The Alberta Journal of Educational Research *Vol. 55, No. 3, Fall 2009, 284-297*

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Science, Metaphoric Meaning, and Indigenous Knowledge

Western cultural approaches to teaching science have excluded Indigenous knowledges and culturally favored many non-Aboriginal science students. By asking the question "What connections exist between Western science and Indigenous knowledge?" elements of epistemological (how do we determine what is real?) and ontological (what is real?) connections can emerge for science educators. Western science as it is presented in Alberta classrooms is characterized as teaching scientism by the degree to which it excludes the presentation of other ways of knowing. The objectivity of Western science is questioned here, and aspects of Indigenous knowledge are suggested that coincide with and can support science teaching. The concept of indeterminacy and flux as suggested by Bohm (1980), Little Bear (2004), and Peat (2002) form a nexus where Western scientific epistemologies and ontologisms are congruent with Indigenous knowledge. Metaphoric meaning is suggested as one useful area of congruence for science education praxis.

Les approches culturelles de l'Occident relatives à l'enseignement des sciences ont exclu les connaissances indigènes et ont favorisé, sur le plan culturel, les étudiants non-autochtones en sciences. Si les enseignants de sciences se demandaient quels liens existent entre la science de l'Occident et les connaissances indigènes, ils pourraient repérer des éléments de liens épistémologiques (comment déterminer ce qui est réel?) et ontologiques (qu'est-ce qui est réel?). La science occidentale telle qu'elle est présentée dans les écoles en Alberta constitue l'enseignement du scientisme en raison de son exclusion des autres façons d'apprendre. Nous remettons en question l'objectivité de la science occidentale et proposons certains aspects des connaissances indigènes qui coïncident avec l'enseignement des sciences et peuvent l'appuyer. Le concept de l'indétermination et du flux tel que proposé par Bohm, Little Bear et Peat, forme un lieu de rencontre où les épistémologies et les ontologismes scientifiques de l'Occident et les connaissances indigènes sont cohérents. Nous proposons la signification métaphorique comme un élément de congruence utile en enseignement des sciences.

A Western scientific approach to knowledge has been characterized as objective, empirical, rational, and singularly truth-confirming (Aikenhead, 1997). That the Western scientific approach to knowledge has provided humankind with astounding discoveries and technologies is undeniable; however, a limitation of Western scientific methodology when used exclusively to describe and explain natural events can be found early in, for example, Bronowski's (1978) works:

> It [science] will work well enough as an approximate model of large events, such as eclipses and hydro-electric dams and the use of penicillin in arresting the multiplication of bacteria.… we must use science as it is, and that is an

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> assembly of observations so ordered that they tell us what we may expect to observe in the future. (p. 103)

Use of the scientific method gives predictability. However, in terms of objectivity, scientific observations require the use of the senses by the scientist, and "what an observer sees is affected by his or her past experience" (Chalmers, 1999, p. 7). Aikenhead (2006), in interpreting Kühn (1970), adds to this with "scientists' perceptions and interpretations depend upon scientists' prior experiences and training" (p. 545) and states that Western science uses a culturally defined methodology. In challenging the common notion of scientific objectivity, postmodern approaches to Western scientific factual knowledge derivation (epistemology) have articulated the presence of subjective affective elements embedded in Western scientific methodology. According to Smith (2002), scientists themselves agree that the practice of science is replete with inferential intuitive subjectivity. Limitations of a solely empirical and rational approach to describing and explaining events in the natural world have been outlined elsewhere (Aikenhead; Chalmers; Little Bear, 1994; Peat, 2002; Smith; Smith, 2004; Weber-Pillwax, 1999). In addition to non-objectivity, a limitation identified here is scientism: the belief that Western science gives the only real description and explanation of reality. This results in the exclusion and rejection of ontological and epistemological understandings of the natural world through other forms of knowledge, specifically Aboriginal ways of knowing. This has been culturally likened to colonialism: "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" (Peat, p. 42). There are other ways of knowing than those of a purely Western scientific way. These ways have described and explained the natural world for millennia. One of these ways, termed *traditional or Indigenous knowledge*, is included here as it relates to Western science, metaphoric meaning, and educational research.

One space in which to enter complex interrelationships in a triad of Western science, Indigenous knowledge, and education can be found in language by examining a difference between the noun *knowledge* and the verb *coming-to-know*. Historically, the Cartesian mind/body split has allowed Western science to externalize the natural world, isolating parts of this world from their holistic contextual interrelationships. Laboratory research requires a paradigm of objective manipulation, with scientists viewing themselves conceptually as external to the event they are observing. This fragmentation and objectification of natural events can be found in the English language when using the noun *knowledge* to describe the outcome of these objective laboratory results. In contrast, the verb *coming-to-know* gives the contextual meaning of a process, where an activity is taking place involving the interrelated participation of both the observer and the observed. Aikenhead describes this "when an Elder inhabits what is taken by English speakers as 'a natural event'" (personal communication).

The co-mergence of the knower and known in education has been identified (Elliott, 2008) from a Western scientific perspective with reference to Davis and Sumara's (1997) article "Cognition, Complexity and Teacher Education":

> Their [Davis and Sumara, 1997] 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 (1966) 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 moves towards Aboriginal wholistic concepts of relationality and interconnection found in Hampton (1999). (p. 58)

Brandt (2007) gives an example of a conflict experienced by Aboriginal students who have come to know the world as a process when this world is presented in science as a product (knowledge). She gives an example of Deborah, a Navajo molecular biologist, who "feels the need to 'stand apart' and critique what is being presented in her science classes; she does not readily consent to all that her biology seems to offer" (p. 601). As a knower, Deborah needs time to reflect on the known:

> How do I as being a Navajo, how really, seriously—what do I think about it? … sit back and think. Does my belief and upbringing—does that really influence how a certain topic is? Because I'm Indian, I have to seriously think about it. Being a Navajo, what does genetics mean?

Here the act of reflection co-joins the knower and the known.

A connection between knower and known is also found enfolded in the verb *coming-to-know*. I describe my process of coming to know Indigenous knowledge (below) based on a seven-year study I conducted for my doctoral dissertation (Elliott, 2008). In the study I approached participants with the intent of examining their responses to two questions: What connections exist between traditional (Indigenous) knowledge and Western science? and What are the implications of these connections for teaching science? questions to which I recursively return to deconstruct their meanings. I approached 45 original participants located in British Columbia, Alberta, and Saskatchewan, including Elders, Aboriginal educators, and Aboriginal community members. Twenty-two participants agreed to further discussion; of these, 21 were fluent in their own language (Blackfoot, Cree, Dene, Nuu Cha Nulth, and Stoney). Eight participants agreed to a formal interview and have given me permission to quote them. All these participants stated that they did not "own the knowledge," and I honored their request of anonyminity. In approaching participants, proper actions to establish protocol were strictly adhered to, including a tobacco or cedar offering and a gift such as tea, blankets, or food, as well as entering dialogue with a clear intention of what I was requesting of

them. I initially visited participants in their local communities and participated in smudges, feasts, round dances, sweats, fasting, and sundance. Guided by the two research questions, I located myself as researcher between two world views (Figure 1). The study was an action research project incorporating indigenous research methodology (for further details of the study's methodology, see Elliott, 2008).

In the study an Elder (JM) stated, "We are part of the all." One interpretation of this statement is that the knower is not separate from the known; that we are not separate from nature, we are a part of nature. This world view gives multiple insights into nature that are incomprehensible from a Western scientific perspective: "We have no theories with which to make sense of many of the phenomena that indigenous people describe" (Knudson & Suzuki, 1992; p. xxx). However, some Western scientists have begun identifying science in a broader context, which includes the process of coming-to-know rather than solely viewing scientific knowledge as a static body of accumulated facts (Bohm, 1980; Peat, 2002; Suzuki, 1997) as commonly occurs when this knowledge is presented to Aboriginal students in high school.

One English translation of Cree *Nehiyaw* is four-part-person (Henry Laboucan, personal correspondence) where mind, body, spirit, and emotion are acknowledged as four elements that exist in each person. For a four-part person understanding occurs not solely in the intellectual/cognitive domain, but in a balanced relationship with all four human aspects. In our study, JM identified elements of scientism that prevent coming to know traditional wisdom as *Nehiyaw* (Elliott, 2008).

> 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, the other wisdom is in the whole being. (Cree Elder, (p. 150)

JM identifies results of this approach with:

> 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

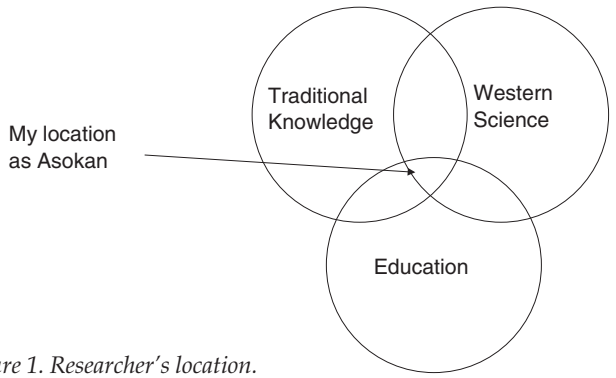

Figure 1. Researcher's location.

> 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. (p. 151)

Heidegger (1966) characterized a Western scientific world view as the "technological understanding of being" and echoed JM's description of the results of this approach to the natural world, "The world now appears as an object open to the attacks of calculative thought.… Nature becomes a gigantic gasoline station, an energy source for modern technology and industry" (p. 50).

An internal relationship between the four elements of mind, body, spirit, and emotion is reflected in the use of the terms *balance* and *harmony*. At this internal level, the meaning of *understanding* requires balance, with knowledge interpreted and understood in all four aspects. A Western scientific educational psychological categorization of this concept of understanding holistically includes both affective and subjective domains, a Western scientific binary. From a Western scientific perspective, the internalized concept of balance is reflected outward into the world, where understanding includes the binary of internal experience (e.g., Piagetian schema) onto which are reflected external events (e.g., scientific factual knowledge). The internal process can be seen as a schema formation, separate from which external knowledge is reflected, as is modeled by matching information to a schematic template. This is found in Western scientific Descartian cognition as the external/internal binary. In Indigenous knowledge an interpretation of JM's statement "we are part of the all" is that there is no separation between internal and external; both dichotomies act in a unitary way giving a holistic concept of natural events. In an educational context Davis and Sumara (1997) have identified this by labeling it as an *enactivist* model where the knower and the known co-merge. Coming to know science from an enactivist perspective includes a unified relationship between these binaries. This holistic connection between internal and external is expressed in Indigenous knowledge when JM states, "We are part of nature and nature is part of us" (Elliott, 2008, p. 165).

In the classroom, the number of students unable to complete the cycle of schooling has resulted in declining enrollment, particularly in science (Aikenhead, 2006; Battiste & Henderson, 2000; Statistics Canada, 2006). This may be "due to students' disenchantment with school science … or due to students' cultural self-identities conflicting with students' perceptions of science and technologies" (Aikenhead, p. 25). Aboriginal students comprise one such group (Aikenhead; Alberta Learning, 2003; Battiste & Henderson; Weber-Pillwax, 1999, 2003).[1] In a science learning/teaching complex, Aikenhead has categorized groups of high school science students for whom learning science is particularly difficult. "Other smart kids" lack a personal interest in science but pass science courses. "I don't know" students have family or friend cultures that are inconsistent with Western scientific world views. "Outsiders" have family and friend cultures that are discordant with the culture of Western science. A fourth group—"potential scientists"—is the only group identified that is highly successful in navigating typical high school science courses. Aikenhead (personal correspondence) suggests that this latter group generally comprises only about 10% of the typical science classroom.

There are many reasons for the discrepancy between Aboriginal and non-Aboriginal students successfully completing high school courses. One specific reason for Aboriginal students experiencing difficulty when taking science courses may be that there is a disconnect between their world view and that presented from a Western scientific perspective. In our study we examined relationships between Western science and traditional knowledge from a science educator's perspective (Elliott, 2008) and suggested that one reason for this discrepancy is a rift that may exist between tacit concepts (paradigms) of Western science and an Aboriginal student's understanding of the natural world through traditional or Indigenous knowledge. The study's participants identified one concept that might bridge these disparate world views: metaphoric meaning.

"Native science is used as a metaphor for native knowledge and participation in the natural world in both theory and practice" (Cajete, 2000, p.14). The use of metaphor to describe and explain events was often seamlessly interwoven into discussion with participants when explaining/describing an Indigenous knowledge perspective. One participant used a tree-branch metaphor when identifying the loss of wisdom when an Elder dies: "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" (Elliott, 2008, p. 126). From a Western scientific perspective, metaphoric meaning is a type of symbolic thinking where our personally derived understanding of an event (i.e., the potentially destructive loss of knowledge) is represented by a symbol (i.e., the tree branch). This initial definition of metaphoric meaning has particular educational application in the Indigenous research methodology that guided our study and in teaching science.

Indigenous research is one methodology we used in examining connections between traditional (Indigenous) knowledge and Western science. It allowed the inclusion of metaphoric meaning to emerge when enacting research. Weber-Pillwax (1999) outlined seven aspects of Indigenous research methodology, which 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)

Paying attention to these aspects of Indigenous research methodology aided me as a white, non-Aboriginal researcher in orienting myself when acting as interviewer/interpreter in our study (Elliott, 2008). In examining this meaning of paying attention, as researcher I internally interpreted the meaning of these principles and externally applied my meaning reflexively, for example, to the interview. As the participants and I explored answers to the research questions (What is the connection between Western science and traditional knowledge? and What are the educational implications of these connections?),

I was required as researcher to clarify my intent, particularly when approaching Elders, the knowledge-holders. One particular Elder's (Dan Alexis) question: "Who are you to tell me about my culture?" helped me with my initial research orientation. I am neither solely coming from and defending a traditional knowledge perspective nor solely from or defending a Western scientific perspective, but placing myself at the dynamic interface between these knowledge systems using my life experience as an educator cooperatively to structure commonalities and differences. This location helped to avoid a hegemonic approach suggested by Dan's question. The orientation evolved as I examined this interface (see Figure 1). This researcher location is adapted from Mike Beaver (personal communication, 2004), which I term *asokan* (Cree "to bridge").

This orientation initially positioned me as researcher coming from a Western scientific educator's perspective and looking toward my understanding of traditional knowledge. For me, this location reflected a personally developing evolution of understanding, contextually dependent on the relationship between the participant and myself where the extent of overlap between these circles is a nonstatic entity. This initial model changed with time and reflection. *Asokan* identifies this location, where the verb use implies a variable activity rather than the solid static noun: *asogan*. Similarly, in education, when identifying the scientific method as a static entity found in texts presented to science students, teachers ignore the active process of the relationship between knowledge and the knower and how this relationship can make science meaningful, particularly for Aboriginal students, by identifying it as one way of knowing science. In Indigenous knowledge the use of the verb coming-to-know includes a process of obtaining knowledge as part of the dynamic meaning of knowledge itself. The activity of coming-to-know and the knowledge itself form an inseparable whole when engaging all four aspects of *Nehiyaw*. This understanding is extended holistically in educational research to human interaction with the natural world where credibility and respect for knowledge (wisdom) keepers—Elders—is determined by actions in the world. Understanding dialogue from this location as researcher demands the use of holistic perspectives, including the interpretation of metaphoric meaning of interview responses.

In this study, the reflective process was subject to my personal internal analysis where I paid attention to van Manen's (1991) "pedagogical thoughtfulness."[2] Analysis, including my structuring of participants' responses into categories, my interview interpretations, and my selection of specific interview segments as "important," was based on my developing and evolving schema. Phenomenologist Hüsserl (1954) describes this activity as, "I operate against the background of myself." As a researcher, I come from a world view or belief structure that defines what I regard as important. World view is embedded in my concept of self. When enacted in a classroom teacher/student complex, students and teachers create template belief structures against which they reflect on their understanding of events in the natural world in order to make sense of their personal worlds, as has been suggested in Western culture by Kantian *Categories of Knowledge* (1791), Piagetian *schemas*, or Vgotskyan *scaffolding*. This is often labeled a world view (Levi-Strauss, 1968). Here the words

world view, developing schema, or *belief structure* are used as metaphors to indicate a truth-determinant template against which a person's life experiences and created knowledge structures such as learning science are measured. For this reason, in Aikenhead's (2006) categories of science students, when students hold a world view that differs significantly from that held in a dominant culturally defined school structure, these same students will encounter difficulty when interpreting cultural contextual meaning, particularly in science. Weber-Pillwax (1992) addresses this from an Aboriginal world view: "[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" (p. 43).

Specifically in science, Brandt's (2007) example cites the case of Deborah, a Navajo woman working in a molecular biology laboratory who is able to stand apart, observe, and describe the Western scientific orientation toward the natural world from an outsider's (etic) perspective. Her reflective hesitation marginalized her from "scientific practice" where "speedy results" based on "productivity" were valued in the science laboratory. Although she generated a holistic understanding of the relationship between scientific results and their meaning to her as a human being living in the world that was being studied, this understanding was not valued from a Western scientific perspective.

In education, our study supported approaching participants with the intention of respecting relationships when asking for responses to the research questions. Some participants, as Pinar (2004) suggests, asked that science teachers do more than "delivering the mail," a metaphor referring teachers' actions to those of a postman.

L., an Aboriginal educator, identified the importance of student-teacher relationship using the term *empathy*: "L: We're missing empathy. Understanding the kids, looking at the kids, and finding out more than their name and their favorite music or what are their … (pause) because if maybe we looked at their interests in science" (Elliott, 2008, p. 145). In another response, an Elder (J) identified the importance for students of making personal meaning.

> It [learning science] 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 there's a lot of different things that pull them in every direction.… 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. (p. 152)

Science can thus be viewed from a perspective that takes into account more than the accumulation of disparate facts. This perspective can be enacted using a research methodology that includes the use of metaphoric meaning in interpreting participants' responses to interview questions. In education, the inclusion of other ways of knowing the world than strictly from a Western scientific perspective may engender the engagement of Aboriginal students. Of course, further research into the complexities of this is needed. I present this model as a non-Aboriginal science teacher of Aboriginal students with the intent of sharing how my process of coming to know (at least a part of) Indigenous knowledge was a significant element of my research methodology.

The model (Figure 2) illustrates one segment of the relationship between research methodology and metaphoric meaning. As a model it identifies three specific loci: (a) interview segment, (b) an interpreted metaphoric meaning of those interviews, and (c) a constructed theme emerging from metaphoric meaning. The term *metaphoric meaning* is used here in a broader context than that of the scientific use of the term *model*, where metaphoric meaning encompasses the Cree *Nehiyaw* use of all four human aspects of mind, body, emotion, and spirit. The interpretation of an interview segment by the researcher includes such elements as intuition, emotional context of the relationship between the participant and the receiver, a conscious awareness of other extant elements affecting the dialogue, and both other known and unknown complexities of my interpretation of that dialogue.

According to Cajete (2000) language used in dialogue is metaphorically interpreted:

> The ability to.… think metaphorically, comes with practice, and the development of meaning and understanding comes with increasing knowledge. Language is more than a code; it is a way of participating with each other and the natural world … Meanings are not solely connected to the intellectual definition but to the life of the body and spirit of the speaker … In the native perspective, language exemplifies our communion with nature rather than our separation from it. (p. 72)

As is found in a photograph that stops a dynamic process, we diagram metaphoric meaning in Figure 2 as a point or locus for discussion. It is one of a multitude of points that emerge from the space or field around it. From a Western scientific perspective, the definition of metaphoric meaning is at this concrete point. However, the use of metaphoric meaning in the Indigenous research process is embedded in the intervening spaces between what is being said in dialogue (to me as researcher) and my own formation of emergent themes. This involves a series of complex human constructs. As described above, before entering into the dialogic relationship of interview, proper actions to establish protocol were carried out. One Elder indicated that the interview began long before I had met him with my request. My intent to examine connections between Western science and traditional knowledge emerged from all my past experiences, my belief structures, my evolving schema, and other unknown and unidentified factors in my life. Elders assessed this personal intent in our initial discussions, often initiating dialogue

about topics that had little to do with what I thought was related to the research. By asking me questions such as where I came from or what people we might know in common and assessing my responses, the Elders, educators, and other community members who agreed to participate with me in the project began the process of forming a relationship with me as another human being. Intent, integrity, respect, and patience were the words that came to mind when I pedagogically reflected on these terms in relationship with my encounters. The developing elements of relationship comprised a dynamic part of the intervening spaces in which metaphoric meaning was embedded. This evolving process moved recursively in flux between the three identified points or loci. Rather than empty spaces between focal points, these spaces contain my thoughts as evolving self as researcher. I became very conscious of my own experientially constructed world view. In these spaces, which offered insight and invited investigation into meaning grounded in metaphoric understanding, I experienced an infinitely expanding understanding of the *other* and myself. What began as a static model intended to identify emerging themes from interview segments through the development of metaphoric meanings evolved quickly to become a dynamic interplay in the spaces between the three loci. This dynamic interplay was replete with insights, questions, answers and more 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? and so on. This process is shown in Figure 2.

From a Western scientific perspective, theoretical physicist Bohm (1980) associated space with fullness: "It may be said that space, which has so much energy, is full rather than empty" (p. 242) and further describes this empty space in terms of a *plenum*:

> It is being suggested here then, that what we perceive through the senses as empty space is actually a plenum, which is the ground for the existence of everything, including ourselves. The things that appear to our senses are derivative forms and their true meaning can be seen only when we consider the plenum, in which they are generated and sustained, and into which they must ultimately vanish. (p. 243)

The complexity of interpreting dialogue by understanding metaphoric meaning of a participant's words is revealed in the spaces between the three identified loci (above). Indigenous knowledge recognizes this complexity as

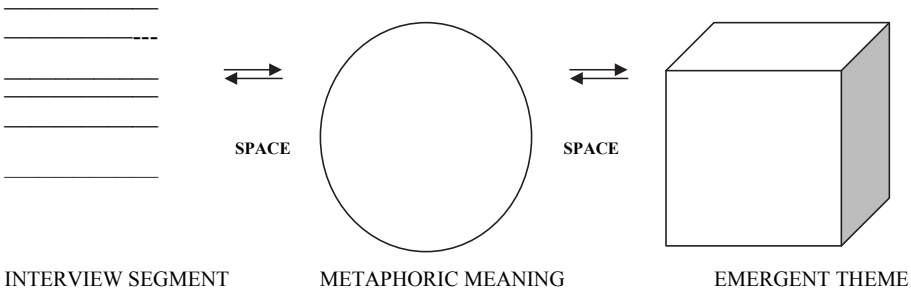

Figure 2. Metaphoric meaning.

including a holistic connection between the knower and the known, acknowledging process rather than solely identifying factual knowledge as a product, and understanding the natural world holistically as in Cree *nehiyaw*, four part person. This inclusion of a holistic meaning of knowledge in science education has been identified by Aikenhead (2006) using the term *humanistic* science as a potential way to bridge disparate world views.

Accessing metaphoric meaning of participants' dialogue allows for the emergence of another way for the researcher to look at science and science education. Aikenhead's (2006) humanistic science perspective identifies conceptual changes needed to foster an acknowledgment of Indigenous ways of knowing science in schools. One example is a multiscience approach reflecting international perspectives (including Indigenous science) in contrast to the strictly Western scientific mono-science approach founded on universalism (Aikenhead).[3] Participants in my study suggested that critical elements in their science learning were lacking either in their own experiences in science classrooms or generally in a Western scientific approach. I have categorized some of these critical elements as metaphoric meaning, narratives, language, oral tradition, Elders, community, and relationship. These elements correspond favorably with Aikenhead's description of a humanistic science approach. I have adapted Aikenhead's "Table 1.1. Possible Characteristics of a Humanistic Perspective in School Science" (p. 3) to include a central column representing the conceptual shift that is necessary for a paradigm shift to occur in how we view "science." These shifts identify a conceptual movement from the present Western scientific approach and, in this work, includes Indigenous scientific knowledge by addressing questions such as: What concepts prevent the intellectual movement (i.e., paradigm shift) of science educators from, for example, mono-science to multiscience? Table 1 suggests some of these conceptual shifts in the general categorized element of metaphoric meaning.

Table 1 and Figure 2 are interrelated from a holistic perspective. In Table 1 paradigm shifts from the Western Science paradigm column to the Resultant Paradigm column require intermediary Conceptual Shifts. Arriving at these conceptual shifts as researcher is described in Figure 2 as occurring through processes taking place in the spaces between the three loci of Interview Segments, Metaphoric Meaning, and developing an Emergent Theme. My interpretation of Aboriginal participant dialogue occurred in these spaces, and the emergent metaphoric meaning was used as a basis to arrive at the Conceptual Shift column. I recursively refer to Figure 2 to include metaphoric meaning, the intervening spaces between the interview segments and the emergent themes as part of an Indigenous research process. The practice of respect and reflection that characterize Indigenous research methodology, when applied to the participant interview segments, reveals how participant interview segments were instrumental in locating the Conceptual Shift column in Table 1. Identification of these conceptual shifts allows for tacit Western scientific unconscious world views to be consciously identified. Rather than positioned as an endpoint, these identified shifts elicited further questions for us (Elliott, 2008).

> In acknowledging this process [i.e. of identifying conceptual shifts] the following further questions emerged for me as researcher. I present these questions as part of my process of examining the connection between two

Table 1
Asokan: Conceptual Shifts

Element	Western Science	Conceptual Shift	Resultant Paradigm
Metaphoric Meaning	• external world is primary and separate from internal	• dichotomies are human-made, intellectual constructs reflecting only part of reality. • Elder's narratives can reflect a more wholistic reality	• inner experience is also a context for learning, including interpreting narratives' metaphoric meaning, listening to Elders, and acknowledging intuitive understandings
Metaphoric Meaning	• knowledge is canonical science • emphasis on external world and analytical, linear, left brain thinking	• knowledge can be obtained through interpreting metaphoric meaning • emotional development and intuition give balance to intellectual reasoning	• knowledge includes epistemology (how we know), it includes nature of science and knowledge about scientists themselves • inner experience, intuition, narratives ('stories'), and metaphoric meaning are legitimate methodologies for learning about science

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?' (p. 192)

As metaphoric meaning becomes addressed directly in science education praxis, one thread of a student's world view will be engaged when metaphoric meaning is an element in that student's belief structure, developing schema, or world view. In teaching Indigenous science, when an Elder tells a narrative, the listener/learner makes meaning of the narrative as metaphor through a personal interpretation of the metaphor and how the metaphor is enacted in a person's life. Engaging all four aspects (*nehiyaw*) of the listener/learner in this meaning-making occurs in Western scientifically defined cognitive and affective psychological domains. For example, the word *insight* implies meaning-making at more than a superficial level of memorizing factual data. In paying attention to an Elder's narrative, for example, a listener/student recognizes

and connects meaning to their personal belief structure, developing schema, or world view. In addition to metaphoric meaning, we identified other critical threads that could be engaged by Aboriginal students to make meaning of science, included the use of Aboriginal language, oral traditions, community-building, and relationship building (Elliott, 2008). Rather than viewing metaphoric meaning as an individual thread affecting a student's belief structure, schema, or world view, it can be seen as forming a part of all the above threads, as an interwoven whole. One interpretation of *Nehiyaw* meaning-making is that it occurs in this interwoven complex at the nexus of all these elements. As suggested by Davis and Sumara's (1997) enactivist model, when this aspect of listening/learning is given primacy in the science classroom, the process of teaching and the topic of science as a natural process become enmeshed in praxis.

Thus the sole use of Western scientific approaches in education for describing and explaining natural events has limitations such as tacitly accepting objectivity and the analytical linear application of a scientific method. Other approaches to the explanation and description of natural events, specifically Indigenous science approaches, are presented that can be included in current Western scientific educational epistemology.

Major conceptual shifts by educators are required to move from a purely Western scientific approach (canonical science) to a new paradigm that introduces newer perspectives of human cognition and meaning-making, as well as new approaches to scientific objectivity and observations of self and others. From a Western scientific perspective, this includes cognitive and affective understanding of events in the natural world. Metaphoric meaning is one of many identified elements that can be useful in broadening the definition of science, understanding, and using Indigenous research methodology, and in teaching and learning science.

Notes

1 On-reserve Aboriginal high school completion rates in Alberta are 32%. Off-reserve Aboriginal high school completion rates in Alberta are 64%. Non-Aboriginal high school completion rates in Canada are about 90%. (J. Richards, C.D. Howe Institute, Backgrounder, No. 116, October 2008).

2 Van Manen's *pedagogical thoughtfulness* concept may have emerged from his doctoral dissertion study of Don Juan. In Blackfoot the word *aohtookisataa* (D. Donald, personal communication) is associated with awareness that occurs, for example, when a hunter pays attention to the natural world with all levels of his or her being.

3. We did not use the term *multicultural* as originally used by Hodson (1992) because it is limited to social cognition and has as yet resulted in little fundamental pedagogical change in science classrooms.

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