science is now being taught, would it still be traditional knowledge?

Can you put either knowledge into printed form? into textbooks, for example? What about videos or PowerPoint?

In what ways can this knowledge best be transmitted?

Is there a difference between the process and the product in traditional knowledge?

Some authors describe how it is for native students to learn science in school. Did you learn science, and if so how was it presented?

The phrase border crossing is used by some to describe an awareness of teaching western science to Aboriginal youth. Does this have any meaning to you in terms of teaching science?

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Procedures for compliance with U of A standards

Attachments:

- Information letter to participants.
- No minors will be participating in this study

You have been invited to participate in a study at (name of community). As a graduate student, I would like to initiate and participate in conversations, discussions, etc. and take notes and audiotape formal and informal interviews on the topic of the educational relationship between traditional knowledge and western science. The purpose of my project for me is to complete the requirements for a Doctor of Philosophy degree at the University of Alberta in the Department of Secondary Education.

In school, the way in which western science is presented to Native youth may be confusing and present unnecessary conflicts in the student's belief structures, particularly for those who have had access to traditional knowledge in their communities. It may be possible to incorporate some of this traditional knowledge into the science curriculum, in order to make science more meaningful to the students. In order to do this, we need to establish where these two worldviews are similar and how the current presentation of science might be enhanced by the inclusion of traditional knowledge. This study will add to the growing awareness of the importance of traditional knowledge in education.

The type of data to be collected will be that of an informal interview lasting approximately one hour in length, depending on how often and how long you wish to speak. There will be ten questions, all designed to ask you about your ideas of traditional knowledge and education. You will be protected from harm by the following rights: All participation in my research will be strictly voluntary and requires your permission. You may withdraw from the study at any time. Any information that you wish to keep confidential, such as your name or any other information that might identify you, can be indicated to me at any time. The University will keep all transcripts, tapes, notes and any additional data for five years before being destroyed.

Before the written report is submitted, data will be made available to participants to verify the accuracy and meaning of the content. A copy of the finished report will be made available to all participants.

Researcher:

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Attachments:

- Consent form for participants
- No minors will be participating in this study.

Letter of Consent

You have been invited to participate in a study at (name of community). As a graduate student, I would like to initiate and participate in conversations, discussions, etc. and take notes and audiotape informal and formal interviews on the topic of the educational relationship between traditional knowledge and western science. The purpose of my project is for me to complete the requirements of a Doctor of Philosophy degree at the University of Alberta (Department of Secondary Education).

The type of data to be collected will be that of an informal interview lasting approximately one hour in length depending on how often and how long you want to speak. There will be ten questions, all designed to ask you about your ideas of the relationship between traditional knowledge and western science. Contributions resulting from this research could be the development of science materials containing traditional knowledge which could be incorporated into community school classrooms.

You will be protected from harm through the following rights: All transcripts of the interview will be reviewed with you for accuracy. Data will ONLY be collected from participants who have consented to the study period. You have the right not to participate; you may withdraw from the study anytime without penalty. If you opt out, your information will not be included in the final report. The university will keep all notes, tapes, transcripts, and additional data for five years before being destroyed. Before the written report is submitted, data reports will be made available to all participants to acknowledge the contents accuracy and meaning. A copy of the finished report will be made available to all participants.

If there is any information you wish to keep confidential such as your name or any other information that might identify you, please indicate this to me at any time. Data for all users will be handled in compliance with the Standards. All research assistants and transcribers will comply with the Standards.

Please complete this form and return it Frank Elliott.

I, ____, hereby consent

to

(print name)

[Please circle EITHER YES or NO for EACH of the following]

1) Be interviewed by the researcher, if selected. YES

NO

2) Be tape—recorded (audiotape) during the interview. YES

NO

Be tape—recorded (on audiotape) during the interview. YES

NO

I understand that:

- I have been invited to be a participant in a research study.
- I am free to refuse to participate or to withdraw from the study at any time, without penalty, having my information withdrawn.
- All information gathered will be treated securely and confidentially, and the anonymity of each participant will be strictly maintained throughout the duration of the study.

This study has been reviewed and approved by the Research Ethics Board of the Faculties of Education and Extension at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Chair of the Research Ethics Board at (780) 492—3751.

____

____

Signature Date

For further information concerning the study or the completion of the form, please contact:

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Research Assistant/Transcriber Confidentiality Agreement (Translators and Transcribers).

Project Title: **The Relationship Between Traditional Knowledge and Western Science**

I,____the Research Assistant (Translator/Transcriber), agree to:

1. Keep all the research information shared with me confidential by not discussing or sharing the research information in any form or format (e.g., disks, tapes, transcripts) with anyone other than the Researcher.

2. Keep all research information in any form or format (e.g., disks, tapes, transcripts) secure while it is in my possession.

3. Return all research information in any form or format (e.g., disks, tapes, transcripts) to the Researcher when I have completed the research tasks.

4. After consulting with the Researcher, erase or destroy all research information in any form or format regarding this research project that is not returnable to the Researcher (e.g., information stored on the computer or hard drive.).

Research Assistant (Translator)/Transcriber:

____

____________________________ ____________________ (print name)

(signature) (date)

Researcher:

________________________________ ______________________________

___________________ (print name) (signature)

(date)

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