EMERGING IDENTITIES:

A PROPOSED MODEL FOR AN INTERACTIVE

SCIENCE CURRICULUM FOR FIRST NATIONS STUDENTS

by

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Abstract

Mi'kmaw students face a complexity of personal, cultural, and social conditions within contemporary educational systems that affect their continued participation in the educational process offered within Atlantic Canada. Despite a variety of approaches developed by educators to address the high drop out rate and lack of interest in science, the statistics remain largely unchanged. Aboriginal educators are calling for a "new story" in education that better meets the needs of Aboriginal students. This study attempts to identify the conditions and contexts necessary to bridge the gap that currently exists for Aboriginal students in science studies.

The research investigates the basic relationship between learning in general and the meaning-making processes engaged in by students of a Grade 7/8 class within a Mi'kmaw reserve school. It leads to a proposal for an alternative pedagogy, or a new narrative, for teaching science to Aboriginal students, and the foundations for a culturally interactive science curriculum. For educators to understand the complexity of issues affecting Mi'kmaw student achievement in science requires a theoretical framework that allows the students' lived experience to emerge. Toward this end, the research includes both phenomenological and ethnographic approaches to understanding the lived experiences and cultural narratives based on interviews with the students, a field trip within the community, and a trial chemistry lesson. I examined how these students perceive themselves in different contexts and how their sense of identity establishes the meaningfulness of particular educational content. I also assessed how person, community/cultural and social contexts affect the students' learning.

Part of creating this new narrative requires recognizing knowledge, including science, as a cultural product. Taking this cultural view of scientific knowledge allows us to view learning as a process of identity formation and culture as a system of symbols including language itself. This identity is based on personal, cultural, historical, and social factors that come to bear on each student's definition of who they are and what knowledge is pertinent to survival and well being.

Five fundamental themes emerged from the interviews and field trips—fragile ontologies, multiple layers of identity (personal, cultural, pan-tribal, and societal), border crossings, the continuing and emerging aspects of culture, and beyond borders to a spiritual narrative—and became the foundation for a culturally interactive science education model of learning. The model assists educators through a visualization of layers of identity, porous borders and seeming paradoxes, and "narrative unity" beyond boundaries—all of which affect the learning of science.

The content of a culturally interactive curriculum is drawn from the cultural heritage of the students, giving them an historical context with which to identify. Working with Mi'kmaw language and notational representation is shown to assist educators in cultural border crossing and creating cultural continuity for the students. Taken into the classroom, this interactive paradigm could be adapted to pedagogical methods as "speaking together" times, in which students explore the processes of doing science while appreciating their own cultural traditions. In so doing, educators can come to know the larger narrative that gives shape to student's identities and ways of relating to the world. Then it becomes possible for educators to recognize the boundaries that obstruct or open a path to meaningful learning experiences.

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Introduction

On the first day visiting the Grade 7/8 classroom in the northern New Brunswick Mi'kmaw community of Eel Ground where I would be doing this research, the teacher mentioned how "educated" I was because I was getting my Ph.D., and how nervous she was regarding my presence in the classroom. This statement immediately hit on the painful point underlying this thesis: that formal education can be a cause of alienation for many people, particularly those of a historically marginalized culture; and that, despite how I perceived myself, I was seen as part of that process of alienation. The irony was that I felt like a nervous student learning from an experienced teacher and was humbled by her courage and willingness to have me in her classroom observing and videotaping.

Her comment brought to the surface long-standing questions for me: How could I create a bridge between the teacher's perception and mine? How could I reduce the distance between those who are perceived as "educated" and those who supposedly are not? How can we make education in general a collaborative human endeavor, inclusive and balanced? How could I engage and create a dialogue of mutual exploration without judgment?

Paul Rabinow has defined what he terms the "dialectic of fieldwork" to describe the mutual construction of meaning between "cultural self" and "cultural other" to create an "intersubjective symbolic language" (Rabinow, as cited in Schultz and Lavenda 1995:358). When an anthropologist or any researcher enters an unfamiliar cultural setting, some exploration and construction of meaning between that person and the

people within the culture has to occur for any communication to be effective. A process of questioning, reflecting upon one's own thinking about how things are perceived and experienced (reflexivity), and interpreting one another needs to occur until some mutual ground of meaning is established. Gradually, over time, "intersections in possible ways of understanding and describing the same strips of behavior" evolve (Rabinow, as cited in Schultz and Lavenda 1995:358). Both the researcher and those within the culture are active participants in the process, causing and affecting the other's way of thinking and actively making decisions about whatever knowledge emerges from this process. Is that, perhaps, what education could be about? Are there implications here for improving science education for Aboriginal peoples in Atlantic Canada?

This process of meaning making between people of different cultures has been part of an ongoing exploration I began ten years ago into how a bridge could be created between science education, as it is presented within the provincial school curriculum of Atlantic Canada, and Aboriginal peoples'[1] knowledge of their ancestral landscapes, specifically the Mi'kmaq of eastern Canada.[2] I had five motives for pursuing this topic, with a specific focus on science.

First, through research, personal and professional experience with a number of cultures – Tibetan, Mi'kmaq, Innu, and African among others – and my reflections on my own German-English, New England/Canadian cultural background, I came to appreciate how people of different cultures perceive, conceive, and express their relationship with the world in very different ways. Many cultural traditions can lay claim to ancient storehouses of knowledge, whether oral, written, or expressed through non-verbal or visual forms of communication. This knowledge was communicated within

systems of relationships, and prior to colonization, was commonly situated within specific landscapes. The history and cultural identity of many peoples were embedded within these landscapes, mirrored in their language and architecture, sung in songs, and danced into existence. I felt we, as both students and teachers within school systems and as citizens of Canada, could gain a far more comprehensive understanding of our universe and humankind if we were open to other ways of knowing and perceiving. We could come to appreciate distinct cultural heritages and their contributions to our now combined histories.

Second, historically there has been a high drop-out rate of Mi'kmaq and other Aboriginal students throughout Canada before completing their high school education. This fact has always struck me as ironic given the long traditions of ecological knowledge Mi'kmaq and other Aboriginal peoples had developed prior to contact with foreign colonial cultures. I have been strongly motivated to see Aboriginal students do well without loss of their own cultural heritage.

Third, I specifically chose science because it is, as science historian J.D. Bernal wrote over 35 years ago, "[science is] one of the most powerful influences in molding beliefs and attitudes to the universe and man" (Bernal 1965:31). I believe the power of this influence needs to be considered and respected along with ways of knowing developed by other cultures, and that these various ways of knowing should be explored within our educational systems. Modern education teaches that we validate what we know about the phenomenal world through evidence and the application of scientific methods; that the scientific method is the legitimizing force behind verifying knowledge. However, many Aboriginal people point out that what we consider evidence and how we

define knowledge is culturally based (Lickers 2001).

To consider science in a more inclusive light, I will use the definition of science developed by Masakata Ogawa, a Japanese science educator:

> [Science is] a rational perceiving of reality where perceiving means both the action constructing reality and construct of reality. Caution should be taken that the 'rationality' in this context never means Western modern rationality alone. If 'rational' is the correct term for behavior in accordance with rules, there can be a kind of rationality in each culture. (Ogawa n.d.:2)

Ogawa further elaborates three categories of science: Aboriginal science, personal science, and Western modern science. Aboriginal science is a "culture dependent, collective, rational perceiving of reality," while personal science is "the rational perceiving of reality...unique to each individual" (Ogawa n.d.:2):

> [Western science is the] collective rational perceiving of reality, which is shared and authorized by the scientific community ... justified only by the scientific community ... [and] pertains to a Cartesian materialistic world in which humans are seen in reductionistic and mechanistic terms...and regarded as the science of specific professionals named scientists. Western science deals with theory while the other two are dealing with every day life situations. Science educators, then, are in the 'multiscience setting.' (Ogawa n.d.:2-3)

Ogawa promotes the view that "science is the culture of a scientific community" (3):

> Western modern science is a total body of specific ways of recognizing the world and its resultant image of the world, which is held by, maintained by, developed (3).by the group of people, who, regardless of their gender and/or socio-cultural origin, works as a social function called 'scientist,' and at the same time, it is only the group that guarantees legitimacy of 'western modern science.' (Ogawa 1999:3)

I believe that taking this view of science as a culture in its own right will benefit developing a culturally inclusive and interactive science curriculum.

Fourth, among many Aboriginal populations, science has become a necessity for self-governance. Many contemporary Aboriginal peoples, despite their local knowledge

of their own ancestral lands, have turned to biologists, environmentalists, and social scientists to help them protect their rights and traditions from exploitation and appropriation, and their lands from environmental degradation. Learning to speak the language of science is necessary given the issues – land claims, resource use and general economic development, environmental protection and management, and health care – facing their communities within the larger context of contemporary Canadian society.[3] Simultaneously, they hope that the knowledge they accrue will ultimately help them protect their traditions, and in turn, assure the well-being of their children (MacIvor 1995:74).

Finally, during the years of my research, the relationship between Indigenous Ecological Knowledge (IEK, also commonly referred to as Traditional Ecological Knowledge (TEK), as well as Indigenous Science) and science has become a global issue tied to trade and development projects throughout the world.[4] My interest is not just how Aboriginal peoples can and will engage in the learning of sciences, but ultimately about how Aboriginal peoples can become self-governing and share equally in a dialogue, or in the process of meaning making, to benefit our society as a whole.

Purpose of the Study

The purpose of this study is to explore an alternative pedagogy for teaching science to aboriginal students. Over the past decade, I have conducted research into Mi'kmaw education, specifically at the foundations for a culturally appropriate science curriculum. I developed and piloted what I now call a "culturally interactive science curriculum." The study reported in this thesis builds on this previous research and grounds it within the reality of a Mi'kmaw reserve school. The term "culturally interactive" refers to the fact

that many Aboriginal students must live, learn and study in different science cultures as they move between their home and community culture in which Indigenous Ecological Knowledge is used and informally taught and their school culture in which Euro-American scientific knowledge is used and formally taught. To fully live and learn in both cultures, the student must hold different world views (or sets of values and beliefs) within each culture and frequently must "cross the border" between them (Aikenhead and Jegede 1999). The study will address the following questions:

1. To what extent do Mi'kmaw students hold multiple world views (sets of values and beliefs) and move back and forth among these views to suit the context in which they find themselves?
2. What would be the characteristics of a culturally interactive science curriculum designed to support and use these multiple world views?
3. How do grade 7/8 Mi'kmaw students respond to a culturally interactive science lesson?

To address these research questions, the study investigates the basic relationship between learning in general and the meaning making processes engaged in by the Mi'kmaw students involved in the research. I examine how these students perceive themselves in different contexts and how their sense of identity establishes the meaningfulness of particular educational content. I also assess how personal, community/cultural and social contexts affect the students' learning. As a result of the study I hope to be able to identify the conditions and contexts necessary to bridge the gap that currently exists for Aboriginal students in science studies.

Historical Context of Science Education for Aboriginal Peoples

Educators Michael Connelly and Jean Clandinin describe curriculum as something that is experienced in situations. They define a situation as being "composed of persons in an immediate environment of things, interacting according to certain processes" (Connelly and Clandinin 1988:6). They further delineate the component parts of the situation, one of which is an historical component, or how the present situation is influenced by what has come before:

> You need to see participants in the situation as having a history and as reflecting that history. More than that, you need to see them continually remaking that history as they deal with the particulars of the situation at hand...When the word "curriculum" is used the picture that flashes before your mind is one in which the persons are storytellers living out their past and remaking that past to deal with their current situations. (Connelly and Clandinin 1988:8)

The historical context discussed in this section continues to be part of a legacy for many Aboriginal students who attempt to learn science. It is important for all stakeholders in science education to appreciate the historical context for these students and their cultural community to better understand the barriers they face in entering into science studies.

What follows is not intended as a condemnation of science or scientists *per se*, but rather an acknowledgement of the residual consequences of history that still affect attitudes and motives for both teachers and Aboriginal students. The current framework for science education in Canada, which promotes scientific literacy for all students, attempts to address inequities within the educational system of Canada, and to acknowledge the socio-cultural context of science education (Council of Ministers on Education, Canada 1997:10). This acknowledgement of the socio-cultural context of

science opens the way for educators to explore and move forward in changing the legacy of colonization for Aboriginal students.

The legacy of colonization in Canada, along with the cultural disruption and social ills left in its wake, is well documented, most notably in the recent and comprehensive Royal Commission on Aboriginal Peoples (RCAP 1996). Perhaps less acknowledged is the legacy that arose from the formal study of cultures in the nineteenth century, which emerged from the scientific thought of the Enlightenment. Anthropologists and sociologists used scientific methods that marginalized and objectified foreign cultures as less civilized and less human than European cultures.

The discovery of foreign and unfamiliar peoples in distant lands during the European voyages of discovery brought to the forefront of religious debates questions of who was and who was not human. Debates in the sixteenth and seventeenth centuries resulted in the inclusion of Aboriginal peoples into the family of man within the Great Chain of Being (Schultz and Lavenda 1995:35). The Great Chain of Being was based on Judeo-Christian beliefs about the natural world and Platonic concepts that different species had an essential unchanging or continuous aspect that distinguished them from other species. Some were closer to God in their essences, and others lower down the chain. Carolus Linnaeus, the father of modern biological taxonomy, remained rooted in this essentialist religious philosophy through the development of his classificatory system of species (Schultz and Lavenda 1995:37, 381). Although Aboriginal peoples were accepted as being in the family of man by the majority of Enlightenment thinkers at the end of the sixteenth century, some still questioned whether or not Aboriginal peoples were of the same species as Europeans as late as the eighteenth-century (Bieder 1986:6-7).

The main debate of Enlightenment philosophers centered on what the nature or primary characteristics of the "Indians" were. Ambivalence existed between the views of "Indians" as innocent children on the one hand and as degenerate products of an adverse environment on the other (Bieder 1986:6). The views of Scottish historian, William Robertson, exemplified this ambivalence. He saw "Indians as children or childlike. They were capable of improving, but their passion for a hunting life limited their intelligence and made impossible not only society, agriculture, and the idea of private property but also law, government, and civilization" (Bieder 1986:6).

As an outgrowth of the scientific revolution, anthropologists and sociologists began incorporating scientific methods in research on Aboriginal cultures during the nineteenth century. These cultural studies searched for the origins of "others" as the clue to the evolution of humankind as the imperial powers of Europe expanded their empires into colonial outposts (Haraway 1989:12). The effect of the research was to "reinforce the prevailing attitude of smug Victorian superiority by demonstrating how modern civilization had evolved from primitive cultures in the direction of 'progress'" (Erickson and Murphy 1998:45). This legacy has led many contemporary Aboriginal peoples to link science and scientific research with such words as "imperialism" and "colonization." As well, they accuse educational institutions of perpetrating a form of subtle mental colonization (Battiste 1998:20).[5] Linda Tuhiwai Smith, a Maori spokeswoman and author, reported this frustration:

> From the vantage point of the colonized, a position from which I write, and choose to privilege, the term 'research' is inextricably linked to European imperialism and colonialism. The word itself, 'research', is probably one of the dirtiest words in the indigenous world's vocabulary...The ways in which scientific research is implicated in the worst excesses of colonialism remains a powerful remembered history for

many of the world's colonized peoples. (Smith 1999:1)

One does not have to look far to find support for Smith's charges regarding the general attitude of both social and scientific researchers. Perhaps the most lurid period of ethnographic and scientific studies of Aboriginal peoples involved the practice of phrenology in the early nineteenth century. Phrenology involved studying and measuring crania to determine intelligence and racial differences (Bieder 1986:59). According to documentation, collecting crania became something of a cottage industry in the North American west and was done in the name of scientific research (Bieder 1986:66). Grisly stories have been documented of "boiling of Indian skulls" and of encounters between grave robbers/researchers trying to steal Aboriginal skeletons and the relatives of the deceased guarding their family graves from these intrusions (Bieder 1986:65-67).

The premise that racial inferiority could be determined by skull measurements was not universally accepted but was a prevalent and socially convenient theory, given the practice of slavery in America and elsewhere (Bieder 1986:63). As an example, Samuel G. Morton, the acknowledged father of physical anthropology, believed "that the Indians' rejection of civilization lay not in willfulness but in their mental inability, given the size of their brains, to absorb civilization" (Bieder 1986:73).

Countering the immutability of racial differences were other theories addressing various cultural and environmental influences that attempted to account for racial differences. As an example, we can follow the influence of John Locke's pre-Enlightenment thinking on modern science, education and cultural anthropology. Locke proposed an educational philosophy that emphasized the development of reason informed by a scientific approach. His goal was the creation of a rational, virtuous, and moral

citizenry based on natural laws tied to religious beliefs propounded in the Bible. Extremely important to his educational philosophy, as well as to the field of anthropology, was the concept of *tabula rasa*, and the role of environmental influences in character formation (Erickson and Murphy 1998:35; Yolton 1998:175). *Tabula rasa,* the "blank slate" theory, ushered in the notion that behavior and thoughts were acquired, not something innate. Locke's scientific approach to education held that a child's experience could be determined by creating appropriate learning environments (Erickson and Murphy 1998:35).

Locke's theories are part of the foundation for the ongoing nature vs. nurture debate among social scientists. As education of Aboriginal peoples became a tool for assimilation of Aboriginal children, colonizers believed that changes in environmental factors would assist in the civilization of Aboriginal peoples. For example, Moses Perley, writing in the mid-nineteenth century as the provincial Indian Agent for New Brunswick, advocated for Indian rights and protection of their lands from squatters encroaching on the Miramichi. But Perley also saw settlement, schooling, agriculture and the building of churches as the answer to the ills that were sweeping through the Mi'kmaw population of the Maritimes (Upton 1979:104-106; Hamilton and Spray 1976:88-99, 116-118). The notion that civilization was linked to settlement, ownership of property, education and agricultural practices is now recognized as an ethnocentric view, especially by Aboriginal peoples who lost their lands in the process.

Near the turn of the twentieth century, efforts to civilize Aboriginal populations had not born fruit in the way many had theorized, nor had scientific research unearthed the root causes for racial differences. In post-Confederation Atlantic Canada, for

example, on-reserve day schools and Catholic-run, residential schools were established as another attempt to deal with the perceived social ills that were affecting Mi'kmaw communities. The first on-reserve school was established in 1879 in Eskasoni, Nova Scotia; eleven more were established by 1909. By 1920, school attendance for Mi'kmaw children (ages 7-15) was compulsory, although fewer than half the school aged children were enrolled (Moore 1983:26).

Edgar Hewitt, writing in 1905, approached the question of education as a scientific endeavor while admitting to the confusing results of previous research. Hewitt illustrated the amalgamation of both physical and cultural theories of the previous century and their impact on views of education as a means for assimilating Aboriginal peoples. His argument against "Americanization" (Hewitt 1976:32) of Aboriginal peoples cited distinct cultural differences, showing his humanitarian understanding of them as people in their own right. Yet, he also referred to them as objects of racial histories to be analyzed scientifically through physiological and environmental theories. He used the term "ethnic mind" (Hewitt 1976:32) to emphasize differences between racial groups:

> Everything in human nature must be regarded as a product of growth. Ideas and ideals that have been rooted for ages in the ethnic mind cannot and should not be eradicated in a generation. Biology has demonstrated that no appreciable increment of brain power can be effected in the lifetime of an individual. Ethnology has shown how ideals of religion, of welfare, of morals that have become ingrained in racial character, along with color of skin, and shape of skull, are likewise persistent under the artificial environment of civilization.
>
> There are facts that are particularly applicable to the great task to which we have set ourselves in the education of alien races. The education of the Indian is a work that we have had on hand for many years, and much diversity of opinion exists to the value of our results. Apparently the idea of educating the Indian away from his native environment is losing ground. The transplanting of isolated specimens of primitive races to a totally new environment has never been productive of happy results. The reservation Indian school is successful so far as its ideal is to make of the

> Indians better Indians. Unhappily, americanization (sic) is often thought to be education. (Hewitt 1976:32)

Hewitt has stated that when researching the causes of "static racial conditions," the "influence of the physiographic environment on the human mind" and "the influence of definite meteorological conditions on mental states [are] important area[s] of research into racial character development" (Hewitt 1976:29).

Following the Second World War, a policy of integrating Mi'kmaq into the provincial public schools was adopted where possible. "Throughout the development of education facilities for Indian children, the Government policy was consistent; this was to acculturate the Indian to Canadian white society and to the English language while extinguishing his [sic] own culture and language. Assimilation remained the major goal" (Moore 1983:26). Little recognition was given to the knowledge and education that had allowed the Mi'kmaq to survive and develop a sophisticated expressive culture for thousands of years prior to European arrival (Indian and Northern Affairs Canada 2003; Knockwood 1992:13-22).

As a consequence, there are many Aboriginal people who currently question the motivation or right of "white" people to do any research into Aboriginal cultures, given the legacy of colonization and the current call for self-determination (Smith 1999; Bear Nicholas 1996). As illustrated earlier in this section, one does not have to look far to find the legacy of social and scientific research that fires the outrage of Aboriginal peoples. Linda Tuhiwai Smith further derides the notion of "post-colonialist discourse" as an invention of Western intellectuals (Smith 1999:14) since, in her mind, colonialism is not over; its legacy lives on and it has simply taken different forms in globalization (Smith 1999:24,34). These critics also face a conundrum as Aboriginal people if they participate

in or work with non-Aboriginal institutions that have undermined or altered the traditions they hope to preserve (Smith 1999; Kawagley 1995).

This notion of "other" is perhaps one of the biggest stumbling blocks to our perception of people in general. Many Mi'kmaq have said to me "we just want to be seen as people." In fact, in Smith's opinion, the "writing down" of research itself has made Aboriginal peoples outsiders to their own histories within the educational systems that purportedly served as civilizing influences (Smith 1999:33). She articulates that the relationship between writing, theorizing and history making, all done in a supposedly objectified fashion, is anathema to Aboriginal peoples' ways of thinking and acting. Furthermore, Smith notes the power of those who design and use the research tools for studying and analyzing cultures, and calls for Aboriginal peoples to claim this power for themselves (Smith 1999:29, 38).

There are softer voices within Aboriginal communities that do not see the "white" educational system in such a harsh light. In my own experience, I receive different messages depending on what community I am in or which individual I speak to. Some community members do not necessarily agree with those in their own culture who take a political stand on issues. However, the predominant message through media and political channels, and at conferences where Aboriginal people are present, is the need for self-determination in defining how their children's educational needs can be met.

Learning science has become part of what it means to be educated in North America. Being scientifically literate is considered integral to being a good Canadian citizen (Council of Ministers on Education, Canada 1997:10). To speak about scientific literacy as it is currently framed can not just be about learning a tradition of accumulated

knowledge; it is about a whole legacy of relationships between those who defined humanity and those who were being defined. Scientific epistemology was the way those relationships were framed within social sciences, including education, yet the pain of that legacy colors science education for Aboriginal stakeholders.

Current Political Context for Aboriginal Education

Concerns for identity, cultural preservation, as well as survival in contemporary society, have led many Aboriginal leaders to review their educational experiences, and propose alternatives for the education of their children. Aboriginal peoples throughout Canada are demanding recognition of their traditions and their right to self government, and most of all, of their right to a greater decision making role in determining the future of their children (Coon Come 2001:18-23; Castellano, Davis and Lahache 1999:xii; Warner 1999:68-93; RCAP 1996:433). Education of their children is a central concern of Aboriginal peoples world-wide as witnessed by the annual World Indigenous Peoples Conference on Education (2002) and the creation of the Coalition of the Advancement of Aboriginal Studies (2001). It is no less a concern to Aboriginal peoples in Atlantic Canada and it is core to their efforts to become self-reliant and self-governing (Paul 2001:17; Hamilton 1997:5). Now, after hundreds of years of social disruption and education in a system not of their design, the education of Mi'kmaw children is being reevaluated.

Since 1991, the Mi'kmaq of Nova Scotia have negotiated to regain jurisdiction for on-reserve education (Gould 1996). This effort required reflection upon, definition of, and reassertion of their values, knowledge, and educational practices to reclaim,

maintain, and move forward with an identity of what it means to be an Aboriginal citizen within Canadian society (Battiste 2000:vii-ix).

As a result of the effort, an Order of Council was signed on April 22, 1999, making the *Mi'kmaq Education Act* (Bill C-30), federal law. The same day, Bill no. 4 proclaimed the *Mi'kmaq Education Act* a provincial law. Chief Lindsey Marshall, chair of Mi'kmaw Kina'matnewey, the governing administrative body overseeing the transfer of jurisdiction, stated the importance of this act in re-affirming the right of Mi'kmaq to govern their own education.

> The completion of this process re-affirms the right of our people to govern the education of our children. As we approach the new millennium, our people can then look to the future with renewed hope and confidence. This step will allow for the development of educational policies that reflect the values, beliefs, culture and language of our people, the Mi'kmaq of Nova Scotia. (Mi'kmaw Kina'matnewey May 4, 1999 press release)

The process of reclamation used by the Mi'kmaq and other aboriginal peoples inevitably reflects upon the values, pedagogies, and types of knowledge that have come to shape our educational system throughout Canada. It is a particular challenge for those championing "science standards for all students" (National Research Council 1996:2). Science can be seen as a powerful influence on local Aboriginal cultures world-wide (e.g., Cobern 1999; Ogawa 1999; Smith 1999; Hess 1995), including within the Atlantic Provinces. Understanding the depth of this influence requires careful assessment of the underlying assumptions within science curriculum frameworks and curricula developed for provincial schools, and a review of the cultural appropriateness of the content included in the curricula (Castellano, Davis and Lahache 2000:xii).

Current Pedagogical Context for Aboriginal Education

The field of education has undergone its own evolution in terms of approaches to researching and analyzing Aboriginal peoples in educational settings. Terry Wotherspoon and Bernard Schissel have summarized these approaches by outlining the four "main orientations to analysis, characterized broadly as individual, cultural, institutional, or social structural in emphasis..." (Wotherspoon and Schissel 1998:3).

The unit of analysis for the individual orientation focuses on the individual student's skill and initiative, combined with potential hereditary or biological factors. Individual explanations described viewed the Aboriginal learner as deficient in the necessary skills or lacking in motivation to achieve. Although less prevalent in current models, it still holds some sway for policy development (Wotherspoon and Schissel 1998:3).

The cultural orientation has been predominant since the late 1960s as the basis for explaining Aboriginal children's performance within educational systems. In the late 1960s and into the 1970s, cultural factors were cited as the predominant cause of underachievement among Aboriginal students. Research increasingly focused on learning styles, cultural beliefs and social behavior and described these influences as being deficient in fulfilling the expectations of the mainstream classroom (Brady 1996:12). The "deficit model" viewed Aboriginal students as disadvantaged, culturally deprived, and lacking in linguistic and social competence (Nelson-Barber and Dull 1998:96). Remedial and enrichment programs were developed to counteract these cultural disadvantages (Wotherspoon and Schissel 1998:3; Banks 1975:4).

In the 1970s, a shift in the cultural orientation framed the obstacles facing

Aboriginal students' education in terms of cultural differences versus deficiencies (Banks 1975:8-9). Sociolinguistic studies, for example, compared competence in different settings (Lipka 1998:196). More recently, research has emphasized the "cultural discontinuity" thesis. Conventional educational practices are seen to act as a "critical filter" that blocks hope and self-esteem (Wotherspoon and Schissel 1998:3-4; Hampton 1995:7).[6]

The institutional orientation delves into the inherent racism (institutional racism) embedded, often unconsciously, into school policies, choice of curricula, teachers and teaching styles (including the lack of Aboriginal teachers), and general organizational processes that are "hostile" to, or lack understanding of, Aboriginal peoples' views. Further jurisdictional issues that control areas of Aboriginal peoples' lives, such as funding and educational policies, perpetuate "internal colonialism" in Canada (Coalition for the Advancement of Aboriginal Studies 2001; Wotherspoon and Schissel 1998:4).

Over the last two decades, related research has also attended to issues of power and systemic factors that perpetuate inequities for Aboriginal peoples and fail to meet their educational needs (RCAP 1996:958-970). Cultural differences within mainstream school settings are considered "one part of a larger historically rooted problem and relationship. The existence of cultural differences and negative stereotyping and evaluating are also issues of conference presentation power" (Lipka 1998:196).

The social structural orientation emphasizes such structural issues as class, gender, labour relations and markets, socioeconomic inequalities, and so forth:

> The education gap between Aboriginal people and the general population is more than cultural conflict between Aboriginal people and mainstream policies and practices. Rather, socioeconomic factors shape the circumstances experienced by substantial segments of the Aboriginal

> population, including high incidences of family poverty, low socioeconomic status, and structural barriers to employment and social opportunities. (Wotherspoon and Schissel 1998:5)

Sam L. No'eau Warner, for instance, points to the mythical promise of upward mobility for indigenous Hawai'ians who learned the English language. "Hawai'ians rank among the lowest of all ethnic groups in Hawai'i on the socioeconomic scale, many being 'houseless' in their own homeland" (Warner 1999:71). He notes examples of situations both within the University of Hawai'i and within the civil service, where indigenous Hawai'ians are sorely under-represented (Warner 1999:73).

Current research acknowledges the multiplicity of factors that create inequality in education for Aboriginal students in mainstream schools. The need for a more comprehensive, integrated study of the multiple and interrelated causes of this inequality is recognized, along with a more comprehensive use of socioeconomic indicators to expand our thinking to "broader bases of diversity" (Wotherspoon and Schissel 1998:5). These more recent studies also point to the diversity within, and the complexity and dynamism of, Aboriginal cultures, thus veering away from "essentializing" and attributing to Aboriginal peoples a narrowly defined and static set of beliefs (Wotherspoon and Schissel 1998:4).

These four orientations—individual, cultural, institutional and social structural—exist within a broader debate surrounding the meaning of multi-cultural education and how educators should address it. Educator Derek Hodson (1993) has synopsized four trends in this debate. These four are: assimilationism, integrationism, ethnic and cultural pluralism, and anti-racism.

The first trend, assimilationism, was the predominant view among educators until

the 1960s as educators attempted to cope with the diverse cultural, religious and ethnic backgrounds of their students. The assimilationist approach is primarily concerned with "the perpetuation, transmission, and promotion of the cultural beliefs and norms of the dominant community" (Hodson 1993:687). Kathy L. Hodgson-Smith scrutinizes the research into learning styles of Aboriginal children as assimilationist, noting the danger of this kind of research in that it essentializes and pigeonholes Aboriginal children. She questions the implications of even suggesting unique learning styles among aboriginal children and the motivation behind the question itself. "I suggest that this line of inquiry is assimilationist in nature. The question is part of addressing the larger issue of how Aboriginal students might find success in non-Aboriginal systems of education. The idea that there is a unique Aboriginal learning style might suggest genetic differences between Aboriginal and non-Aboriginal students" (Hodgson-Smith 2000:161).

The second trend, integrationism, superseded the assimilationist approach in the 1960s, and focused on "equal opportunity within a culturally diverse and mutually tolerant society." The cultural mosaic metaphor encapsulated the vision "that mainstream society would become enriched by the admixture of attitudes, beliefs, customs, languages, and cultural achievements of ethnic and religious minorities," and that "differences would be accepted, tolerated, and absorbed..." (Hodson 1993:687).

The third trend, ethnic and cultural pluralism, takes a more radical and proactive approach. Pluralism involves not only accepting diversity but actively promoting it. Minority spokespersons, joined by radical educators, criticized the integrationist approach as veiling fundamental assimilationist motives. Instead, they advocate that "members of the dominant community learn to appreciate, understand, and value the

different conventions and cultural norms of other and smaller groups of citizens, and that members of racial and ethnic minority communities reinforce and perpetuate their own cultural identities, thereby developing more positive self images" (Hodson 1993:688).

The fourth trend, anti-racism, views cultural pluralism as still suffering from tokenism and "exoticizing" of cultural differences as depoliticizing "the notion of culture by abstracting the concept from the social formations that gave it meaning" (Giroux 1983:197). "Antiracism attempts to reveal and combat racist attitudes and practices that disadvantage and discriminate against some minority groups and result in an unequal distribution of opportunity, wealth and power" (Hodson 1993:688). Beyond learning to appreciate and promote other peoples' cultures, anti-racists seek to uproot racist practices that are embedded within our societal structures and institutions (Callilou 1995:48).

There is no doubt that the research into the educational experiences of Aboriginal peoples' involves the interaction of complex factors from the individual styles of learning to the cultural, socioeconomic and historical contexts. Furthermore, these approaches can be framed within specific discourses, such as those espoused by feminist, post-modernist, modernist, and post-colonialist writers (Giroux 1992:21-22). Contemporary critical and post-modernist writings question the motivation for research into "others," and the ideals and assumptions fueling that research, in the first place (Giroux 1992:17; Haraway 1989:12).

Aboriginal Approaches to Education

In the 1995 publication of *The Circle Unfolds*, Eber Hampton, Past-President of the First Nations University of Canada, delineated five different meanings of "Indian" education. Each meaning raises different questions about Aboriginal peoples' education.

They are:

1) traditional Indian education;

2) schooling for self-determination, which is characterized by the use of Native languages, positive attitudes toward Native cultures, good school-community relations, and an emphasis on self-determination vs. assimilation;
3) schooling for assimilation;
4) education by Indians, which Hampton notes is a shift from "education of Indians," and entails the creation of schools for First Nations students, training First Nations teachers, and more First Nations people actively engaged in curriculum discussions; and
5) education *sui generis*, which is defined as education uniquely structured entirely by First Nations culture (Hampton 1995:8-10).

Of these, "education by Indians" has been gaining impetus since the passage of the Indian Education Act in 1972 in the U.S. and the Canadian government's adoption of the National Indian Brotherhood document, *Indian Control of Indian Education,* a year later (Hampton 1995:9). This move toward self-determination resulted in an increased number of schools and school boards controlled by Aboriginal communities, such as Eel Ground. Aboriginal peoples began to take an active role in the schooling of their children; more Aboriginal people obtained teaching certificates, and Aboriginal curriculum content was developed. However, most of the structures, methods, content, evaluation standards, teacher training programs, pedagogies, and educational outcomes remain predominantly non-Native (Coalition for the Advancement of Aboriginal Studies 2001). In the Eel Ground First Nation School, for instance, the provincial curriculum is used, although cultural classes are integrated into it. Language immersion programs are actively being promoted and researched, but the majority of the teachers are neither Mi'kmaw nor members of any other Aboriginal peoples.

Hampton's fifth category, *education sui generis*, is a central aspect of Aboriginal peoples move toward self-governance. It involves developing models of education, pedagogy, and curriculum content by Aboriginal peoples for Aboriginal students and moving away from grafting Aboriginal curriculum content onto the existing provincial curriculums. Education is redefined by Aboriginal peoples, using their own standards, cultural values and definitions of knowledge developed and taught by their own people (Hampton 1995:10). This approach does not neglect the need for Aboriginal students to learn math, sciences, and other curricula necessary to work and live in Canadian society; however, the way these would be taught would be determined by Aboriginal peoples.

At some time in their lives, most Mi'kmaw children are faced with entering the provincial school system where they often experience racism and/or a general lack of encouragement, both at school and home, to pursue higher or specialized levels of education (RCAP 1996:(3) 435; Hampton 1995:7). Although some reserves have their own schools, only a few continue through to high school.[7] Some reserve schools, such as Eel Ground First Nation School where I conducted my research, only go to Grade 8. This means students have to make two transitions in two years – the first to attend the last year of junior high school, and the second to enter high school the following year (Sable 1993:14).

Whether attending band controlled schools or provincial schools, most Mi'kmaw children will receive their education from teachers of a different cultural background, who have received little support or training from the provincial school system to address Aboriginal students' needs (Wotherspoon and Schissel 1998:4; Taylor 1995:224) In the Eel Ground First Nation School there are two full-time Mi'kmaw teachers, a few

Mi'kmaw support teachers, but the majority were not from Mi'kmaw communities. The pedagogy currently employed to teach Aboriginal students, as well as the content presented in the curriculum, may be culturally inadequate and may inadvertently prevent the full participation of Mi'kmaw children in the educational process as promoted by provincial schools.

In general, a gap of one to two grade levels exists between Aboriginal children in the Atlantic Provinces and their counterparts when they enter the provincial schools from reserve schools; they fall further behind by Grade 12 (Sable 1993:14; Hamilton 1991). On average, 50% of Aboriginal students drop out (Statistics Canada 1996 & 2001; Wotherspoon and Schissel 1998:1; RCAP 1996:960-968). Statistics compiled on New Brunswick Aboriginal high school students reflect similar facts (Statistics Canada 2001; Arkwright-Alivisatos 1998). The reason for this "gap" between Mi'kmaw children and their counterparts from other cultural backgrounds has not been definitively determined, and is considered a critical problem facing Aboriginal peoples throughout Canada (Wotherspoon and Schissel 1998:1; RCAP 1996:959-970; Hamilton 1991).

Many Aboriginal educators throughout the Maritimes have also noted the paucity of Mi'kmaw cultural content in the curriculum (Sable 1993). Even within band controlled schools this lack of cultural content can prevail because, in order to obtain funding, Aboriginal educators are required to accept provincial curricula despite the acknowledged cultural bias of provincial curriculum content (Battiste 1998:20).

A general lack of interest or connection to the material may play a role in Aboriginal students' low academic performance. Research into other Aboriginal communities indicates that:

> The strongest benefits, both in provincial/territorial and Aboriginal schools, are observed when Aboriginal culture is incorporated holistically or integrated through all aspects of programming and school culture, regardless of improvements fostered by specific initiatives or interventions.... (Wotherspoon and Schissel 1998:7)

Although the reasons for the gap may be numerous, the fundamental issue is that the needs of Mi'kmaw children are not being sufficiently addressed (Indian and Northern Affairs, Canada 2002:1). This may be changing as more Mi'kmaq are entering university and completing programs of studies in a variety of fields. Few, with some notable exceptions, are entering fields of science (RCAP 1996:969; MacIvor 1995:74; Sable 1993). Aboriginal students generally remain in the lower levels (levels 3 and 4) of the science programs and graduate lacking the academic achievement necessary for university level course work (LaFrance 2000:103; Hamilton 1991).

Ironically, even as Aboriginal students fail to graduate into higher courses of science programs, research conducted over the last decade has compiled a growing body of documentation of Indigenous knowledge systems (commonly referred to as Traditional Ecological Knowledge or Indigenous Ecological Knowledge). This body of research illustrates that a rich and comprehensive body of knowledge about the physical and natural world exists within many Aboriginal cultures, including the Mi'kmaq (Leavitt 1995; Davis 1995; Clement 1995; Inglis 1993; Deloria 1992; Sable 1992; Dene Cultural Institute, 1991; Andrews 1990; Whitehead 1982). Yet Aboriginal children have little desire and few means for applying that knowledge within a scientific discipline as it is taught in provincial educational systems.

The Mi'kmaq traditionally had a holistic approach to educating their children, integrating learning into everyday experience. As well, pre-contact Mi'kmaw culture

relied more on what we consider a narrative approach to communicate scientific knowledge. Learning was multi-sensory and occurred through a variety of media – story, song, dance, and visual images – through which knowledge of the world was understood, expressed and communicated in a meaningful way. Mnemonic devices were also used that could rapidly relate multiple levels of information within a simple symbolic message, and the language itself mirrored and articulated the rhythms and experiences of the environment (Sable 1998; Le Clercq 1968:23-24). This meant people could access information through a variety of sensory channels and media, and knowledge was communicated in a number of ways.

In the provincial educational systems of the Atlantic Provinces little recognition is given to the cultural perspective and history of the Mi'kmaq. Some efforts have been made, such as the development of Mi'kmaw Studies 10 as an elective for the high school history requirement (Nova Scotia Department of Education 2003). However, the question remains, "What is 'Indian' education?" It is a question being raised by numerous Aboriginal bands as they develop their own educational goals. At the heart of their efforts Aboriginal peoples are defining what it means to be an Aboriginal person in a contemporary world (Battiste 1995:vi).

Making science education meaningful may require the integration of alternative methods of teaching that include integrating subject areas and teaching science through the arts. This is not intended as a watering down of science into "fun and games" but a way to expand avenues of learning in ways that allow children to embody and experience principles being taught in the classroom.

Researchers have highlighted the need for more sensitivity on the part of

educators to understand the cultural transition of Aboriginal students into mainstream educational settings, as well as the legacy of mistrust of these institutions the students carry with them. Many researchers now view culture as dynamic and complex, and respect the diversity among Aboriginal peoples across Canada and the United States. For substantial and effective change to occur within schools and curriculum, the depth and complexity of Aboriginal cultures must be thoroughly comprehended (Wotherspoon and Schissel 1998:3-4; Stairs 1994). The study reported in this thesis is dedicated to exploring how the teaching of science can become a culturally aware enterprise to engage Aboriginal peoples, without compromising the integrity of the discipline of doing science.

Assumptions of the Study

At the heart of my research is the assumption that all children can learn and apply science, and that personal, cultural or social barriers to learning are surmountable given appropriate learning conditions. The second assumption is that there are methods for identifying appropriate learning conditions. Third, perhaps most fundamentally, I assume there is or will be a willingness on the part of educators to look deeply into their own beliefs as well as into the lived experiences of Aboriginal children.

Limitations of the Study

My research was conducted on one Mi'kmaw reserve, within one classroom, with a small group of students and staff, during a two-and-a-half year time period. Although limited in scope, I also drew on my years of research on other reserves.

This was the first time I had interviewed young adults, although I have spoken with many children of my Mi'kmaw friends. Working with young, pubescent adults was a challenge in itself; but to be a white, female researcher from a doctoral program interviewing young people within an Aboriginal community added to the challenge. I was just one face in a sea of researchers from institutions of "higher learning" who have conducted research in Aboriginal communities. Recording teaching and interview sessions using audio tape and video tape further added to my "researcher" image, and created unexpected barriers to communication.

This was a new community for me, a place where no one knew my history or background. For these reasons the children were reluctant to be interviewed, but most (nine out of eleven students in the class, with one dropping out later) did so. Those who did not grant permission to be interviewed were the ones who appeared to have the most personal and emotional challenges at home. This is an observation based on anecdotal remarks from staff or students, and was not a line of inquiry I pursued. Thus the research does not include the voices of those students who might be considered the most resistant and hardest to reach.

A further limitation is that the majority of my time on reserves has been in Nova Scotia, and I was not as familiar with the local politics, family structures, and basic avenues of communication within the Eel Ground community. Conversely, although I have spent a great deal of time over the last fourteen years traveling to Aboriginal reserves and working on a variety of projects, it is also a challenge to take a fresh look at each new situation.

Other limitations had to do with particulars of the situation, such as faulty

recording equipment. I overheard anecdotal remarks from staff members and the classroom teacher shared personal reflections with me. I have respected these private remarks and have consciously left details out that I know would enhance this research.

Summary

This study identifies some of the conditions and contexts necessary for Mi'kmaw students to learn science as it is taught in current Atlantic Canadian curricula. By first looking at the legacy, past and current political and research contexts, along with the efforts of Aboriginal peoples toward self-determination, I identified a complex web of factors that affect the learning situation of Mi'kmaw students. The study was situated within a Mi'kmaw community school and is based on the words and experiences of students in the grade 7/8 class and on my personal observations within the classroom and on field trips. The classroom used to conduct the research acted as a mirror of the many issues facing young Mi'kmaw teenagers attempting to learn science.

Organization of the Thesis

In Chapter Two, I present my literature review and the theoretical foundations for my research. This chapter includes a discussion of current theory on science education, scientific literacy and the nature of science. I then present my working definition of culture, followed by a discussion on the importance of cultural narratives in providing a meaningful context for learning to occur. The discussion on cultural narratives includes a working definition of "spirituality" as a building block used by students to find their identity in the creation of a culturally interactive science curriculum. I then delve further

into the cultural origins of knowledge. A discussion on language provides further elucidation of the profundity of these narratives as a system of symbols, and sheds light on why language revitalization among Aboriginal cultures could be relevant to the teaching of science. I further explore the concept of the "cultural production of the educated person" (Levinson, Foley, and Holland 1996).

The dynamic and emergent nature of culture is presented followed by the notion of cultural borderlands (Rosaldo 1989) and border crossings (Aikenhead and Jegede 1999). These concepts are introduced as a means to consider the different ways students relate or do not relate to learning science. I continue on to discuss the phenomenological approaches of Francisco Varela, Max van Manen, and others to understanding the lived experience of individuals as foundational to learning. I then present the view of learning as a web of relationships and networks of meaning that form the basis for personal, cultural and social identity. I further look at Varela's concept of "fragile ontologies" (Varela 2000:12) as an alternative to constructivism. Varela's philosophy is proposed as a means for thinking about Aboriginal peoples' education, particularly as a complement to the medicine wheel paradigm proposed by several Aboriginal educators. Finally, I demonstrate the potential for adapting a contemporary pedagogical model (Duschl 2000) to develop a culturally interactive model for science education.

In Chapter Three, "Methods of Research and Project Description," I discuss the research approach used within this study. I describe Max van Manen's (1990) hermeneutical phenomenological research approach and methods for applying this approach to the interpretation of lived experience. This approach is supplemented by the work of Francisco Varela (1996, 2000). Ethnographic research methods, which were also

employed in the research, will be described and distinguished from the phenomenological approach. I then go on to provide a description of the project, the various stages of research and field work, as well as the analysis methods employed.

In Chapter Four, "Webs of Significance and Phenomenological Themes," I present my research results and analysis of the data from the interviews with the Grade 7/8 students. I discuss the multiple layers of meaning and the concept of "fragile ontologies" (Varela 2000) that exist within the minds of the students and the fluidity of their thinking process as they weave together these multiple layers into a meaningful context. I explore specific issues regarding their personal, cultural and societal identities, and ways they come to view themselves in the world and form an identity. From that, I derive the significant themes that guide this process of identity formation.

In Chapter Five, "Creating a Narrative: A Culturally Interactive Approach to Science Education Pedagogy," I carry forward the themes that emerged in Chapter Four to illustrate their presence in material from field trips conducted on the reserve with Steven Ginnish, and the pilot curriculum presented in the classroom. I present the lesson on chemical changes I developed for the pilot project, as well as the field trip project I adapted from the "Diversity of Living Things" lessons from the *Science Plus* text used in the school. I then look at ways to open avenues for creative learning and cultural interaction, including through artistic media, and I provide an example I have used for teaching science through a Mi'kmaw dance.

In Chapter Six, I present a model of learning, drawn from the analysis and themes presented in the previous chapters. This model is then compared to other models for learning. In Chapter Seven, I further discuss the implications of instituting such an

approach, and make recommendations for policy change. I then offer a summary of my conclusions regarding the research.

Endnotes

1. The use of the term "indigenous peoples" is used by Linda Tuhiwai Smith. Although I am using Aboriginal, I am including her definition to show the rationale for the use of 's' on peoples. Smith (1999:7) states: "The final's' in 'indigenous peoples' has been argued for quite vigorously by indigenous activists because of the right of peoples to self-determination. It is also used as a way of recognizing that there are real differences between different indigenous peoples. The term that has enabled the collective voices of colonized people to be expressed strategically in the international arena....they share experiences as peoples who have been subjected to colonization of their lands and cultures, and the denial of their sovereignty, by a colonizing society that has come to dominate and determine the shape and quality of their lives, even after it has formally pulled out."

2. In 1993, I was contracted by Energy Mines and Resources, Natural Resources, Canada, to develop a cross-cultural earth science program in cooperation with the Mi'kmaq Education Authority for use within Mi'kmaw reserves. To do this required a great deal of research of archaeological and historical records on traditional use of rocks and minerals, and of legends that contained references to rocks, minerals and landscape features. I also interviewed many Mi'kmaq within communities throughout the Maritimes. The program was piloted at a Mi'kmaw science camp in the summer of 1994, before the funding for this and many other programs was cut.

3. As the Director of the Labrador Project, for the Gorsebrook Research Institute at Saint Mary's University, I am working in collaboration with the Innu Nation of Labrador and Environment Canada to create an educational program for a group of "Innu Environmental Guardians" in preparation for the Innu Nation to become self governing. The program brings together formal western sciences and other disciplines with Innu Environmental Knowledge.

4. As an example, see Alan R. Emery's *Integrating Indigenous Knowledge in Project Planning and Implementation,* published by the International Labour Organization, The World Bank, Canadian International Development Agency, and KIVU Nature Inc.

5. Educational anthropologist, Harry F. Wolcott, provided a riveting example of this legacy in his description of his experience teaching Kwakiutl children in the 1960s. Noting the cultural gap between him and his students, as well as the antagonism he felt from the students, Wolcott alighted on the phrase, "teacher as enemy." Wolcott's likening of his students to prisoners of war arose from the gulf he was experiencing between himself as a member of the dominant Euro-Canadian culture and the

marginalized culture of these Aboriginal children experienced daily. Beyond the classroom, these children lived with the legacy of colonization and the many social and cultural problems that arose from it. The student-teacher relationship was akin to forming pacts for cultural survival in an unwanted situation (Wolcott 1994:279). "He, and the culture he represented was the enemy." The teachers were the captors representing one cultural group who were expected to convert the prisoners to their way of life, yet the prisoners were not expected to acculturate the captors (1994:281). Wolcott surmised that if the teacher could perceive him/herself as an enemy captor he or she might understand how students felt toward him/her. For Wolcott, the fundamental question became. "What is it these students would ever want to learn from an enemy?" (1994:281)

6. For example, research conducted over the last few decades on the education of indigenous children indicates that some may have different learning styles that are often incompatible with the pedagogical methods employed by the teachers in their classrooms (Cleary and Peacock 1998; Lipka, Mohatt and The Ciulistet Group 1998; Allen 1995; Battiste and Barman 1995; Cajete 1994; McPherson 1987; Wolcott 1967). These differences may be based on learned cultural practices and behaviors. Examples include: the focus on cooperative learning vs. individual achievement (Cleary and Peacock 1998); lack of eye contact with the teacher as a display of respect versus direct eye contact to show comprehension and attention (Stairs 1994); differences in perceptions of the world in what they attend to or choose not to attend to such as spatial or visual information vs. numerical data (McPherson 1987); and differences in how they conceptualize the world such as conceptualizing the world as a dynamic process in which shapes have shifting boundaries vs. as a static and unchanging entity (Pinxten, as cited in Hampton 1995).

7. Within the Maritime provinces, Eskasoni, Whycocomagh, Wagmatcook, Indian Brook, and Big Cove Reserves have schools that continue through to Grade 12.

Chapter Two
Theoretical Framework

Introduction

Mi'kmaw students face a complexity of personal, cultural, and social issues within contemporary society. Understanding how this complexity of issues relates to their achievement of scientific literacy requires a theoretical framework that allows the lived experience of these Mi'kmaw teenagers to emerge. In so doing, we can begin to come to know the larger narrative that gives shape to their identity and ways of relating to the world, and potentially find the boundaries that obstruct or open a path to meaningful learning experiences. To create the theoretical foundation, I will first look at science and science education as it is currently presented in curriculum frameworks guiding the teaching of science. Emerging from that discussion will be the call for a new narrative and consideration of some Aboriginal people's view of education. I will then explore cultural narratives as the foundation for culturally responsive science education. This discussion will explore the cultural origins of knowledge, culture as a system of symbols including language, and different cultural perceptions of what it means to be an educated person. The dynamic and emergent nature of culture will then be introduced, followed by the concepts of borderlands, borders, and border crossing as a way to conceptualize the various students' experiences as they relate to their lives. Finally, I will explore models of learning and the role of the learner's sense of identity, which I believe is complementary to the medicine wheel model used by many Aboriginal educators. The chapter will conclude by returning to the nature of scientific thinking and establishing the ground for a culturally interactive paradigm of learning for Aboriginal peoples.

Science and Science Education

Science educators face the challenge of providing adequate preparation for all Canadian citizens to become scientifically literate to allow Canada to compete in the global economy (Council of Ministers of Education, Canada, 1997:5). My review of four flagship policy documents published in the U.S. and Canada for contemporary science education shows that science, math and technology are viewed as the lynchpins of human survival in the future.[1] This is clearly stated in *Benchmarks for Scientific Literacy (Project 2061),* published by the American Association for the Advancement of Science:

> The terms and circumstances of human existence can be expected to change radically during the next human life span. Science, mathematics and technology will be at the center of that change, causing it, shaping it, responding to it. Therefore they will be essential to the education of today's children for tomorrow's world. (AAAS 1993:xi)

Although stated in slightly softer terms, *Common Frameworks of Science Learning Outcomes* published by the Council of Ministers of Education, Canada, echoes these same concerns:

> Canadian society is experiencing rapid and fundamental economic, social, and cultural changes that affect the way we live. Canadians are also becoming aware of an increasing global interdependence and the need for a sustainable environment, economy and society. The emergence of a highly competitive and integrated international economy, rapid technological innovation and a growing knowledge base will continue to have a profound impact on our lives. Advancements in science and technology play an increasingly significant role in everyday life. Science education will be a key element in developing scientific literacy and in building a strong future for Canada's young people. (Council of Ministers of Education, Canada 1997:5)

The general tone of these documents is that science is essential for everyone. To make science more accessible to students, the policies place an increasing emphasis on making science relevant in social and personal contexts. Science educator, Derek

Hodson, in an overview of science curriculum development since the 1960s, notes the shift in emphasis from the acquisition of scientific knowledge "ensuring familiarity with the structure of scientific theories and the processes of scientific inquiry," to such factors as:

- addressing "real life" situations;
- relating science to wider societal and technological issues;
- developing scientific literacy in the context of active and responsible citizenship;
- promoting science as a cultural phenomenon;
- ensuring that science is more person oriented;
- starting from and building on children's existing knowledge and experience;
- using problem-solving activities to develop creativity and promote decision-making social skills; and
- enhancing each student's self-image and self-worth (Hodson 1993:685).

New standards proposed by the National Research Council (1996) place emphasis on students "becoming aware of the larger context in which science, math and technology occur." The authors call for an increased emphasis on "learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science," and a decrease in the study of "subject matter disciplines (physical, life, earth sciences) for their own sake" (National Research Council 1996:113).

This new emphasis on relevance is explicitly intended to be inclusive of all students whatever their cultural background:

> The intent of the Standards can be expressed in a single phrase: Science standards for all students. The phrase embodies both excellence and equity. The Standards apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science. Different students will achieve understanding in different ways, and different students will achieve different degrees of depth and breadth of understanding depending on interest, ability and context. But all students can develop the knowledge and skills described in the Standards, even as some students go well beyond these levels. (National Research Council 1996:22)

These standards will remain important guidelines for the path of the would-be scientists, or any students, but do they actually take into account and address cultural differences? Do they accommodate the "real life" perceptions of Aboriginal peoples? Can there be a dialogue between various cultural frameworks and ways of knowing in the teaching of science?

Hodson maintains that the emphasis on making science education more accessible, society-oriented, and learner-centered now requires a multicultural perspective (Hodson 1993:685). He points out that various interests, aspirations and expectations of different cultural and ethnic groups locally, nationally and internationally need further consideration within the discussion of science education and its role in preparing Canadian citizens:

> Emphasis on the value of science education in promoting responsible and active citizenship raises questions of interests and values, both within and between societies, majority vs. minority interests, aspirations and expectations of different cultural and ethnic groups, matters of international concern, third-world issues, and so on. Addressing real-life situations demands that we consider a range of perspectives. After all, real life varies enormously between different countries, between different areas of the same country, and, of significance in the context of the discussion between different social, cultural and ethnic groups. (Hodson 1993:685)

Mi'kmaw educator Dr. Marie Battiste underscores the variation in "real-life"

situations by pointing out the discrepancy between what the educational literature says, and what is actually being done. Little has been done by provincial governments to revamp curricula to reflect the diverse populations served by schools, especially the Aboriginal youths currently in provincial schools. Educational efforts have been limited to increasing access to existing programs and introducing thematic content (Battiste 1998:19).

One of the "General Learning Outcomes" under the category of *Scientific Inquiry* in the Canadian standards for Grade 5-6, states that the students should "Open-mindedly consider nontraditional approaches to science." Further down the same list, another outcome states that student should, "Base conclusions on evidence rather than preconceived ideas or hunches" (Council of Ministers of Education, Canada 1997:140). On the one hand, there is a positive implication in the fact that students are being encouraged to consider other approaches to science, whatever they may be. On the other hand, the document raises questions about what comprises evidence and how that evidence is used to form conclusions. As we cross from one culture to another, we find that the nature of acceptable evidence depends on context. The context is what Battiste and others are referring to as "real life" situations. What may be sufficient in certain contexts does not describe the whole of reality for all peoples (for examples, see Meyer and Ramirez 1996; Deloria 1992:12-18; Cole and Scribner 1974:117).

Educational anthropologist, David Hess points out that science, unlike other subjects, remains imbalanced in the inclusion of other "voices":

> It is no longer possible to compose a syllabus in the humanities without considering questions of balance, bias, and the inclusion of historically excluded voices. However, such is generally not the case for introductory surveys of engineering, medicine, and the natural sciences, or for surveys

> of the history, philosophy and social studies of the technical fields. (Hess 1995:viii)

From the point of view of some Aboriginal educators, our mainstream assumptions and biases in education and science can quickly become linked with such terms as colonialism and imperialism. Gregory Cajete highlights the need to look at the assumptions that underlie education and the "colonization of perception" other cultures have endured in the Western educational system:

> The paradigm is founded on the Western mechanistic philosophy of control of Nature and the idea that homogenization allows greater freedom. It is based upon a body of accepted theory that underpins modern society's assumptions of reality. It considers that reality to be the only reality....This is what the hidden curriculum of modern education communicates. This paradigm so guides the consciousness of American mainstream education, that it forms the nature of thought, research and education. This conditioned orientation has resulted in a colonization of perception with repercussions of a magnitude almost beyond description. One can begin to understand such colonization by realizing that there are alternative cultural realities and by honoring their presence. (Cajete 1994:78)

Science is viewed as integral to the globalization process yet is itself considered a "culture of scientists" and science education as a "subculture of science", with its own world view and ideology (Ogawa 1999:3; see also Aikenhead 1996; Hess 1995:3; Hodson 1993:685). It is in response to this "culture" and "subculture" with its perceived ideology that many indigenous peoples are asserting their own cultural practices and traditions (see for example, Ermine 1995:102; Hampton 1995:10).

According to anthropologists Emily Schultz and Robert Lavenda, "...the birth of science was the birth of a new world view. Scientists believed that remarkable new insights about the universe, the objects in it, and even ourselves, could be gained if we carried out observations according to a new set of rules" (Schultz and Lavenda 1995:17).

They define world view as "encompassing pictures of reality created by the members of cultures" (Schultz and Lavenda 1995:221). In *Benchmarks*, the scientific world view is actually defined:

> A scientific world view is not something that working scientists spend a lot of time discussing. They just do science. But underlying their work are several beliefs that are not always held by nonscientists. One is that by working together over time, people can in fact figure out how the world works. Another is that the universe is a unified system and knowledge gained from studying one part of it can often be applied to other parts. Still another is that knowledge is both stable and subject to change. (AAAS 1993:5)

Interestingly, the word "beliefs" is used, and an acknowledgment that underlying the doing of science are some distinct beliefs unique to scientists. An argument I have often heard regarding why Indigenous Ecological Knowledge can not be considered science is because of the inclusion of their beliefs about reality into their ways of knowing. However, the articulation of the beliefs held by scientists could become the ground for an intriguing dialogue between indigenous peoples and the scientific community.

According to the authors of *Benchmarks*, the beliefs held by scientists are subtle and are not to be considered dogma. Scientists differentiate between believing that the world *can* be understood and believing that it ever *will* be understood to the point that scientists can pack their bags and go home. The authors continue on to describe the uncertainty of science, the continual generation of further questions, and the variability and relativity of truth in that conditions under which a subject is studied can change the outcome (AAAS 1993:5).

The acknowledgment in *Benchmarks* that there is a scientific world view gives credence to the claim that science is the culture of the scientific community. The authors

of *Benchmarks* also define science as "a *way of knowing"* and the study of science as an "intellectual and social endeavor" (AAAS 1993:3). They also discuss how this way of knowing differs from other methods:

> Over the course of human history, people have developed many interconnected and validated ideas about the physical, biological, psychological, and social worlds. Those ideas have enabled successive generations to achieve an increasingly comprehensive and reliable understanding of the human species and its environment. The means used to develop these ideas are particular ways of observing, thinking, experimenting and validating. These ways represent a fundamental aspect of the nature of science and reflect how science tends to differ from other modes of knowing. (AAAS 1993:5)

The goal in science teaching is therefore to teach the processes of scientific research – "How scientists go about their work and reach scientific conclusions" (AAAS 1993:3) – along with the limitations that arise in these processes and the conclusions derived from such processes. This is a hopeful trend in the recognition of science's place among other disciplines in a multi-cultural context.

Along with learning some key concepts of science as building blocks for further exploration, the goal of scientific literacy, according to the authors of *Benchmarks*, is to become thoughtful human beings who understand science as a way of knowing and following the "story" of science. "They can follow the science adventure story as it plays out during their lifetimes" (AAAS 1993:3).

It is important to note that science is being likened to an adventure story. Furthermore, the means we may use for explaining the world, e.g., scientific inquiry, are based on certain assumptions about reality. These explanations are to assist in the integration of people into a wider set of assumptions within a global community.

From Battiste's perspective, "educators are challenged to unravel stereotypical assumptions and theories entangled in cognitive imperialism – the persisting ideologies from our colonial past that remain part of our educational systems.... Aboriginal people need a new story" (Battiste 2000:viii-ix). The perspective offered by the authors of *Benchmarks* of science as a "way of knowing" with a distinct "world view," and as an "adventure story" students can follow, is a wonderful foundation for creating this new story.

Finding the Story: The Function of Cultural Narratives

Neil Postman, Professor and Chair of the Department of Culture and Communication at New York University, distinguishes between two problems in education that need to be addressed – one regarding how education is engineered, and the other about the metaphysical questions of education. According to Postman, the problems of engineering have to do with the "means by which the young will become educated" (Postman 1996:3). These means include methods, pedagogies, curriculum development, and how, when and where things will be done. The metaphysical problem has to do with the reason children are in school at all and why they are learning (Postman 1996:4):

> This kind of reason is somewhat abstract, not always present in one's consciousness, not at all easy to describe. And yet, without it, schooling does not work. For school to make sense, the young, their parents and their teachers must have a god to serve, or even better, several gods. If they have none, school is pointless. Nietzsche's famous aphorism is relevant here: 'He who has a why to live can bear with almost any how.' This applies to learning as to living. (Postman 1996:4)

Postman used "gods" synonymously with narrative:

> A god, in the sense I am using the word, is the name of a great narrative, one that has sufficient credibility, complexity, and symbolic power to

> enable one to organize one's life around it....The purpose of the narrative is to give meaning to the world, not to describe it scientifically. (Postman 1996:6-7)

Postman is not invoking a religious God or a dogma necessarily, although religion has certainly provided the "narrative" for many educational institutions. These great narratives or gods provide a purpose for why we learn in the first place (Postman 1996:5); and offer schools a "transcendent, spiritual idea that gives purpose and clarity to learning. Even the skeptics and nonbelievers know why they are there, what they are supposed to be learning, and why they are resistant to it. Some also know why they should leave" (Postman 1996:5).

Educators Michael Connelly and Jean Clandinin discuss the notion of "narrative unity" in curriculum development, which complements Postman's concept of an overarching narrative:

> Narrative unity is a continuum within a person's experience and renders life experiences meaningful through the unity they achieve for the person. What we mean by unity is the union in each of us in a particular place and time of all we have been and undergone in the past and in the tradition (the history and cultures) that helped to shape us. It is a meaning-giving account, an interpretation, of our history and, as such, provides a way of understanding our experiential knowledge. Within each of us there are a number of narrative unities. Ongoing life experience creates the narrative unity out of which images are crystallized and formed when called on by a practical situation. (Connelly and Clandinin 1988:74-75)

This narrative unity is what many would term "spirituality", or what Postman is referring to as the "spiritual dimension." The meaning of the term "spiritual dimension" is captured in a quotation by noted theologian, Wayne Teasdale:

> Being religious connotes belonging to and practicing a religious tradition. Being spiritual suggests a personal commitment to a process of inner development that engages us in our totality. Religion, of course, is one way many people are spiritual. Often, when authentic faith embodies an individual's spirituality the religious and spiritual will coincide. Still, not

> every religious person is spiritual (although they ought to be) and not every spiritual person is religious. Spirituality is a way of life that affects and includes every moment of existence. It is at once a contemplative attitude, a disposition to a life of depth, and the search for ultimate meaning, direction, and belonging. The spiritual person is committed to growth as an essential ongoing life goal. To be spiritual requires us to stand on our own two feet while being nurtured and supported by our tradition, if we are fortunate enough to have one. (Teasdale 1999:17-18)

Spirituality is a word commonly used by indigenous peoples as fundamental to their education, and therefore, as important to contemplate in discussing science education for indigenous peoples. Eber Hampton places spirituality at the center of Aboriginal peoples' education, and the respect for the spiritual relationships that exist among all living things (Hampton 1995:19):

> Indian Education orients itself around a spiritual centre that defines the individual as the life of the group. The freedom and strength of the individual is the strength of the group. The individual does not form an identity in opposition to the group but recognizes the group as relatives included in his or her own identity. (Hampton 1995:21)

In Hampton's opinion, this spiritual orientation is how Aboriginal peoples find identity, or "an unalienated self" (Hampton 1995:19).

The concept of spirituality as a way of being in the world in a meaningful way, as distinct from being specifically religious, has entered mainstream education as a topic of exploration.[2] If we can equate Teasdale's concept of spirituality with Postman's overarching narrative, it would be an important step toward cross-cultural communication within the teaching of science.

In Chapter Four, I will illustrate some of the narratives identified in student interviews and will analyse them in terms of "phenomenological themes" (Van Manen 1990:90) and "webs of significance" (Geertz 1973:5) that form the basis of meaning or narrative underlying identity. These concepts are discussed later in this chapter. The

themes and webs reflect the "why" of life, the meanings that create unity in the students' sense of being and reasons for engaging in scientific literacy.

How can we help create a new narrative that will bridge the gap for Aboriginal students in the sciences? In the next four sections I will identify four central issues that are fundamental in addressing this question. These four are:

- the cultural origins of knowledge in which I will include discussions on language as cultural capital, and the concept of the "cultural production of the educated person" (Levinson, Foley and Holland 1996);
- the dynamic and emergent nature of culture;
- the notion of cultural borderlands and border crossings; and
- networks of meaning: learning models and the role of identity.

The Cultural Origins of Knowledge

Discussions concerning education are inextricably tied to discussions about culture. Defining and understanding what is meant by culture is necessary to creating a "new story" for Aboriginal students. There is an abundance of definitions of culture.[3] Clifford Geertz, a renowned anthropologist, defined culture as "interworked systems of construable signs (what, ignoring provincial usages, I would call symbols)" (Geertz 1973:14). Culture "is a context, something within which [social phenomena] can be: intelligibly – that is thickly described.... Understanding a people's culture exposes their normalness without reducing their particularity" (Geertz 1973:14). He continues "Believing with Max Weber, that man (sic) is an animal suspended in webs of significance he himself (sic) has spun, I take culture to be those webs, and the analysis of

it to be therefore not an experimental science in search of law but an interpretive one in search of meaning" (Geertz 1973:5).

Culture, seen as webs of significance, is a narrative in which people develop their identity and reflect on who they are, what is meaningful, how to behave, and what to value as right and wrong. Taking this one step further, culture is not just a context for identity but is identity in the making.

Also drawing on the metaphor of a web, educator Max van Manen refers to "phenomenological themes" as fundamental guidelines to meaningful living:

> ...phenomenological themes are not objects or generalizations; metaphorically speaking, they are more like knots in the webs of our experiences, around which certain lived experiences are spun and thus lived through as meaningful wholes. Themes are the stars that make up the universes of meaning we live through. By the light of those themes, we navigate and explore such universes. (van Manen 1990:90)

David Hess views "culture as a symbolic apparatus that underlies a wide range of ideas and practices" (Hess 1995:ix). What Hess terms symbolic apparatus is a crucial aspect in discussing multi-cultural education because everything is symbolic and symbols are imbued with cultural meaning. Language, including scientific language, is a powerful system of symbols that encodes the values, parameters, and rules of a whole world view. It is through learning the meaning of these symbols and their "webs of significance" (Geertz 1973:5) that children learn to interpret the world and navigate through their universes (Van Manen 1990:90).

Language as Cultural Capital

Yvonne Hebert, Education Professor at the University of Calgary, sees the importance of literacy in general in terms of knowing symbol systems including knowledge and skills:

> In order to function in the symbolic worlds in which we live, worlds in which knowledge and skills are cultural creations, we must be proficient in the use of the symbol systems--written and spoken language, mathematics, signs, gestures--that are valued by one particular society. The forms that represent our worlds to ourselves and to each other shape our perception of those worlds. Looking at literacy as the ability to use symbolic systems that are culturally valued enables us to make a distinction between resources, understandings, and underlying assumptions that constitute social reality in a literate world. Adopting this dynamic conception of literacy permits us to recognize the importance of education and, especially, of literacy and language education. One of the main goals of education then, is to transmit and provide access to symbolic knowledge; and language is the primary vehicle through which this occurs. (Hebert 2000:55)

Hebert also views Aboriginal languages as essential to the development of future Aboriginal citizens, as ensuring security in 'their being, their languages, and their cultures; citizens who are able to participate in the (re)construction of society; citizens who not only exercise their rights but also their responsibilities and duties while participating actively in society" (Hebert 2000:55). For instance, language immersion at Eel Ground is a primary goal, one the Band Council and school board are actively supporting and researching in cooperation with other bands. There is a language immersion program in the kindergarten, and language classes are offered in subsequent grades twice a week for one half hour, while French is taught every day. This too is being evaluated.

Gregory Cajete, a Tewa Pueblo educator, looks at teaching itself from the point of view of language and communication, and the importance of language revitalization to science learning (Cajete 1999:146):

> Language revitalization, along with a resurgence of cultural identity, will have a direct effect on perceptions and attitudes students have toward science. The comparison of a particular Native American view of science with that of Western science can have the direct effect of broadening students' perspectives of science. It can help all students to become more open and less isolated within the confines of one cultural view point. (Cajete 1999:146)

Cajete goes further and proposes that science with its scientific vocabulary should be thought of in terms of language acquisition studies (Cajete 1999:142). "If science is a kind of literacy, the concept relates to science as language with its unique content, symbol systems and structure which can be learned very much like a second language" (Cajete 1999:144). Cajete suggests how we teach this language has important implications for both the teaching and learning of science. This requires students be in an "acquisition rich" environment in which scientific language is continually nurtured.

In my Master's thesis, I delved into the different ways the Mi'kmaw language expresses the world, and the subsequent difficulties the language could pose for children learning science (Sable 1996). I looked at such things as animacy and inanimacy, the concept of self, the verb-like and relational character of the Mi'kmaw language and many other aspects of the language Language, as MacIvor says, is one of the most obvious culturally specific forms of communication (MacIvor 1995:78).

On yet another level, lack of competence in English is often cited as a barrier to learning for Aboriginal students, and science with its specialized vocabulary creates further barriers for some students. Its impersonal and passive style can be alienating (MacIvor 1995:78). Aboriginal students who have their tribal language as their first language are often caught in a process of translation that not only takes time but often has no corollary words or concepts in English. For instance, in a meeting between an Inuktitut leader and a group of Inuit students attending a special two-week session at Saint Mary's University, the leader described her own translation process as we spoke together. Sometimes, she said, she could not respond quickly because she could not find an adequate English translation for what she wishes to say. The same was true for some

of the students who participated in the program.

Many Mi'kmaq have told me the same story, citing experiences they have had trying to understand instructions given by teachers not of their cultural background. The concept of "wait time" proposed by some researchers as part of Aboriginal students' learning styles may be partly due to this translation process. I often wonder if it also has to do with the volume and speed with which English words are spoken. One Mi'kmaw woman, Eleanor Johnson, once said in a lecture, it takes her a whole sentence in English to say one word in Mi'kmaq. "Can you think of how frightening it felt to write trying to think out a thousand words?" (Sable 1996:116; Johnson, 1994).

Looked at from another angle, ethnobotanist, Wade Davis, in a CBC Ideas interview (February 4, 2002), noted that we talk so much about bio-diversity as fundamental to a sustainable environment, yet our linguistic diversity is diminishing by as many as 3,000 languages in our life time alone. We are losing the environmental knowledge used by Aboriginal peoples to survive for millenia (Davis 2002).

The role of language in learning has a number of pedagogical repercussions. First, students are finding both emotional and cognitive borders that they do not want to cross. Second, students have little time to explore alternative concepts in learning science. Third, the whole concept of teaching as communication on multiple levels must be deeply contemplated not only from the point of view of how the teacher teaches but also how students learn.

The Cultural Production of the Educated Person

From the perspective of educational anthropologists, education is part of a complex whole that places individuals within a larger, more holistic context, rather than being a series of psychological developmental phases through which individuals move, unrelated to the larger socio-cultural context (Roberts 1976:2):

> Both anthropologists and educators are...vitally concerned with culture, the ways of living developed by a group of people, and with cultural transmission, the processes of continuing and enlarging the cumulative heritage between generations. Thus learning must stand as a concept basic to enculturation, the process of becoming a functioning member of a particular group of people. (Roberts 1976:1)

Through education, students within any society learn cultural and social norms and come to shape or adjust their identity according to what is culturally defined as becoming a responsible member of the society. In modern society science education is part of enculturation. If this is acknowledged, we can ask, where does science education reside in the cultural inheritance of Aboriginal people?

Every culture forms its own conception of an "educated" person – someone who has learned how to survive as a person and contribute to the society. Bradley Levinson, Douglas Foley, and Dorothy Holland's book, *The Cultural Production of the Educated Person* (1996), proposes that knowledge is a kind of "cultural capital," and educational sites are the locations where an exchange of relevant knowledge is negotiated. In essence, cultural capital is what is necessary for people to succeed within a given society (e.g., knowledge, ways of speaking, certain manners, styles of dress, etc.). Language, as previously discussed, is also a form of cultural capital (Hemmings 2000:70):

> ...all cultures and social formations develop models of how one becomes a fully "knowledgeable" person, a person endowed with maximum

> "cultural capital"...while we use the "educated person" as an analytic construct, we argue that an indigenous conception of the educated person is variably present in all known cultures and societies. (Levinson and Holland 1996:21)

The meaning of being knowledgeable is relative to the system of social truths (webs of significance) that circulate throughout the culture and become embedded within its institutions. The people who will implement changes in the communities, provinces, or nations have to be regarded by their peers as knowledgeable to some degree. For Levinson and Holland, it is within educational systems, whatever forms they take, that social truths are defined and negotiated, and methods employed to propagate those truths (Levinson and Holland 1996:18).

Anthropologist James Leach offers an example from his fieldwork on the Rai Coast of Papua, New Guinea, that crystallizes the notion of the cultural production of knowledge:

> During my fieldwork among Nekgini speakers in Reite hamlets during 1994/5 and 1999, people were concerned to only tell me of knowledge that they themselves 'owned'. This was not an issue for them of concern at providing inaccurate accounts to an anthropologist, but rather that they would be liable, in a local legal sense, for any knowledge they claimed to own by passing it on to me. People there have clear ideas about who owns certain knowledge, and therefore who has the right to elucidate it. I make the argument that passing on knowledge, ritual forms or designs is open to challenge for a specific reason. That is, expressing knowledge amounts to claiming inclusion in the relationships (including those to land and spirits), which generated that knowledge...knowledge is intimately bound up with the production of persons and identity. (Leach 2000:1)

Leach has brought an important element to the discussion of knowledge and its production. For any body of knowledge to be meaningful there needs to be a kind of ownership of it and identity with it. As a further example, when conducting research among the Innu of central Labrador in 1998 on cultural perceptions of the landscape, I

was informed that every family had their own body of stories, which they alone could relate. Furthermore, some stories could only be told at certain times of the year.

Kenneth Ruddle, in a detailed exploration of Traditional Knowledge (his term for IEK) transmission, emphasized the pivotal role knowledge plays in any community:

> ... knowledge assumes a pivotal role in any community; integration of an institutional order is understandable only in terms of the knowledge that its members have and share...Such knowledge underlies the dynamics of institutionalized conduct and defines the areas of such conduct, as well as both defining and constructing the roles to be played in the context of such institutions. By definition, such knowledge also controls and predicts conduct by the operators within a resource system. Since such knowledge comprises a body of generally valid truths about reality, any deviance from the social order is a departure from reality. (Ruddle 1993:19)

Eber Hampton among others (see also Callilou 1995:47-72) proposed a model of an educated Aboriginal person in contemporary society. His model is a step toward forming a new "narrative" or a model for identity-in-the-making. He noted that there was no theory of Indian education or coherency among the pedagogical models used in various band controlled schools (Hampton 1995:11). As a result, Hampton began interviewing Aboriginal students at Harvard about their educational experiences. From his research, he isolated twelve standards for Indian education: spirituality, service, diversity, culture, tradition, respect, history, relentlessness, vitality, conflict, place, and transformation. He also proposed a six directional model (north, south, east, west, spirit, and earth) based on his own traditional practice of the pipe ceremony. Each direction had its own meaning and related to different standards. Such a model was a way to understand complex and dynamic interrelationships and to find individual identity within the webs of relationships, both visible and invisible (Hampton 1995:5-46). In his own research with Aboriginal students, Hampton isolated six aspects basic to a theory of

Aboriginal education.

1. Spiritual concerns are an important part of Indian Education;

2. There are distinctive Indian styles of thought and communication with educational implications;

3. For most Indians, education has the dual purpose of promoting Indian features as well as providing skills and information relevant to non-Indian society;

4. Indian education cannot be understood apart from historical analysis;

5. Indian education occurs in a cultural atmosphere that is permeated by both strong group bonds and great individual freedom; and

6. Indian education is service oriented (Hampton 1995:15).

For many Aboriginal peoples, the Medicine Wheel or Sacred circle has become a symbol of their world view and concept of education (Castellano, Davis, & Lahache 2000:xi). It has been widely adopted by indigenous peoples throughout Canada and the U.S. Originating from the Aboriginal peoples of the Plains, it "has gained a broad acceptance as a means of maintaining awareness of the interrelatedness of all life while deepening our understanding by focusing on segments of the whole" (Castellano, Davis and Lahache 2000:xii):

> The vertical and horizontal axes of the Medicine Wheel reach out in the four directions to include all peoples of all cultures and draw attention to the harmony that can be achieved when divergent elements are brought into balance within the circle of life. Applied to education, the Medicine Wheel illustrates the necessity of attending to the physical, emotional, intellectual and spiritual dimensions of learning and personal development. (Castellano, Davis and Lahache 2000:xii)

The basic notion is one of holism, interrelatedness, balance, and continuity which

includes all aspects of the human psyche in a nondualistic relationship within the cosmos. It is the union of body (appearance and form), speech (emotions - the communicative energy between mind and body) and mind (cognition):

> The symbolism of Sacred Circle represents unity, interdependence and harmony among all beings in universe and time as the continual recurrence of natural patterns. Cyclical patterns and recurrences constitute the reality in which humans can understand purpose and meaning. (Regnier 1995:315)

Medicine wheels are mirrors of ourselves and the cosmos simultaneously, a microcosm and macrocosm, an interdependent network of relationships of which we are one part. Because it is a circle, there is no beginning or end, but a continuous cycling through various seasons, moods, phases, in an constantly emerging process of coming to know and knowing (See Regnier 1995:316). The arising of a number of conditions at any moment in time is where we meet the world and the world meets us in a process of becoming and dissolving over and over again.

These social and cultural realities must be comprehended for successful inter-cultural communication, whether with Aboriginal students or students of any culture, entering public schools or working within communities. To be meaningful, knowledge needs to express a relationship that helps the learner create an identity within a recognized and meaningful cultural context. Mainstream science education may fall short of the "new narrative" expressed by Marie Battiste and Eber Hampton; but, given the earlier discussion on science as narrative, it does not have to fall short, as the next chapters will show.

The Dynamic and Emergent Nature of Culture

Culture and the cultural production of knowledge is not a passive process nor is culture

discrete and static; it must also be viewed in terms of change and active negotiation (Stairs 1994; Levinson, Foley and Holland 1996). Raymond Williams (as cited in Bauman 1977) proposed the concept of "emergent culture" as a way to dispel the notion that there is one unchanging tradition on which all knowledge and cultural practices can be hung.[4] Williams warns that looking back to the past frame of reference can serve to disqualify the "study of the creations of contemporary culture" (Williams, as cited in Bauman 1977:48). The concept of an "emergent culture" includes the idea that "new meanings and values, new practices, new significances and experiences are continually being created" (Williams, as cited in Bauman 1977:48).

The concept of emergent culture is important to conversations about Indigenous Ecological Knowledge and Aboriginal education. At the Association of Social Anthropologists conference in the Spring of 2000, a number of discussions arose around the actual definitions of "traditional ecological knowledge" and "indigenous knowledge", as well as the differentiation between "indigenous" knowledge and "local" knowledge. Many researchers have opted to use the term "Indigenous Knowledge" or "Local Knowledge" instead of "Traditional Ecological Knowledge" to better reflect the inherent cultural changes that have occurred, including the loss of land-based practices, and to recognize the difficulty of defining "traditional" (Snively and Corsiglia 1998). Indigenous peoples also see the word "traditional" as casting them in the past as antiquated cultures. Jerry Lipka, long time educator and researcher among the Yup'ik Eskimo of Alaska, notes the presumptuousness of those researchers who do not understand how Aboriginal peoples themselves view change:

> ... the modern world is extremely complex, and different indigenous groups are defining themselves in different ways. To assume that more

> 'traditional culture' is what people want is presumptuous. We believe that the long-term struggle of the Ciulistet and the inclusion of the elders shows that many elders are very interested in their traditional knowledge being transmitted, but they also realize quite strongly how the world has changed and the need for the Ciulistet teachers to find modern applications and uses for this knowledge. In a sense, schooling becomes part of cultural construction and evolution. (Lipka 1998:197)

Hess cites numerous studies of how scientific traditions themselves are emergent, or what he calls reconstructed, not only by various gender, cultural, ethnic, class and other groups, but by nations (Hess 1995:41, 48; also see Trujillo 1996:120). Hess draws on Claude Levi Straus's concept of *briccolage* (taking whatever materials are available to build our knowledge structures), as an image for how scientific traditions are reworked to fit specific socio-cultural traditions (Hess 1995:69).

Battiste indicates that Aboriginal education itself has undergone continuous reinvention throughout generations:

> Every generation of Aboriginal parents has had to reinvent "education" for its children. Every generation of Aboriginal peoples has had to struggle with the painful contradictions inherent in humankind's earthly situation. Aboriginal peoples have had to learn to be flexible and patient in their approach. In my generation, "Indian education" has become a particularly adaptable site for confronting the formal contradictions besetting Aboriginal consciousness within Canada. (Battiste 1995:vii)

For Battiste, Aboriginal peoples are faced with the question, "What does it mean to be an Aboriginal person?" (Battiste 2000:ix). This process of redefining, reinventing, and producing knowledge occurs in every generation. Battiste believes the old story of contradiction and pain is being gradually replaced by the emergence of "ongoing vitality of Aboriginal people, from whose experience we can learn" (Battiste 2000:ix).

Cultures everywhere are emerging from their historical past and merging with current realities in the way most fitting or most accessible for survival and well being.

For example, in the language of the Mi'kmaw people of Eastern Canada the term, *anku'kamkewey* was used for treaty. It means "to add more to" or "to dance further to"—a verb not a noun, a process not an end product. By "dance" I am interpreting the Mi'kmaq to mean creating change together in harmony and complementarity. When the treaty no longer served contemporary reality, it was "danced further to" or added to (Sable 1998).

In my own research of Mi'kmaw culture, I have postulated that everything was continually "sung and danced" into reality, much like the way that "songlines" of Australian Aboriginal peoples sang the Australian landscape into existence and showed people their paths across it (Sable 1998; Chatwin 1987). Singing and dancing are not necessarily just metaphors. Singing and dancing were how people came to know, to tune into, the world as it was manifested and changed. This was a way people gained knowledge and found their relationship to each other, the world, and the forces between them. This is not irrelevant to the teaching of science. To accommodate modern skills and knowledge, the new narrative for Aboriginal children may emerge with and through the identity-making forms and local knowledge they inherit.

Cultural Borderlands and Border Crossings

Not only is culture emergent but it shares ambiguous borderlands where people are often betwixt and between discrete identities. In response to a changing world including the rise of indigenous peoples calling for self-determination, the field of anthropology has undergone a major reorientation. Anthropologist Renato Rosaldo notes the shift since the 1960s away from the concept of culture as a discrete unit of shared patterns of meaning,

in which "processes of change and internal inconsistencies, conflicts and contradictions were considered annoying exceptions rather than central areas of inquiry" (Rosaldo 1989:28). Noting the limitations of this view, Rosaldo focuses on "zones of difference within and between cultures" (Rosaldo 1989:28):

> Analysts no longer seek out harmony and consensus to the exclusion of difference and inconsistency. For social analysis, cultural borderlands have moved from a marginal to a central place. In certain cases, such borders are literal. Encounters with "difference" now pervade everyday life in urban settings.... Borderlands surface not only at the boundaries of officially recognized cultural units, but also at less formal intersections, such as those of gender, age, status, and distinctive life experiences....We all cross such social boundaries in our daily lives. Encounters with cultural and related differences belong to all of us in our most mundane experiences, and not to a specialized domain of inquiry housed in an anthropology department. Yet the classic norms of anthropology have attended more to the unity of cultural wholes than to their myriad crossroads and borderlands. (Rosaldo 1989:28-29)

Rosemary Henze and Lauren Vanett have looked into the realities that face indigenous communities. They have tried to deconstruct an overly simplistic and, in their view, harmful metaphor often used to describe Aboriginal children learning western culture as walking in two worlds. Their research rapidly dispels the notion that there are two distinct worlds in which a person can walk comfortably as they note the lack of coherence in both the Yu'pik culture they studied and the western cultural influences encountered by the culture (Henze and Vanett 1993:119). In the authors' opinion, the metaphor has underlying and misleading assumptions that do not account for numerous variations in language, the amount of cultural traditions still present, conflicting messages they receive through numerous channels, as well as the lack of role models available to them in both Yu'pik traditions and Western ways (Henze and Vanett 1993:124).

Henze and Vanett believe the goal implied in the metaphor –to achieve success in two worlds – has become idealized and is unattainable. The reality they see facing indigenous students is that there are diverse worlds that coalesce. Therefore, the implicit assumption that it is possible to "walk" in both worlds, white and indigenous, sets students up for failure since these two worlds are non-existent as distinct entities. Ironically, the metaphor becomes a barrier rather than a model of how to live in the world today (Henze and Vanett 1993:123). Battiste and others seek an emerging new narrative, as opposed to idealizing a traditional and an alien narrative.

In his research and experience within his own community, Oscar Kawagley (1995), Yupiaq educator, sees the youth being swept up in the technologies that have inundated their world while trying to adopt values that accompany modern living as projected through the media. These youths also find themselves confronted with the ideals that are perpetuated in the non-Native educational systems they are required to attend. They often become confused and lost, neither finding identity in their cultural traditions nor the means to achieve the new but alien identities projected to them through the media and the education system.

Kawagley understands that this will not stop, and that the technologies that have become part of his community will not cease. He also recognizes that they have some use, but what use they have must be carefully assessed by the members of the community, and some informed decisions made before these technologies enter the community:

> From my perspective, it seems that each region needs to determine whether it is going to maintain a quasi-traditional lifestyle with only a few basic, culled-out Native values to mix with chosen outside values. This, of course, presupposes that the Native people exercise self-determination and

take on the responsibility to work for solutions to their own problems. (Kawagley 1995:109)

As an example of the variations within emerging Native cultures, I was told by a member of the community in which I was doing my research that I might have more success if I were to go to another reserve in Quebec. She said that in the Quebec community the language was more intact and the influences of non-Native culture less invasive than in her own community. This comment suggested that another reserve would be purer or more traditional, not swirling with mixed influences that were confusing the issues I sought to explore.

Similarly, while conducting research with an Innu community in Labrador regarding their cultural perception of the landscape, one man told me I would have to interview four generations to really comprehend their culture. The eldest members were those who directly lived and knew the traditions; the next generation down saw some of these traditions in practice; the next generation heard about them through their parents; and the youngest generation were now caught up in "white" traditions or were being swept up in a Pan-Indian identity. A number of times, Mi'kmaw elders have related how they don't like the singing and drumming of the younger generation, and that they feel the youth do not know the real meaning or context for these practices.

This discussion illustrates the complexity of the situation faced by indigenous peoples who seek a voice and representation within educational systems. In my own experience, I receive different messages depending on what community I am in or what individual I am speaking with. There are, for instance, a number of voices that do not see the "white" educational system in a harsh light. There are also many community members who do not necessarily agree with those in their culture taking political stands

on issues, or that their language and traditions need preservation. Others see no need for change within the dominant system, but are concerned with their children succeeding and surviving within the dominant society.

Border Crossings

The concept of culture and cultural border crossings has been relevant to education for some time (Aikenhead 1996:7). In 1992, Henry Giroux published *Border Crossings: Cultural Workers and the Politics of Education* in which he proposed his concept of "border pedagogy" as part of his radical educational theory (Giroux 1992:28). For Giroux, there must be a critical recognition of "those epistemological, political, cultural, and social margins that structure the language of history, power and difference" in which "those borders forged in domination can be challenged and redefined" (Giroux 1992:28). This requires that conditions be created within education for students to cross borders to understand the construction of "otherness" and to "create borderlands in which diverse cultural resources allow for the fashioning of new identities within existing configurations of power" (Giroux 1992:28).

In essence, Giroux challenges the boundaries of knowledge as institutionalized within Western education and calls for the necessity for students to understand multiple cultural identities, languages and narratives that define and limit reality, including their own (Giroux 1992:28-29). These multiple identities require border crossings from one context or one narrative to the next throughout our lives.

In terms of learning science, science educators, Glen Aikenhead and Olugbemiro J. Jegede, in looking at cross-cultural issues in science education, view the learning of science as one of border-crossing between different cultures and sub-cultures. Border

crossings occur wherever we move from one social community to another, between one micro-culture and another throughout our lives. Depending on the cultural and community background of the student, these border crossings into the "subculture of science" (Aikenhead 1996) can be smooth, manageable, hazardous or impossible (Aikenhead and Jegede 1999:6):

> Many border crossings are so smooth we don't notice, and occur when the cultures of family and science are congruent. When the cultures of families and school are congruent but different from the culture of science, border crossings tend to be manageable. In cases where the culture of the family and that of school are divergent, then the border crossing is hazardous and coping strategies are required. Border crossings become impossible when families and schools are highly discordant. In the context of students learning science O'Loughlin, Tobin and Lee argue that the language and conventional actions of many Euro-American teachers may be experienced as symbolic violence by students belonging to a different culture. (Aikenhead and Jegede 1999:6)

Aikenhead and Jegede further describe "collateral learning" as occurring when the learner has "two or more conflicting schemata held simultaneously in long-term memory" (Aikenhead and Jegede 1999:17). Three types of collateral learning are identified: parallel, secured, and dependent. They are descriptions of varying degrees of success students have in making a successful border crossing into the culture of science. Depending on which of type of collateral learning students encounter, their learning experience could range from total assimilation of the scientific material into their way of thinking to complete rejection and dropping out of science studies altogether.

"Parallel collateral learning" occurs at one extreme of the spectrum where no interaction between conflicting schemata occurs. Students will draw on one or the other depending on what is required for the context. "Secured collateral learning" occurs when conflicting schemata consciously interact and the conflict is resolved in some manner the

student finds satisfactory. The knowledge is integrated into the student's way of thinking on a conscious level. "Dependent collateral learning" occurs when a schema from one world view or domain of knowledge challenges another schema from a different world view or domain, to an extent that permits the student to modify existing schema. It is different from secured collateral learning in that students are often unaware of conflicting schemata. Dependent collateral learning is the process of acculturation in which "selected modification of currently held ideas and customs occurs under the influence of another culture" (Aikenhead and Jegede 1999:19). A fourth and uncommon type, "simultaneous collateral learning," involves a "situation in which a concept in one domain of knowledge can facilitate the learning a concept in another milieu" (Aikenhad and Jegede 1999:21).

Gloria Snively's work in British Columbia illustrates that scientific knowledge can be acquired and understood while maintaining the student's cultural world view if careful attention is paid to the student's cultural framework. She did this through careful planning of a project involving an Aboriginal youth, Luke, who interviewed elders from his community, respecting Luke's cultural environment and world view. In this case, Snively made the border crossing more manageable and thereby allowing Luke to learn seashore ecology while holding his own metaphor for life intact (Snively 1990).

Although the scope of this thesis does not include primary research on reverse border-crossing, I have previously questioned whether this "border crossing" for Aboriginal students into science could go the other way with non-Native students learning how to think as Luke did (Sable 1996:43-44, 47). Could Luke teach his fellow students to see the seashore from the perspective of his traditional way of knowing? Some Aboriginal people have been asking for this type of education for quite a long time:

> To say that the Lakota and Dakota see the world holistically as one spirit is not the same as to see the world that way. For another to see the world that way would require a kind of gestalt switch involving a shift in 'styles of reasoning' as well as ways of perception. It would entail responding to the world according to the exhortation: *Mitakuye oyasin* – "We are all related." (Meyer and Ramirez 1996:104)

F. Henry Lickers, Director of the Department of the Environment for the Mohawk Council of Akwesasne, provides a glimpse of what this type of "gestalt switch" would mean in his description of his own border crossing into the culture of school science:

> And what I'll say to you is this: when I was living at Akwesasne with my grandfather, I came home to him during my fourth year of university, and I was very worried. I'd spent four years in school, learning ecology, learning biology, and I was afraid that I was losing my own traditional ideas and how they work together. I said, "Grandfather, I'm really worried, I want to drop out of university. I'm trying to tell these people how we think, and every time I do, somebody tells me it's wrong. Every time I say something about our knowledge and how our knowledge operates, somebody tells me it's not right, but I know in my heart that these are the ways things operate, and that's the way they should be."
>
> And he said to me, "Henry," he said, "let's just talk about that then." So we were sitting there.
>
> "When you're working at a table, and you're working on your science," he said, "what are you doing?"
>
> I said, "Well, Granddad, I've got numbers, you know, and we're showing trends and how things operate."
>
> He said, "What does that tell you?"
>
> I said, "Well, it describes the way in which the world operates."
>
> And he said, "I see you draw these graphs, like this. I'll tell you what's happening. What you're seeing is the dance of numbers. The numbers dance across their page, and as they dance, that dance tells you the way in which the world operates. The problem with Western science and the Western people is that as the scientists look at the dance of numbers, they have no music, and that's a pretty tough thing to do. Can you imagine trying to dance with no music? Really tough." He said, "But Henry, you have an advantage, and the advantage that you have, is that you have the sound of the drum, and that sound of the drum is the sound of the spirit of

> the world that operates around you. So, what you have to do, is take that dance of the numbers, and combine that with the sound of the drum, and sing this to as many scientists as you can, so that they can hear that wonderful voice as well." (Lickers 2001:12-13)

In this case, it was Lickers' own grandfather who made this crossing manageable by providing a "god" or "narrative" that gave meaning to his learning; but the fragility of the process is striking.

The theories of borderlands and border crossings are relevant to this thesis in a number of ways. First, the concept of borders, border crossings, and boundaries are an important component to understanding the creation of avenues of communication between different cultures. I have applied this concept in discussing the interviews with the students as a means to reveal what students perceive as borders – personal, cultural and societal – and how this affects their learning. For Aikenhead and Jegede, the level of cognitive conflict experienced by the students' experiences, such as Lickers describes, determines how effective their learning of science will be.

Second, many Aboriginal communities are highly concerned with both defining and asserting boundaries of their identity through a number of efforts, e.g., language revitalization, legal cases involving land claims, re-institution of traditional practices, and the research of traditional knowledge. Simultaneously, these communities are trying to facilitate the successful transition of their children into the surrounding community schools and organizations in hopes of bettering their career opportunities (Cleary and Peacock 1998; Lipka, Mohatt and The Ciulistet Group 1998).

At these perceived borders, some sort of mediation in the form of dialogue could occur. The whole issue of territory (or identity) is fundamental to curriculum design or any model we develop for cross-cultural communication. Mi'kmaw acquaintances have

told me a number of times that they just want to be seen as people by those who are not from their community. Because of the complexity of the situation, multiple conditions bear on each situation, requiring a dialogue to work with "people as people" and to come to understand what is most appropriate in each situation.

Networks of Meaning: Learning Models and the Role of Identity

Pedagogy within the past decade has been dominated by constructivism, as evidenced in *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum* (Council of Ministers of Education, Canada 1997). Within constructivism there are variations and debates, but a main concern of the constructivist program is with "understanding how students engage with particular science content, and the nature of the relationship between the learner's prior knowledge and the learning environment" (Erickson 2000:278). In so doing, the students' conceptual frameworks are taken into account and these frameworks are gradually transformed into scientific ones through well planned teaching strategies and sequential instruction (Erickson 2000:278-280).

My Master's thesis (1996), was critical of the constructivist goal of progressively changing a student's conceptions of the world "towards a more sophisticated formal and coherent knowledge structure," and that "sometimes they may have to 'unlearn' in order to continue to learn" (Driver and Bell 1986:454). Similarly, Kyle and Shymansky's Generative Learning Model sought to "enable the learner to construct meaning" (Kyle and Shymansky 1988:7). I questioned these approaches because of their view that children held misconceptions of reality that needed to be corrected or replaced with new

frameworks of scientific thinking. The scientific conceptual framework was the preferred conception of reality. The idea of replacing one conceptual structure with another one deemed more sophisticated and correct did not seem appropriate to current cultural concerns. A more profound view is necessary.

To a degree, social and cultural constructivists developing science curriculum could accommodate the concepts of border crossing, production of knowledge, and the emerging nature of culture. Social and cultural aspects of learning have been recognized in their evolving mental models of the learner (Erickson 2000:280; Stairs 1994:156). "Situated cognition" and other schools of constructivism present learning as "a continuously dynamic participatory process" (Stairs 1994:156). For instance, Arlene Stairs' concept of cultural negotiation "redefines education as culture-in-the-making at multiple levels. School becomes a forum for negotiation among surrounding cultures, between itself and the community, and in the personal negotiations of students with their cultural worlds, including the school culture, as they construct and reconstruct identity" (Stairs 1994:156).

However, at the core of constructivist thought remains the assumption of internal mental models as a representation of an independently existing external world (Erickson 2000:284). From the perspective of some Aboriginal cultures, this assumption is questionable, if not in direct conflict. Gregory Cajete describes the path of knowing as a multi-dimensional journey versus what he perceives as an outward journey taught in the western educational system:

> Objectivist research has contributed a dimension of insight, but it has substantial limitations in the multidimensional, holistic, and relational reality of the education of Indian people. It is the affective elements--the subjective experience and observations, the communal relationships, the

> artistic and mythical dimensions, the ritual and ceremony, the sacred ecology, the psychological and spiritual orientations that have characterized and formed Indigenous education since time immemorial. These dimensions and their inherent result have been given little credence in mainstream approaches to education and research. Yet, it is these aspects of indigenous orientation that form a profound context for learning through exploring the multidimensional relationships between humans and their inner and outer worlds. (Cajete 1994:20)

In light of these and other criticisms of constructivism,[5] together with the general call among indigenous peoples and researchers for a new educational paradigm, I am proposing that a phenomenological approach toward learning would be more appropriate. It is because of the complex and multiple layers of reality that students face – personal, cultural, institutional, societal/systemic – that I examine how the students themselves experience these layers of reality in webs of significance, multiple contexts, and emerging identity.

Some may see Aboriginal world views as a retreat to a faith-based world view and the antithesis of "science." Science, as it has been taught in the modern classroom, assumes duality of self-other, mind-body, and subject-object relationships. In the opinion of Jeremy Hayward and Francisco Varela, when you question objectivity, then you are thrown back on perception being subjective, and perception becomes an invention of the mind. "Why are we stuck with only these two alternative extremes of subjectivity and objectivity? Deeply rooted in Western thinking is a belief in the duality of mind and matter, subject and object" (Hayward and Varela 1992:14).

The first step is to understand how the students experience the world itself. In my analysis, I will also be looking at their perceptions/experiences of the world – how they layer reality and move in, out, around or away from different contexts.

A Phenomenological Approach

Recent efforts in cognitive science and phenomenology are shifting the focus of research from the individual as the cognizing agent in the construction of knowledge to a more non-dualistic model of knowledge creation (Erickson 2000:281). Phenomenologists are re-focusing the research on the relationship between the individual and their world and proposing a more non-dualistic or co-emerging model of knowledge creation which looks first at experience (Erickson 2000:280):

> For phenomenologists, learning is not an act of construction of mental structures, but rather consists of a set of relationships between the learner and the world. One of the tasks of phenomenological researchers, then, is to focus on illuminating the nature of these relationships....At the centre of phenomenological approaches is a commitment to understanding how people experience the world and learn to act in the world. This perspective on learning is different from that of the Piagetian and constructivist programmes in that these earlier programmes posited an independent, external world and that learners progressively develop or construct more sophisticated internal models of that world. However, the phenomenological programme rejects this notion of a person-world dualism. (Erickson 2000:281)

The phenomenological approach offers a reevaluation of the importance of experience and the issue of objectivism. For Francisco Varela, renowned cognitive scientist who draws on phenomenology and his background in Buddhist philosophy, the importance of first person experience must be taken seriously in the study of consciousness, and by implication learning. More examination of first-person experience is necessary. It has been largely bypassed as a proper domain for science (Varela 1996:2).

From Varela's point of view, the concept that we, as individual cognizers of the world, form internal representations of the world is incorrect. Alternatively, he proposes the "enactive viewpoint" which is "whatever you know is not separable from what you do. So you don't encounter the world; the world and you as knower shape each other, you

are mutually interdependent" (Varela 1996:3).

This more inclusive view provides a foundation that could truly accommodate other world views, in particular those of Aboriginal communities. This is not a denial of science itself but rather points to the importance of the experience of those learning it. Ference Marton, science educator and phenomenographer, concurs (phenomenography is similar to phenomenology but distinct in its purpose) (Marton 1996:193). He purports that conceiving of or experiencing something is not a "mental representation or a cognitive structure. It is a way of being aware of something" (Marton 1996):

> Awareness is a relation between subject and object. Furthermore, when something is the object of attention it is always seen, or thought about or whatever, in some way, by somebody. We simply cannot deal with an object without experiencing or conceptualizing it in some way. In this sense subject and object are not independent, but they form a unity; there is a relation between them which can be called their internal relation. Subject and object are what they are in relation to each other. Following from this, a way of experiencing or understanding a phenomenon says as much about the experienced, understood phenomenon as it says about the experiencing, understanding subject. (Marton 1996)

Learning, for Marton and colleague Shirley Booth, is "coming to experience, and subsequently *to see,* the world in different ways... rather than constructing representations of the world" (Marton and Booth, as cited in Erickson 2000:282). This approach is not limited by rigid categorization and descriptions (borders) of cognitive functioning, but rather seeks to map and describe the variability of relationships and experiences an individual has within any setting.

We are in a continual relationship within multiple levels of conditions, and, as Varela points out, consciousness and experience are not private – they are not something that is truly constructed in our own separate corner (Varela 2000:10):

A phenomenologically inclined cognitive scientist reflecting on the origins

> of cognition might reason thus: Minds awaken in a world. We did not design our world. We simply found ourselves with it; we awake both to ourselves and to the world we inhabit. We come to reflect on that world as we grow and live. We reflect on a world that is not made, but found, and yet it is also our structure that enables us to reflect upon this world. Thus in reflection we find ourselves in a circle; we are in a world that seems to be there before reflection begins, but that world is not separate from us. (Varela, as cited in Erickson 2000:282)

The phenomenological approach is intriguing in that the main focus is on the relational:

> The goals of phenomenology are other than those of normal science; it is supposed to be propaedeutic to the latter. According to the basic tenets of phenomenology, all knowledge and hence all scientific knowledge, is rooted in our immediate experience of the world. It is the task of phenomenology to depict the basic structure of our experience of various aspects of reality to make us conscious of what the world was like before we learned how to see it. (Marton 1996:193)

Children exist in an increasingly multi-cultural world. The aim of employing a phenomenological approach is to enhance students' capabilities to appreciate different ways of experiencing the world and to recognize which ways are most appropriate for the context or purpose at hand (Erickson 2000:284). "Learning requires a change in one's capability to experience phenomenon" (Erickson 2000:283). In other words, education needs to provide the conditions in which students can appreciate variability of how they and others conceive of their experience of the world (Tullberg, Stromdahl and Lybeck 1994).

Identity and Learning

At this point, the phenomenological alternative requires that we look at the whole notion of identity and its relationship to learning. Arlene Stairs notes how the "the construction of identity has also been equated with learning" (Stairs 1994:165). She cites an example of an Inuk colleague who described how her adolescent Inuit students, despite being taught about traditional Inuk tools, had no awareness of the values or right relationships associated with

the use of the tools. The values and relationships associated with the tools could be taught in relationship to any modern day tools such as computers, "but the students were not relating actively to either in terms of their own decisions, responsibility, and futures."

> School for these modern adolescent Inuit must engage them in the questions of who they are and where they are going, questions of present identity and "future pictures"...before they will actively attend either to stories of the elders or modern secondary curricula. It is this dimension of engagement in the cultural negotiation of education, to depths of relationship and identity which we label process...The process dimension concerns the move from meaning to meaning-making, and ultimately to culture-making. As an example, negotiation at the initial language level in our model can result in a superficial process of introducing add-on "cultural inclusion" indigenous language classes once or twice a week, unrelated to and with no effect on other school programs. On the other hand, it can result in the deep process of elder and community involvement, collective efforts at language renewal, and the strengthening of local indigenous identity around the language, its use, and the cultural values it uniquely conveys. (Stairs 1994:165)

Stairs establishes the need for educators to attend to identity formation. Francisco Varela speaks in terms of "fragile ontologies", a phrase that encapsulates the insubstantial nature of identity formation. Varela posits there is no central, stable, locatable self: "since it is not within the head, since it is not just in language. It's none of those dimensions, it's somehow in a figure of multiple levels of emergence, but it is always fragile....These emergences occur within the social emergence of human life" (Varela 2000:12-13). Or, one could say, self co-emerges with social life.

Varela likens this notion of constant emergence, this multi-leveled, fragile process of identity formation, to describing a cloud or turbulence, which is more the arising of a pattern. Self, in this case, is like transitory, emerging patterns with which we then identify (Varela 1996:6). He also uses recent biological discoveries in evolution to illustrate that natural selection involves a multiplicity of factors and conditions, not one unit of

selection. "Life is individual, but it is also historically determined by the components that form it. It is essentially a pattern of life – the entire biosphere" (Varela, 2000:13).

This view is almost identical to what I found within the ancient Mi'kmaw culture (Sable 1996, 1998). Looking at the language and legends, the world is expressed as "in process," in flux, becoming and continually shape changing. From a videotaped discussion on the Mi'kmaw language I organized with linguists Doug Smith and Bernie Francis, Doug Smith articulated the difference between the Mi'kmaw language and English. When I asked, "Can you tell me what is unique about the Mi'kmaw language in the sense of how it might express the experience of reality differently than the English language?" he replied:

> You mentioned the verb-like quality of Mi'kmaw and that it reflects the Mi'kmaw world view, where the world is perceived primarily as flow, flux, or movement, as opposed to the Indo-European noun-centered languages which objectify the world and turn the world into objects which can then be analyzed. These objects can be gotten hold of, taken apart, and put back together, and treated as things as opposed to movements. In the Mi'kmaw language there is an inherent dynamism or movement that Mi'kmaw speakers themselves are always aware of. Whereas in English we tend to be more aware of nouns. We are a thing-oriented society rather than a movement-oriented society. (Smith 1994)

Vine Deloria, Jr., a Standing Rock Sioux and professor at Colorado University, describes the world as a unified whole:

> The realization that the world, and all its possible experiences, constitutes a social reality, a fabric of life in which everything had the possibility of intimate knowing relationships because, ultimately, everything was related. This world was a unified world, a far cry from the disjointed and sterile world painted by western science. (Deloria, as cited in MacIvor 1995:75)

If one contemplates Aikenhead and Jegede's concept of collateral learning, fragile ontologies are present if we consider secured, dependent and parallel types of collateral learning as ways a student forms relationships with the culture of science. Students,

whether consciously or unconsciously, are in an active mode of relating to the culture of science or choosing not to relate all the time. Again the notion of fragile ontologies, or identity formation, comes in. Personal, cultural, and social identity cannot be separated, and as they evolve, they strongly affect the ground for learning.

The ability of students to integrate scientific knowledge is also about how each student forms a relationship to the scientific content within a specific context. Part of this fragility has to do with the spectrum of feelings students experience depending on whether they feel nurtured, threatened or disinterested. The students are therefore engaged in a continual process of consciously and unconsciously questioning, reevaluating, and testing. At the deepest level, the continual questioning is based in a fundamental uncertainty. This same process underlies science in the making, as stated in *Benchmarks*:

> ... scientific knowledge is always open to improvement and can never be declared absolutely certain. In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to an increasingly better understanding of how things work in the world but not to absolute truth. (AAAS 1993:8)
>
> Indeed, as students move through school, they should be encouraged to ask over and over, "how do we know that's true?" (AAAS 1993:4)

The concept of a variable, continually emerging and interrelated reality is ancient and can be seen in Asian and Native North American cultures. In my Master's thesis (Sable 1996), I discussed the multi-layered and interdependent nature of reality that was expressed and encapsulated in Mi'kmaw language, legends, songs and dances.

Toward a Culturally Interactive Pedagogy

If we return to Hampton's criteria for Aboriginal education, he begins with spirituality as the first standard. Hampton is looking at the student finding his or her own place in the

world, as part of a network of relationships, and experiencing an "unalienated self" (Hampton 1995:19). Spirituality, then, is simply defined as the student's experience of relatedness, or interdependence. This corresponds to Varela's sense of a dynamic self.

The concept of spirituality involves the notion of relatedness or interdependence, taking care of relations. Suspending our preconceptions and looking at the patterns of relating we have fallen into in our world takes hard work. The more we can understand the notion of a "fragile self" (this should not be confused with weakness) the more we are able to understand the interrelated aspect of existence. The more we can understand this connectedness, the more we are able to come to know the world and accommodate its variability:

> The more there is the opening into space to accommodate or to take care of the other, there is kind of an intrinsic decenteredness, and therefore the other appears as closer. Solidarity, compassion, care, love--all of the different modes of being together--appear when the self owned is decentered. Now that to me, is kind of a great gift of the universe. Since we are not solid and private and centered, the more we get close to all our reality, the more in fact that means that we're more who we are. That is both you and I. (Varela 2000:14)

The space that Varela mentions can also be accessed by looking at our borderlands and where these boundaries around identity arise. When we look closely, these borders shift depending on contexts, again coming back to the notion of cultural borderlands (Rosaldo 1989). Borders are relative to how we are experiencing the world in a particular situation, and based on that experience, our relationship to them. Realizing the interconnected and relative nature of experience can become the basis of cross-cultural communication and learning. Communication, then, occurs when we recognize that the borders we create are porous, not solid. From the point of view of designing a culturally interactive science curriculum, it is essential to come to know the perceived

borders of our identity as teachers, as well as those of the students. This is the point where suspension, letting go, and redirection can occur. To do this requires we create the space to open up a dialogue through which these relationships can be clarified.

Creating a Culturally Interactive Pedagogy: Opening the Borders

To science educator, Richard Duschl, the most crucial aspect in science education requires an "epistemological break" with common sense (Duschl 2000:192). In his opinion, educators to date have failed to assist students in making the epistemological break crucial to understanding the nature of science:

> The educational path to understanding the nature of science is a path that requires an epistemological break with all common sense, or what I refer to as a boundary crossing from sense perception 'folk explanations' to theory-driven science explanations. The evidence from [other writers]...suggests that in spite of years of science education, we have failed in helping our pupils make the epistemic break and boundary crossing. (Duschl 2000:192)

According to Duschl, science in the twentieth century has come to rely much less on

> ... information from direct sense perception and more on complex instruments, technological devices, experimental designs and inferential reasoning practices.... Over time, the cumulative effect of these refinements and extensions has created a break from common-sense perceptions and common sense explanations... the epistemological break with common sense. (Duschl 2000:191)

For Duschl, the problem with current science education is that there is an imbalance in "instruction between the use of scientific instruments and the opportunities to use and develop a scientific language.....The epistemic break with common sense, the boundary crossing, requires the refinement and extension of the discriminating language" (Duschl 2000:193 &195).

Duschl delineates three "important transformations in moving from the raw data

of observation, investigation and experimentation to the theories and explanations that account for the data" (Duschl 2000:190). These three transformations are preceded by decisions (informed by theoretical commitments and ideas) about what data to collect. Transformation 1 involves evaluating what raw data becomes the selected data evidence. Transformation 2 involves evaluating how the evidence can be manipulated to locate patterns and models in the selected data. Transformation 3 involves evaluating how the patterns and models fit, or do not fit, scientific theories and explanations. This complex relationship between evidence and explanation, or observation and theory, in science warrants an explicit examination of three domains of criteria:

1) criteria for assigning data to one of four categories: fact, artefact, irrelevant or anomalous;
2) criteria for identifying and representing patterns/models in selected data; and
3) criteria for generating theories or explanations to account for the patterns/models (Duschl 2000:190).

Drawing from the research of Rosalind Driver, he notes the lack of "conversations about data texts" in classrooms, which would assist students in understanding the relationships between theory and observation, and evidence and data, or the stages of transformation he outlined (Duschl 2000:192). To facilitate an "epistemic break" with common sense, he proposes engaging students in conversations at transformation stages in the journey from data to theory. This approach puts more demands on teachers to listen with an analytical ear to the students' discourse to determine what kind of discriminations they are making and whether or not it follows scientific thinking (192). He supports instructional sequences that involve students in both the investigative aspect and conversations about the investigation or "speaking together opportunities" (195). These

conversations allow students to share data and their different perspectives of the data, to work together on presentation and display of the data for further discussion, as well as the opportunity to reflect upon and assess the data. Instruction is so designed to provide diverse experiences and diverse outcomes with the overall goal of refining students' scientific language and ways of thinking (195).

Duschl refers to this process of conversing about the learning of science at these transformation boundaries as the "dialectic between data and theory" (Duschl 2000:192), a conversation he sees missing in education. It is within this type of conversation, within an overall sequenced instructional design, that a crucial engagement in understanding the nature of science occurs. This process takes students beyond just the doing of science.

Duschl also proposes more time is needed for approaching science to include "speaking together" models, which help make the process of learning more visible to teachers and students. "The allocation of time affords opportunities for learners to investigate, construct and evaluate both the knowledge claims and criteria used to answer a question, solve a problem, or pose and explanation or model" (Duschl 2000:202).

Whether or not we accept Duschl's concept of an epistemic break requires a deeper level of research than is being presented here, but one that does need investigation. What is relevant to developing a culturally interactive science curriculum is his proposed "speaking together opportunities....for learners to investigate, construct and evaluate both the knowledge aims and criteria" (Duschl 2000:195 & 202). This approach, if put together with the goal of *Benchmarks*—that science teaching is to teach the processes of scientific research or how scientists go about their work and reach scientific conclusions (AAAS 1993:3), along with the limitations that arise in these processes and

the conclusions derived from such processes—could be an intriguing opportunity for a cross-cultural dialogue.

Criteria for Assigning Data

As an example, the assigning of data to one of the four categories outlined by Duschl– fact, artefact, irrelevant or anomalous – is a process we could use to discuss other cultural practices for determining criteria. Deloria describes how different cultures determine criteria for what is considered data:

> The first question to be asked, prior to a comparison of the results is how the two groups gathered information. What makes the data that each group considers in making decisions about the natural world reliable either in their own eyes or in the view of impartial observers? The initial approach to experience, the process by which we identify data as important or irrelevant determines how we choose to connect experiences with facts. We formulate the subsequent patterns of arrangement and interpretation which we impose on experience after this initial identification. (Deloria 1992:3)

As an example, Deloria describes the differences and similarities about how scientists might approach research on buffalo herds, noting the inclusion of indicators and sources of information, including dreams and visions that scientists would not permit in their criteria (Deloria 1992:3). Both approaches, however, would locate the herds.

As another example, Biologist Robert Stephenson noted, from his studies of wolves in northern Alaska, that the Nunamiut are willing to attribute more importance to individual variation and to volition than biologists. As witnessed in the following quotation, the Nunamiut had criteria for seeing some wolf behaviour as foolish, and other behavior as significant, while scientists might see what is significant to the Nunamiut as anecdotal, or what is foolish as adaptive:

> The Nunamiut...believe that some decisions wolves make are likely to be foolish, inefficient, or ambiguous of interpretation. In contrast, it appears

> that biologists and even more so, the wildlife-oriented public, look for adaptive value in most details of animal behaviour. The wolves I observed did many things that Western science normally refers to as anecdotal behaviour, but which the Nunamiut believed contained rather significant behaviour. (Stephenson, as cited in Canadian Environmental Research Council 1991:9)

Individual idiosyncrasies, the report continues, are difficult to quantify. In Stephenson's work, he noted that generalized knowledge can interfere with direct observation, and that anomalous behaviour can be as important as general behaviour patterns (Stephenson, as cited in Canadian Environmental Research Council 1991:9). In contrast, quantification is an important component of Western science. It permits measurement, which in turn substantiates theory and allows control of the subject material within a scientific paradigm.

One sees that observation is also fundamental to accruing information for the Nunamiut hunters, the first step in the scientific method of western science. A difference, however, lies in a lack of a prevailing theory which can restrict or screen information gathering, as seen in Stephenson's work. The hunters are concerned with understanding as much as possible about the habits of the animals, and these habits are understood to be potentially idiosyncratic. On a purely practical level, these idiosyncrasies could alter a person's ability to survive. Thus, there is no ultimate confirmation but there is knowledge of possibilities. Furthermore, no observations are discounted, whether multiple or single, enhancing the hunter's awareness of possibilities versus probabilities.

Duschl's "speaking together" opportunities are methods by which the students undertake diverse avenues of inquiry and are provided with times for "speaking together" (Duschl 2000:195) to discuss and debate their insights, methods, models and conclusions. Much of his pedagogical suggestions are about making the nature of science and the

scientific process more explicit (192).

The whole concept of teaching as communication on multiple levels must be understood from the point of view of student's learning. Many students are finding both emotional and cognitive borders in their daily learning experience, without time to explore the nature of these experiences in their learning of science. Expanding these "speaking together" opportunities at the transformation points or boundaries to include a wider cultural dialogue would engage students and teachers in looking at these perceived boundaries. It would assist in discriminating what science is and is not, and the reasons for choosing one way over another for perceiving reality. This approach could help fulfill some of the Science Technology and Society (STS) vision and assist students to grow up to be contributors both to their own and the larger society with a sense of their own cultural identity, or and "unalienated self" (Hampton 1995:19).

Conclusion

I began this chapter with a discussion on how science and scientific literacy are being presented in flagship documents produced in Canada and the U.S.A. The notion of science as a "way of knowing" and as an "adventure story" articulated by the authors of *Benchmarks* (AAAS, 1993) provides an opening for the creation of a new narrative in education that could accommodate other ways of knowing. Specifically, I looked at how some Aboriginal educators are calling for a "new story" that better meets the needs of Aboriginal children. Part of creating this new narrative is to recognize knowledge as a cultural production as seen in the work of Eber Hampton and in the use of the Medicine Wheel in Aboriginal peoples' education. This concept views knowledge as a process of negotiation, one based on cultural, historical, and social factors that come to bear on each

community's definition of who they are and what knowledge is pertinent to survival. A crucial characteristic of this production of knowledge is the emergent nature of cultures, a concept important to understand the fluidity of knowledge production and the ongoing nature of the process. This fluidity, as well as uncertainty, is supported by Rosaldo's concept of borderlands and Aikenhead and Jegede's use of the concept of "border crossing." I posited that borders are not solid, and I drew upon the current research in phenomenology and cognitive science as well as Francisco Varela's concept of the emergence of a virtual self and fragile ontologies. The process of an emerging and interrelated self, as opposed to the assumptions we make about individuality, was reviewed in light of establishing the ground for a culturally interactive paradigm of learning. This paradigm is founded on the notion of experience being based on networks of relationships or the interrelated aspect of our existence. Understanding this interrelatedness is the foundation for developing a culturally interactive pedagogy. Taken into the classroom, I suggested this interactive paradigm could be explored by adapting such pedagogical methods as Richard Duschl's "speaking together" times, in which students could explore the processes of doing science while appreciating their own cultural traditions.

Endnotes

1. These are *Benchmarks for Scientific Literacy (Project 2061)* published by the American Association for the Advancement of Science (1993); *National Science Education Standards* published by the National Research Council (1996); *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum* published by the Council of Ministers of Education, Canada (1997); and a provincial version of *Common Frameworks* published by the New Brunswick Department of Education (1998) entitled, *Foundation for the Atlantic Canada Science Curriculum.*

2. At Saint Mary's University, Halifax, Nova Scotia a Centre for Spirituality in Business is being established. Other organizations, such as Contemplative Mind in Society in Amherst, Massachusetts, are investigating the role of contemplation and spirituality in education.

3. Geertz made note of Anthropologist Clyde Kluckholm's numerous definitions of culture. "In some twenty-seven pages of his chapter on the concept (of culture), Kluckhohn managed to define culture in turn as: 1) 'the total way of life of a people'; 2) 'the social legacy the individual acquires from his group'; 3) 'a way of thinking, feeling, and believing'; 4) 'an abstraction from behavior'; 5) 'a theory on the part of the anthropologist about the way in which a group of people in fact behave'; 6) a 'store-house of pooled learning'; 7) 'a set of standardized orientations to recurrent problems'; 8) 'learned behavior'; 9) 'a mechanism for the normative regulation of behavior'; 10) 'a set of techniques for adjusting both to the external environment and other men'; 11) 'a precipitate of history'; and turning, perhaps in desperation, to similes, as a map, as a sieve, and as a matrix. In the face of this sort of theoretical diffusion, even a somewhat constricted and not entirely standard concept of culture, which is at least internally coherent and more important, which has a definable argument to make is (as, to be fair, Kluckhohn himself keenly realized) an improvement" (Geertz 1973:4-5).

4. Williams defines "residual culture" as those "experiences, meanings and values which cannot be verified or cannot be expressed in terms of the dominant culture, [but] are nevertheless lived and practiced on the basis of the residue – cultural as well as social – of some previous social formation... cultural elements may become part of a residual culture as a part of a continual social process, and parts of residual culture may be incorporated into the dominant culture in a complementary process (Williams, as cited in Bauman 1977:47-48). Anthropologist Paul Sillitoe, from the University of London, critiques the use of "residual" as questionable. In a personal conversation, Sillitoe commented that residual means tacked on or leftover at the end, and finds this a poor choice of words to describe aspects of culture that have been in use for hundreds or thousands of years. For this reason, I am using only Williams "emergent culture" concept.

5. Other criticism of the constructivist approach has included lack of agreement on descriptive language, lack of results showing improvement in scientific learning, lack of congruency between constructivist research into individual construction of knowledge with real classroom settings; questions about the stability of conceptions; and overly rational models that exclude affective factors in cognition (Erickson 2000:279).

Chapter Three

Methods of Research and Description of Study

The multilayered nature of this research required a combination of phenomenological and ethnographic methods. A phenomenological approach was used to understand the first research question – to what extent do Mi'kmaw students hold multiple world views that influence their learning of science and move back and forth between these views to suit the context in which they find themselves? Interviews with the students were used as the primary source for unearthing thematic patterns, or "webs of significance," that guide the students thinking and inform their identity. I drew on Max van Manen's phenomenological methods of analysis for the interviews, along with Francisco Varela's interview strategy. The second research question – what would be the characteristics of a culturally interactive curriculum designed to support and use multiple world views – was addressed through the literature review and discussions with both Aboriginal and non-Aboriginal educators. The third research questions – how do grade 7/8 Mi'kmaw students respond to a culturally interactive science lesson – was addressed through a micro-ethnographic study of the "culture" of the classroom and two field trips led by Steven Ginnish, a silviculturalist and forest manager for the reserve.

Ethnographic Methods

As is true of the definition of culture, the definition of ethnography cuts a fairly wide swath. Broadly defined, ethnography is a "description of a particular culture. It is an anthropologist's written or filmed description of a particular culture" (Schultz and Lavenda 1995:13). It is an aspect of anthropology that is concerned with both the

diversity of culture and with defining culture itself (van Manen 1990:13).

Paul Atkinson and Martyn Hammersley provide a more comprehensive definition:

> Definition of the term ethnography has been subject to controversy. For some, it refers to a philosophical paradigm to which one makes a total commitment, for others it designates a method that one uses as and when appropriate. And, of course, there are positions between these extremes. In practical terms, ethnography usually refers to forms of social research having substantial number of the following features:
>
> - strong emphasis on exploring the nature of particular social phenomena, rather than setting out to test hypotheses about them;
> - tendency to work primarily with "unstructured" data, that is data that have not been coded at the point of data collection in terms of a closed set of analytic categories;
> - investigation of a small number of cases, perhaps just one case, in detail; and
> - analysis of data that involves explicit interpretation of the meanings and functions of human actions, the product of which mainly takes the form of verbal descriptions and explanations, with quantification and statistical analysis playing a subordinate role at most. (Atkinson and Hammersley 1994:250)

Ethnographic fieldwork is based on participant observation which requires interacting with members of the culture in which the research is taking place. As reflected in Paul Rabinow's description of "dialectical holism" (see Schultz and Lavenda 1995:358), interest in social scientific fieldwork is increasingly turning to phenomenology and hermeneutics, "philosophies that blur if they do not demolish the subject object distinction so central to traditional ethnography" (van Manen 1990:34):

> To gather data about a culture, anthropologists are obliged to interact closely with the sources of that data: their informants. As a result, field data are not subjective but intersubjective: they are the product of long dialogues between researcher and informant. These dialogues are often patient and painstaking collaborative attempts to sort things out, to piece things together. When successful, the outcome is a new understanding of the world that both anthropologists and informant can share. Recognizing the humanity of one's informants in this way has nothing to do with trying, through sheer imagination, to reproduce the inner psychological states of those informants – which is what positivists have often accused their critics of trying to do. Such an imaginative effort, assuming it is possible, is solitary, whereas fieldwork is a dialogue. The focus of fieldwork is the range of

> intersubjective meanings that informants share. Fieldworkers can come to understand these meanings by sharing activities and conversations with their informants. That is what participant-observation is all about. (Schultz and Lavenda 1995:354-355)

In Chapter One, I discussed Paul Rabinow's use of the phrase, "dialectic of fieldwork" to describe "dialectical holism," or how the mutual construction of meaning occurs between "cultural self" and "cultural other" to create an "intersubjective symbolic language" (Rabinow, as cited in Schultz and Lavenda 1995:358). To create this deep level of communication, it is necessary for a process of questioning, reflecting upon one's own thinking about how things are perceived and experienced (reflexivity), and interpreting one another to occur until some mutual ground of meaning is established. Gradually, over time, "intersections in possible ways of understanding and describing the same strips of behavior" evolve (Schultz and Lavenda 1995:358). Both the researcher and those within the culture are active participants in the process, causing and affecting the other's way of thinking about how she or he thinks, and both are actively making decisions about whatever knowledge emerges from this process.

Integral to my research was to understand the socio-cultural aspect of the students' lives as Mi'kmaq, and how that aspect affected their sense of identity and world view and their "border-crossing" into the culture of science within a school setting. In my case, I strove to find intersections of meaning and mutual interests within my interviews with the students and, to varying degrees, with the teacher and Steven Ginnish, the forest manager with whom I worked on field projects for the students. In our discussions of the classroom research, the field trips, and the pilot curriculum project, I further attempted to understand the students' experience beyond the socio-cultural dimension to the more fundamental question of how the students considered themselves as individuals. To

understand their experience as individuals, and how they related to multiple influences affecting their learning of sciences, I turned to phenomenological methods as articulated by Max van Manen.

Phenomenological Methods

Educator Max van Manen notes that phenomenological research is similar to ethnography in the means of gathering data – interviewing, participant-observation, document analysis, and so forth. However, phenomenology goes beyond documenting the subjective experiences of people or groups of participants, to the deeper question of "what is the nature of this phenomenon...as an essentially human experience?" (van Manen 1990:62):

> Phenomenology is less concerned with the facticity of the psychological, sociological, or cultural peculiarities or differences of the meaning structures of human experience. (van Manen 1990:40)
>
> To bring the difference between phenomenology and other so-called qualitative research approaches (such as ethnography, ethnomethodology, symbolic interactionism, conceptual analysis, biography, etc.) better into focus, we should recognize the force of the essential phenomenological question. No matter how any particular parent (or group of parents) relates to a child, we always want to know: How is this parenting? Is this what it is like to parent? Is this what it means to be a mother or father? (van Manen 1990:62-63)

Van Manen regards phenomenological questions as core to research and to understanding the human experience of the phenomenon being studied (such as parenting in his own research). Phenonomenology is not concerned with culture *per se* but with human experience. It is driven by a research question oriented toward understanding the "full significance of some aspect of human experience, in the context of the whole human experience" (van Manen 1990:63). The focus is on a "human phenomenon" and the data

gathering should focus on the "meaning of the experience," which in this case, is the essence of being a Mi'kmaw teenager learning science in today's world.

According to van Manen, a research method is only a way of investigating certain kinds of questions:

> The questions themselves and the way one understands the questions are the important starting points, not the method itself...The method one chooses ought to maintain a certain harmony with the deep interest that makes one an educator (a parent or teacher) in the first place. (van Manen 1990:1-2)

Fundamental to developing the questions is to first identify how we as researchers are orienting ourselves to the phenomenon we wish to study. Van Manen describes this process as "identifying what it is that deeply interests you or me and of identifying this interest as a true phenomenon, e.g., as some experience that human beings live through... So when one orients to a phenomenon one is approaching this experience with a certain interest" (van Manen 1990:41).

As the researcher, I have had to delineate the different aspects of who I am as the person doing this research in the first place. I am a doctoral candidate fulfilling requirements to complete my thesis with the view of an anthropologically-oriented educator who wishes to understand how Mi'kmaw students come to know material, how they learn, and what obstacles they perceive to that learning. After much reflection, I have realized that I am also approaching this research as a concerned friend. I have listened to many Mi'kmaw friends over the past fourteen years describe their experiences growing up on reserves and going to both on-reserve (federal) day schools and the residential school in Shubenacadie, Nova Scotia. I have found it painful to listen to these stories and have felt a sense of sadness and injustice to it all, especially when

contemplating the loss of language and other ways of knowing and expressing knowledge that are generally not taught in our school systems. Through my own research, I have come to see that a rich library of environmental knowledge was being lost and that all children could be enriched by sharing of knowledge within our educational systems. I have also been amazed at the humour and dignity that is still intact within many Mi'kmaq I know, despite these losses. My orientation as an educator is tinged by these personal feelings and experiences of deep sadness.

In van Manen's approach, phenomenological research is about questioning what "something is 'really' like. What is the nature of this lived experience?" (van Manen 1990:42). The abiding question for me throughout the research has been to try to understand: What is it like to be a Mi'kmaw teenager in today's world growing up on a reserve within a larger context of a non-First Nation mill town? What is it like for a young Mi'kmaw student to be in an educational setting, a setting which arose from another cultural framework yet is now part of his/her cultural identity? What is it like to look at the world from the eyes of a Mi'kmaw teenager learning subject material, in this case science, developed in another culture? What are their reference points for living in the world? What is each student's experience of the world? How can I come to know this?

Van Manen continues to explain how one finds the "essence" of a lived experience or phenomenon:

> By essence we do not mean some kind of mysterious entity or discovery, nor some ultimate core or residue of meaning. Rather the term "essence" may be understood as a linguistic construction, a description of phenomenon. A good description that constitutes the essence of something is construed so that the structure of a lived experience is revealed to us in such a fashion that we are now able to grasp the nature and significance of this experience in a hitherto unseen

> way.... So an appropriate topic for phenomenological inquiry is a lived experience: a certain way of being in the world.
>
> A phenomenological concern always has this twofold character: a preoccupation with both the concreteness (the ontic) as well as the essential nature (the ontological) of a lived experience. Phenomenology is not concerned primarily with the nomological or factual aspects of some state of affairs; rather, it always asks, what the nature of the phenomenon as meaningfully experienced is. (van Manen 1990:39-40)

Van Manen explains that in phenomenological research, a researcher would be unlikely to use some hypothetical variable(s) or testable skills for comparison between the experiences of individual children, classes of children, or schools as a whole. For instance, a phenomenological question might be "what is the reading experience itself for children? What is it like for a young child to read?" (van Manen 1990:40). Such questions cannot easily be addressed through hypotheses or testing.

In this research, the primary means for accessing the students' experience was through interviews conducted with the students in pairs. The interviews were semi-structured and wide ranging in subject matter in order to understand the complexity and multiple levels of their experience as Mi'kmaw teenagers in today's world. My intention was to gain a comprehensive understanding of the students' lives, which would allow for thematic patterns to emerge regarding how they related to their life and how they found their identity within the world. Seeing these patterns would then help me situate the students' classroom experience within the larger context of their lives, and to understand how learning fit into a larger web of relationships (ontological). Specifically, it was important to see what emerged from their life experiences that could relate to learning science and developing science curriculum (the ontic). With this deeper understanding of how these students situate or orient themselves in the world, alternative educational models can be developed for teaching science within the provincial schools.

Francisco Varela's method of conducting social science research involves three persons: the first person is the person whose experience we wish to understand; the second person takes an empathetic role with the first person and helps guide them to accessing and articulating their experience without judgment; and the third person makes note of and later interprets and analyses the experience of the first person. The second person becomes a partner or social mediator in the process of exploration. Varela likens this to the anthropological concept of participant/observation but notes that the process is more similar to a mid-wife helping a woman to give birth rather than simply being a neutral participant in the process (Varela 2000:7-9).

During interviews with participants, I attempted to be the second person, the empathizer, trying to allow the voices of the students to emerge, whatever the subject matter. In doing so, I was challenged to recognize my own assumptions and agenda, and to let go of the answers I wanted to hear regarding science and culture. I gradually came to realize there was no "right" answer. Rather, I came to understand that whatever the students said was relevant to understanding them as people and their reference points for identity, no matter what their cultural make-up.

I drew on van Manen's concept of a hermeneutic interview, and his definition of a collaborative hermeneutic conversation. These interviews are seen as collaborative between interviewer and interviewee in exploring the research question, as well as reflective in terms of participants reflecting deeply on their experiences and the meaningfulness of them. Van Manen speaks of conversations as being structured as a triad. "There is a conversational relation between the speakers, and the speakers are involved in a conversational relation with the notion or phenomenon that keeps the

personal relation of the conversation intact" (van Manen 1990:98-99).

In using van Manen's conversational interviews, I was looking for a process of mutual reflection and collaboration in trying to understand the meaning structure of situations, and how these structures fit into a larger "web" of relationships. This collaborative process seems a natural extension of Rabinow's definition of "dialectical holism" in conducting ethnographic research.

Ideally, a series of interviews with the participants would be conducted to allow for more reflection on and interpretation of the transcripts from their previous interviews (van Manen 1990:99). This is part of the collaborative aspect of hermeneutic interviews that van Manen proposes. In my case, I knew it would be an imposition on the students to ask for more after-school time, and was grateful to those who had reluctantly consented, mainly through the teacher's efforts, to being interviewed in the first place. However, within the interviews, I sought to provide as conducive an atmosphere as possible, given the library setting within the school and our mutual apprehension. My hope was to find a narrative that went beyond our sense of individuality, and to create a space in which we could connect as human beings and find something of mutual interest. It was important to me that the students were enough at ease to open up beyond nominal conversation and to describe the personal, and sometimes even intimate, frames of reference not ordinarily accessible in conversations with strangers. At times, I also simply engaged in conversation with them to ask their input about developing a science curriculum integrating some of their ancestral knowledge, much like a focus group leader looking for input. By not imposing a way they had to answer, most of the students seemed to feel comfortable exploring different ideas with me.

As criteria for the level of comfort or trust the students may have felt, I can only point to the length of the interviews (45 minutes to one hour average) and the level of engagement and openness exhibited within the conversations. To my delight, one pair of students agreed to a second interview after my recorder had malfunctioned during the first interview. In all these conversations, the students exhibited moments of self discovery and self-motivating factors in identifying themes of their identity.

In terms of Varela's "third person", the one observing and interpreting the interaction, I am relying primarily on van Manen's method for revealing phenomenological themes. Van Manen's method requires the researcher to find an interpretive framework for discriminating "phenomenological themes" around which we can fashion a "phenomenological description" (van Manen 1990:90-92). In Chapter Two, I quoted van Manen's definition of phenomenological themes as "like knots in the webs of our experiences, around which certain lived experiences are spun and thus lived through as meaningful wholes....Themes are the stars that make up the universes of meaning we live through" (van Manen 1990:90).

Van Manen delineates three ways to isolate thematic statements – "the holistic or sententious approach; the selective or highlighting approach, and the detailed, line by line approach" (van Manen 1990:92-93). In applying the holistic approach, the text is looked at as a whole, and the researcher attempts to capture the fundamental significance or meaning of the text. The researcher must then encapsulate and succinctly articulate that meaning. The selective approach entails finding phrases or statements that reveal the essence of the phenomena being researched. The detailed approach requires the researcher to assess every sentence or sentence cluster to find what it reveals about the

experience or phenomena.

I have drawn on all three approaches but applied the first two approaches more frequently. The holistic approach is most helpful in finding the fundamental rhythm or theme of a text, much like the base drum in a musical score calls the listener back to a basic beat. The selective approach highlights ways this more fundamental theme can be expressed or brought into a cluster of thoughts. The third approach adds further detail to the composition (van Manen 1990:92-93).

I have also used Weber's concept of webs of significance to look at the interrelationships among these thematic "knots." I have used the metaphor of a web as the most appropriate image for conveying the fluidity or quality of Varela's fragile ontologies. A web is a woven pattern of durable threads, yet it is also fragile in nature. Spider webs, as I have experienced them, can survive hurricane winds and rains, yet be torn away in an instant by my hand or broom. With almost equal rapidity, they can be woven again, to whatever size is necessary, in whatever place is convenient. Such is the nature of identity formation as I have experienced it in my research.

Description of the Study

This study was conducted within the Eel Ground First Nation School in northern New Brunswick with the cooperation and permission of a Grade 7/8 class of eleven students and their teacher, the students' parents, and the principal of the school. Chief George Ginnish gave verbal permission for the research. Steven Ginnish, silviculturalist and manager of a forest project on the reserve also worked closely with me on two field trips during which he wove in Mi'kmaw environmental knowledge with the science

instruction. Steven also discussed the research with me on a number of occasions, as did the teacher and principal; all provided helpful feedback. Furthermore, I also had many informal discussions with other staff and teachers who taught this grade. On two occasions I had meetings with the Chief and various members of the Band Council's education committee.

The research extended over three-and-a-half years (Autumn 1998 to Spring 2002) and comprised four basic components:

1) background research and literature review;

2) on-site observation, interviewing and participation;

3) model science lesson development and implementation; and

4) review and analysis of data.

Background Research and Literature Review

The background research and literature review was conducted over the full duration of the project. These activities included:

- research of current policy and "best practice" teaching and curriculum development for First Nations students, and of multicultural educational literature and extension of my own research conducted over the last fourteen years on Mi'kmaw history, culture and environmental knowledge;
- research into how Mi'kmaw knowledge of the environment can be included into the teaching of science based on case studies conducted in other First Nations cultures;
- identification and review of "best practice" teaching and curriculum in science

including the analysis of such recognized documents as the American Association for the Advancement of Science's *Benchmarks for Scientific Literacy* (1993), National Research Council's *National Science Education Standards* (1996), and the Council of Ministers of Education, Canada's *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum* (1997). This review was reported in Chapter Two;

- review of science textbooks currently used in Maritime provincial and reserve schools for Grades 7 and 8 to assess their cultural references to Mi'kmaw culture and history, and an investigation into whether an increase of Mi'kmaw cultural content would be beneficial to Mi'kmaw students' learning of science; and
- a comparison of different pedagogical philosophies. Pedagogical research included indigenous models for education as well as how the arts could be applied to teaching science within a Western framework. The arts were reviewed for their pedagogical value but this review is not included in this thesis due to the complexity of the subject in its own right, and the lack of time to test the integration of arts into pedagogical models for teaching Aboriginal students science. Rather, an artistic component was included in the trials lesson and the proposed field trip lessons (see Appendix F). Models for Aboriginal education can be found in Chapter Six, and discussions relating to the approaches to Aboriginal and multicultural education can be found in Chapter One and Chapter Two.

On-Site Observation, Interviewing, and Participation

On-site research and participation in a reserve school classroom setting with Mi'kmaw students was core to understanding the important aspects of the students' relationship to

science as it was then being taught and related to within their school. This Grade 7/8 classroom and the two field trips were used to pilot and evaluate new pedagogical ideas and materials developed in the course of the research. The research site was ideal for this study for the following reasons:

- The school included middle grades 7 & 8, a recent development stemming from the community's dissatisfaction with their children's experience at the provincial middle school in the nearby town. According to the principal, the provincial school did not address the needs of the Mi'kmaw students, which was reflected in their poor academic performance, particularly in the sciences;
- The principal acknowledged that despite this action, the science program at the school was weak. He expressed a desire and willingness to support appropriate research and the development of recommendations that would ultimately strengthen it;
- The students would be entering the provincial school in Grade 9 and the parents and educators at the school did not wish to see these students follow the drop-out trend discussed in Chapter One; and
- The Grade 7/8 teacher was using the *Science Plus* series, a science curriculum series co-authored by one of my thesis advisors, Dr. Charles McFadden. This was a unique opportunity to draw on the expertise and experience of both parties.

This component of the research involved ongoing, on-site observation, and reflection and evaluation in collaboration with a team of university-based educators and scientists; Mi'kmaw representatives who had knowledge of their ancestral environmental

knowledge; the Grade 7/8 teacher and others at the school with professional interests in the project; and the Grade 7/8 students. These students were active participants in the study through interviews, class participation, and field trips. These activities were conducted from November 1998 to the Spring 2001 and included:

- meeting with the principal of the school and the Grade 7/8 teacher in November 1998 to discuss the project and gain approval and permission to be in the Grade 7/8 classroom;
- seeking and obtaining permission from the Chief and Council of the reserve to conduct the research;
- sending out permission forms with accompanying letters of explanation to all the parents of the students, the students themselves (eleven at that time), the teacher and the principal. The forms requested permission to be in the classroom once a week for the duration of three to four months, to conduct taped interviews with the students, and to do a few sessions of videotaping within the classroom (see Appendices A, B, and C). Separate permission slips were required for the two field trips organized with the forest project manager. Both field trips were videotaped. Anonymity was assured the students, along with the promise that the material from interviews, audio and videotapes would not be used for any purpose other than this research, without permission;
- submitting a project description and statement of intent with ethical guidelines regarding anonymity, confidentiality, and the right of any participant to withdraw from the research to the University of New Brunswick Ethics Review Board following a consultation process with the participants on the reserve. Approval

was given to proceed with the project;

- arranging a meeting with the parents of the students to answer any questions about the research, and to explain my motives for doing it. Ten people attended;
- compiling field notes in the Grade 7/8 classroom during a four-month period (late February to early June, 1999) of observation to identify how the students learn, how they connected to the material, and what pedagogy seemed most effective;
- videotaping three days of classroom activity and two field trips. The purpose of the videotaping was to look at non-verbal communication, identify focal points of the students' interest, and generally capture a wide range of activity that could never be documented by field notes. Anonymity was promised for all participants. Copies of these videotapes have been sent to both the teacher and the leader of the field trip;
- coordinating two field trips with the forest project manager and the teacher. The field trips were designed to teach forestry management practices along with environmental knowledge of the Mi'kmaw people who traditionally had inhabited the land;
- conducting semi-structured interviews with eight students in pairs (four interviews of two students each) to gain comprehensive understanding of a number of factors regarding their relationship to the sciences; and
- conducting on-going reflection with the teacher, principal, and team of educators, scientists, and band representatives to discuss obstacles to learning, as well as arenas of effective learning.

Commentary

This K-8 grade school was chosen on recommendation of a Mi'kmaw friend. It is located within the Eel Ground reserve near the city of Miramichi in northern New Brunswick. The town is host to a large paper mill, which factored into the research for two reasons. First, concomitant with my research, a legal case was pending with the paper mill regarding the development of a treatment plant on a piece of land adjacent to one corner of the reserve. This piece of land was considered a traditional-use site and was used for spiritual practice by some members of the community. A lawyer (who contacted me about assisting in his case) was interviewing and conducting research on the reserve on behalf of the community in preparation for the case. Part of his process was to interview some of the students I was intending to interview. Second, this particular land rights issue was brought up by some of the students in their interviews with me, and may have influenced their thinking about traditional land use.

The choice of Grade 7/8 students was intentional. These grades are often the transition year for Mi'kmaw students going from community schools to provincial schools. Research has shown that students in these grades are at an age when they either move ahead successfully or begin to drop behind in their educational achievements (Nova Scotia Education and Culture 1997:1-2).

In November, 1998, I met with the principal of the school and the Grade 7/8 teacher. The teacher had understandable reservations about being observed and videotaped, but consented to my presence in her Grade 7/8 classroom under certain time restraints. The principal and the teacher, as well as all the children in the class (eleven in all), were asked to fill out permission forms for me to be in the class, to videotape them,

and to interview them (see Appendices A, B, and C). The Chief of the reserve gave his verbal permission for me to conduct the research. The parents of the students were asked to fill out consent forms, which they did with the teacher assisting in the effort (see Appendix D). Nine of the eleven children consented to interviews and to being videotaped, some reluctantly and with the teacher's prodding. One student reneged on his commitment, partially because it had been his mother who had wanted him to do it and potentially because he had little interest in being in school at all.

I arranged a meeting with the parents with the help of the teacher to discuss the project and answer any questions they had about the research. Ten people attended the meeting, which was held in the classroom. I attempted to explain why I wanted to do the research. Many were supportive but some of the parents were concerned that the students' regular schooling in no way be compromised.

My visits to the classroom began in late February, 1999, after two previous attempts to drive from Fredericton had been thwarted by blizzards. For the first few visits, I simply observed and attempted to familiarize myself with the students. On the third visit, I requested an interview with one of the students. She immediately asked if she could do it with a friend. I agreed to this knowing her comfort level would increase and that the two might spark each other to discuss topics in greater depth. All the interviews – four in all with a total of eight students – were done in this way.

The teacher later told me how reluctant the students were to do these interviews, and how she had to convince them to do so. Their reluctance reflected their unwillingness to have to "work" past the end of school hours. However, the richness and length of the discussions did not reflect an unwillingness to talk although two students did express

some concern someone would hear the tape and be able to tell that it was them speaking.

The interviews lasted 45 to 60 minutes. All were conducted after school in a small library/resource room on the second floor of the school. The interviews were semi-structured to allow for spontaneity, something which became increasingly interesting to me as I listened to them talk. The questionnaire was purposely designed to address a wide range of topics that influenced the students' lives, and the attitudes, values and skills they brought to bear within various contexts (see Appendix E). The purpose of these interviews was to identify students' motives, attitudes and interests regarding the sciences and learning in general, as well as to look at core research questions regarding multiple world views and identity formation. I was interested in the various layers of the students' realities and how the intricacies of their lives unfolded and related with one another. Who were they as people in the world and how did they bring their lived realities into the learning process? Conversely, how did they bring the learning process into their lived realities, particularly the learning of science?

The class was a mixed Grade 7/8. All students participated in the same science lessons (the teacher alternated the Grade 7 and Grade 8 textbooks each year), but the grades were separated for Math and Language Arts. As the 7^{th} graders worked on their Math, the 8^{th} graders might be working on a writing project or a homework assignment or be in another class such as French. A few students went to special education classes in Math. All of the students were computer literate. Computers at the rear of the classroom were often used by students to complete assignments, do research, or play games during breaks and transition periods.

Tuesday mornings were designated as my time for visiting because this was the

day science was taught. However, I also was present through Language Arts, Social Studies, Math, English, two sessions of cultural studies taught by another teacher, one music class, and two sessions of Drug and Alcohol Use and Abuse taught by another teacher in another classroom. Within the classroom, I took notes and audio taped a number of subject periods sitting wherever convenient depending on the activity in the classroom. The teacher agreed to allow me to videotape three of the mornings I was in the classroom. I also participated in and videotaped an all-day event, Earth Day, during my time in the community.

No matter how discreet I tried to make myself while videotaping, it was evident the camera inhibited behavior. On the first day I used the video camera, one student, who was directly across the room from the camera, spent most of the morning slouched down in her chair with the book propped on her desk obscuring her face. On one of the field trips, I was unaware that one of the students had not given me permission to videotape him. Later, on seeing the videotape, he commented on my inclusion of him without permission. On the second field trip, the same student refrained from giving permission. I then had to ask the teacher to request he not situate himself in the middle of the group because I could not videotape the rest of the group, all of whom had given permission, with him there. He complied.

The teacher, too, felt self conscious with the videotaping but also consented to it being done. Her cooperation, kindness, and courage to undertake this research was consistent. The only part of my proposal she requested I not carry out was to include a Mi'kmaw or other First Nation student from the Faculty of Education at UNB as an apprentice/assistant in the process. For her, having a second person in the classroom

would be too disruptive whatever their cultural heritage. After visiting the classroom, I understood her reluctance. As the last teacher these students have before entering the provincial high school, she was under tremendous pressure to adequately prepare them for the transition. Having me in the classroom inevitably altered the behavior of the students, and increased her own tension to be a good teacher despite my assurances I was not there to critique her teaching abilities. The pressure on First Nations teachers from both inside and outside their community is something that should not be overlooked, and could easily be the topic of another thesis.

Aside from spending one day a week for three-and-a-half months in the classroom observing and videotaping, I also arranged two field trips with Steven Ginnish, a member of the community who oversaw a forestry project within the community. Part of the forestry project involved research on the environmental knowledge of Mi'kmaw elders. Steven was the father of one of the Grade 8 children I interviewed.

The field trips were designed to explore the potential for the creation of a dialogue between the traditional knowledge of the Mi'kmaq regarding the environment and science as it is taught in the classroom. Unfortunately, the first planned field trip had to be postponed to the following autumn, which meant that some new Grade 7 students were included, and some of the old Grade 8s were no longer in the school. The reason for the postponement was a rumour circulated by someone outside the community about the intentions of my research and the grant money I had received to carry out the research. When this rumor became known to me, I chose to suspend the research until I could meet with the Chief and members of the band council to confirm their confidence in my intentions and their approval to continue. Approval was given but at that point it was too

late in the school year for the field trip and it had to be postponed until the fall, 1999. The second field trip was arranged for the spring of 2000.

In preparation, I had developed some curriculum ideas and materials for Steven and the teacher to review and potentially introduce into the field trips. Some of the material was introduced but more time was needed to fully develop an actual curriculum design. For instance, I had developed two role-taking activities. One activity was to take on different roles of people who might use the forest – botanists, geologists, firefighters, artists, etc. The second was to take on different animal roles. These activities were to introduce the students to the multiple perspectives that could bear on how one viewed the land as well as experiment with artistic expression. A third activity was an expansion of an exercise from the *Science Plus* text to study an ecological zone.

These activities did not get used until the second field trip, and then there was only time for the two role playing activities. The first field trip was led by Steven, with the teacher assisting in the process. During the second field trip, Steven again led the teaching during the morning, and the teacher introduced the activities I had developed after lunch. All the students participated in the activities with varying amounts of interest. However, it was evident that doing such activities immediately after lunch, having already been walking through the woods for three hours in the morning, was not an ideal time. The students were getting tired, and their attention, as was true in the first field trip, was less focused in the afternoon. In retrospect, having reviewed the videotapes of the field trip, I think that what Steven did was the most valuable part of the lesson. He was able to introduce the students to an important community project to manage and protect their forests, as well as show the students plants and trees their elders traditionally

collected for medicines and making tools. He also discussed and demonstrated some of the practices involved with silviculture. He moved easily between the two types of knowledge about the forest ecosystem showing connections where they existed. Equally important, he was able to relate directly to the students' backgrounds and point out people within the community who still related to the land in the ways he was describing.

Model Science Lesson Development and Implementation

Following the months of observation in the classroom, the interviews, and the field trips, I developed a sample science lesson for the classroom. I had originally intended to write a complementary, alternative lesson to the "Diversity of Life" chapter in the *Science Plus* textbook, but quickly shifted to chemistry because of the teacher's schedule and time restrictions. Fortunately, I could draw on much of the information I had accrued from my previous research on Mi'kmaw culture, as well as my work on the development of a Mi'kmaw Earth Science program for Energy, Mines, and Resources, Natural Resources, Canada, in 1993/4. Other activities related to the development and implementation of the sample science lesson included:

- working with the Nova Scotia Museum of Natural History and university specialists to develop a trial lesson on "Chemical Changes," which integrated Mi'kmaw traditional knowledge with the chemistry lesson they were learning in their *Science Plus* textbook (see Appendix F);
- determining objectives for the lesson based on past research, my recent observations and interviews, and discussions with the teacher;
- presenting the sample lesson and lesson objectives to the Chief, the principal and

a member of the Education Committee for review, comment, and approval;

- presenting the sample lesson and lesson objectives to the teacher and one member of the Education Committee in the classroom the day prior to the trial lesson for review and comment;
- assisting the Grade 7/8 teacher in presenting the unit in the Spring, 2001; and
- handing out a simple feedback questionnaire to the students after the trial lesson (see Chapter 5).

Commentary

In April, 2001, I designed a lesson on "Chemical Changes" (see Appendix F) to complement the lesson being taught by the teacher from the *Science Plus* textbook. This was sent to the Chief, one member of the Education Committee, the forest project manager, and the teacher to review. The Chief then agreed to organize a meeting to discuss the curriculum design. The teacher also agreed to clear a morning of classes to test the lesson once the Education Committee approved. Other copies were made with the intention of handing them out to those members of the education committee who attended. An overhead presentation was also prepared.

The meeting was attended by the Chief, the principal, and for a short while, one member of the Education Committee. The Chief was extremely supportive, and he discussed the desire of the Band Council and Education committee to move in the direction of a more culturally interactive curriculum. An initiative was already underway to assess and strengthen the Mi'kmaw language program in the schools.

A meeting with the teacher that afternoon was inspiring, although earlier in the day she had voiced concern that the material was too sophisticated. We were joined by a

member of the Education Committee who had been unable to be at the earlier meeting. Both seemed genuinely interested in some of the cultural research I had done, as well as some of the lessons that involved the language. The teacher then asked if she could pick one of the three projects I had designed. She chose one that used red ochre – a mineral traditionally used by Mi'kmaq for paint, medicine, and ceremonial use – to discuss and demonstrate physical change.

The next morning the lesson was carried out. I had agreed with the teacher not to videotape the session since permission would again be required from the parents and students. Also, she was reluctant because she felt the children were more self conscious with the camera. There was also the risk of one student not wanting to be videotaped as had been the case for the field trips. Interestingly, I had begun to audio tape the session thinking that this was acceptable from my previous permission to do so, but the same student who had not wanted to be videotaped, shouted out "Hey, she's recording this!" Another student said, "I wouldn't have said some of the things I did if I had known." I immediately became aware of my oversight. I quickly took the tape out of the recorder and gave it to the teacher and apologized to the students. This was a sad moment as a researcher and also part of my continuing education. This was about rights, not about the larger ideal of doing something that, in the long run, might benefit the education of all Mi'kmaw children. These children had become very politically aware. There was no discussion about it. I had made a mistake. There was no appeal to a larger idealism about the benefit of the research. This was their time, their energy, their thoughts. They were doing me a favor.

As with all mistakes, I learned something. Although I lost the recording and

perhaps one of the most fascinating dialogues about the environmental knowledge of their ancestors and science to date in my research, it also substantiated what Armando Trujillo (1996) and a number of other researchers have asserted about the agency of children in negotiating their identity. This was an example of active resistance and reflected a larger political context that had been gaining momentum among Aboriginal peoples for the last few decades. The students who challenged the recording were politically correct. Had I been with the original class, it would not have happened since I had blanket permission to record classroom interactions, a permission I had mentally carried over to the new classroom. Each changing situation required permission and there was no rest from that rule. The incident also revealed that, given the change in the classroom population over the two-and-a-half years of the study, a long term trust had not been established with all the students. Agreed upon rules were fine, but outside those, there was no slack. My main fear was that I had lost the trust of the teacher, who had supported and helped me throughout the project. She later told me I had not.

The lesson continued, and I was able to jot down some of the initial dialogue in notes, but I then became involved in setting up and presenting a slide show on Mi'kmaw traditional life and assisting in the experiments. Later that day, I sat and tried to reconstruct my memory of what had occurred.

In all my research, cooperation with people from the community was core. Without their input, my work was meaningless. In this particular incident, I unwittingly broke my own rule, even though I had been conscientious to be clear and above board about my agenda in every situation up to that point. Creating collaborative relationships does take time, a long-term effort, and trust. That trust can be fragile if the ground for its

existence – permission forms for every new situation – is not respected.

Review and Analysis of Data Gathered

As noted in the discussion on phenomenology earlier in this chapter, I used van Manen's method of interpretation. I approached the material first through a holistic reading of the text out of which some themes emerged (van Manen 1990:92-93). Engaging the transcripts this way led to the creation of a three-dimensional model for thinking about the interviews. This model was an evolution of an earlier model I had developed while designing a family resource program for Mi'kmaw families living off reserve (Sable 1993). This model looks at the multiple layers of influence on learning and their relationship to one another. This three-dimensional model is described in detail in Chapter Six.

The holistic reading of the transcripts led me to further contemplate the notion of individual identity formation within cultural communities, as well as cultural identity formation within the larger society and the role education does or does not play in that formation. My interest became increasingly focused on tracking the students' experiences along an individual-community/culture-society continuum and how understanding this journey could influence teaching in general, and science education specifically. I was interested in determining whether First Nations children believe in a "scientific" view of reality or are more influenced by an alternative cultural narrative.

My interest in the question of identity formation increased my focus on how the students experienced their world, and how they described those experiences and made choices within each context. I became intrigued by how they moved between the personal, cultural and societal spheres in a continual weaving of patterns of associations.

In one sense, it did not matter to me what was being discussed, but more how and what they were choosing to relate to and express. On the other hand, I was keenly interested in the content of their thoughts and their opinions about a variety of matters. I wanted to know whether they would like to have more culturally relevant content in their science studies, what they had learned from their parents and elders, their views on science and education, and how they determined truth. Where did boundaries come up, or did border-crossings, as described by Glen Aikenhead and Olugbemiro Jegede (1999) occur? What were their natural reference points in discussing anything? The more self-awareness they brought into these reflections, the more possibility there was for dialogue. In this way, I began to see the multiplicity of issues these students face as First Nations children in the contemporary world.

The more I listened and contemplated these interviews, the more I reflected on the work of the educators and social scientists mentioned in Chapter Two. The ideas most relevant to my continuing analysis of the data were: Glen Aikenhead and Olugbemiro Jegede's (1999) concept of border crossings along with Renato Rosaldo's (1989) discussion of cultural borderlands; Neil Postman's (1996) discussion of a new narrative in education; Francisco Varela's (1999 and 2000) phenomenological model of learning and Max van Manen's (1990) hermeneutical phenomenological research method; Eber Hampton's (1995) "Toward a Redefinition of Indian Education," and a number of discussions on the Medicine Wheel by other Aboriginal researchers and educators such as Sharylyn Callilou (1995). The work of Bradley Levinson, Douglas Foley, and Dorothy Holland (1996), who investigated the "cultural production of the educated person," also proved important to the larger social vision of education I hope to establish, as well as

Raymond Williams' (as cited in Bauman 1977) definition of an emergent culture.

Through the student interviews, I have focused on science education and the potential for creating a dialogue between science as it is currently taught in Maritime provincial schools and the traditional knowledge of the Mi'kmaq. I have inserted my own comments which also pay close attention to what students deemed relevant and what criteria students used in their process of determining relevance. My approach was to depict a mental map of the meaningful relationships and relevant associations that emerged from our discussions, and to illustrate application of Varela's concepts of "suspension, letting go, and redirection" (2000).

Summary

The multiple layers of this research required the project be conducted in a number of stages, some overlapping, and that both phenomenological and ethnographic methods be used in the research. The research began with a literature review as a way to evaluate some observations of other researchers working within indigenous educational settings. As well, I familiarized myself with the current educational theories and curriculum frameworks used in provincial schools. This review helped me to understand the social narrative and concepts of education at play within these schools.

On-site participation and observation within a Mi'kmaw school was core to the research in helping me to experience the everyday reality and learning conditions of these students within their own community. Personal interviews with the Grade 7/8 Mi'kmaw students helped unearth thematic patterns regarding what it means to be a young Mi'kmaw within a school system learning science in contemporary society. Further, the

students' perceptions about differences between the world described by science and the world described by Mi'kmaw culture are crucial building blocks to creating science curriculum that is meaningful for these students. The interviews and the classroom participation were also used to see what personal, cultural and social factors were at play affecting that experience. From an ethnographic point of view, participating and observing within the classroom, along with the two field trips, helped me understand how these students functioned as a group, and the culture of their classroom. The field trips allowed the classroom learning to expand to the larger context of the reserve, and offered the opportunity for the students to learn about current and traditional forms of Mi'kmaw knowledge and the relevancy of that knowledge to their lives.

Chapter Four

Webs of Significance and Phenomenological Themes

Introduction

Following on van Manen's definition of phenomenological themes as "knots in the webs of our experiences, around which certain lived experiences are spun and thus lived through as meaningful wholes" (van Manen 1990:90), this chapter will focus on delineating five themes or webs of significance and the narratives that surround them that have emerged from the interviews with the students. The five themes were first identified through an analysis of the Interview with S1 and S2. The later interviews were then used to expand these five themes. I have used these themes and narratives as a foundation for a cross-cultural science curriculum.

Interspersed throughout the excerpts are my comments. These are italicized and present my reflections on what is significant about particular segments of the dialogue. These comments are a way for me share my own journey through the interviews, and allow me to introduce the themes and narratives that emerge from the data. The excerpts from the interviews and my comments are accompanied by more general discussions that relate the themes and narratives to the theoretical concepts introduced in Chapter Two and to a consideration of how they might influence a culturally interactive science curriculum.

Personal and Cultural Perceptions of Reality: Real or Not Real?

In the first example, I explored the question, "Can you tell me how you tell if something is true?" with two students, S1 and S2. Both these students were female, one Grade 7 and

one Grade 8, and both were at the top of their class in most subjects. One, S2, aspired to be a scientist.

I had become interested in this question because science is one way we validate truth or what we consider to be reality. This question led to a lengthy conversation in which S1 and S2 made a number of distinctions between such concepts as real and not-real, truth and lying, human and not-human, Mi'kmaq and not-Mi'kmaq, and others. Along with making these distinctions, the students began to express certain values that could be viewed as the part of the border crossing process as truth turned into lying, or real turned into not-real, or science turned into myth.

TS: Can you tell me how you tell if something is true?

Comment: Here I made the assumption that the students have a definition of truth or criteria for assessing truth. I also felt that this was a fundamental question to ask in terms of delineating between learning information and truly experiencing new ways of knowing, or the practical – what we need to know –and the meaningful – what guides how we function in the world. I asked this question because science, as it is practiced in our society, is often perceived to be a final seal validating or legitimizing things as true or real.

S1: When it's right there. Or when you know it's there or something.

Comment: This comment indicated to me that the students have an interpretation of truth, or some implicit criteria, which is why I was interested in exploring the question further.

TS: What about when you read things in books? Is there something you consider to be...

Comment: In this question I was attempting to see how truth was confirmed or not confirmed, and what the students thought of as authoritative sources of truth. I used books to see if they were viewed as an ultimate authority.

S2: Yeah. If you think it's the truth, and you believe it's the truth, then it probably is. But if you have second thoughts then you don't... if you don't like say that it's right 100%, then it probably ain't.

Comment: The students seem to be saying that truth is existential and intuitive, at least to some degree. It is self evident in the moment and pragmatic in the sense that one decides, given the conditions of the moment, if it is appropriate. Here we have the notion of truth being without doubt, despite what others have told you or what you have learned. This has further implications about the role of doubt in learning and about how people come to trust one another.

TS: So what if someone came running up to you and said, "I saw a ghost" or something, or "an alien was there."

Comment: Here I am introducing a hypothetical experience in order to look deeper into the student's criteria for telling how something is true. I brought up ghosts or aliens without making a judgment or assumption about whether ghosts or aliens exist, an open ended way of introducing a subject.

S1: If they were crying I would believe them.

S2: Yeah. If you knew this person real good, and you knew that they wouldn't lie to you, then you would have to believe it.

Comment: The notion of personal trust is important here. Knowing the person, knowing they wouldn't lie to you, and seeing their emotional response as genuine.

TS: But you said something is true if you can see it.

S1: If you were there and saw an alien, you would know it's true but if you tried to tell somebody else, nobody would believe you. They would just think you were trying to be on the news or something.

Comment: This is an interesting comment because traditionally, Mi'kmaq view dreams and 'supernatural' experiences as real and as equally informative as empirical evidence. In this statement, there is the notion that someone could be doing it just to get attention.

TS: So I guess it takes a lot of courage, huh?

Comment: The students did not directly respond to my own value laden assumption about truth telling as requiring courage. It was difficult to tell if the 'yeah' in the next response was linked to the notion of courage in truth telling. My guess is they did not register the statement I made and were already thinking about the grandmother.

S1: Yeah. My grandmother tells me all about these old Indian legends like about the story of the *pukalatamu'jk* and all that stuff – these little men that live by the river.

Comment: The students easily shifted to talk about pukalatamu'jk instead of aliens as something more culturally relevant and present in their experience. It also shows their particular openness in the interview process to share this with me. Further, it is evidence of traditional beliefs being passed down to the younger generation.

S2: We have *pukalatamujk* caves down there.

Comment: Here the pukalatamu'jk become real and locatable. The students are not saying "my grandmother told me there are pukalatamu'jk caves down there" as in their first statement about pukalatamu'jk. They are stating that these caves exist as a reality for them.

S1: Yeah there's little caves in the side of the river where there's like a cliff, not very high, not even as tall as this school eh? Just about a few feet. Maybe like 15 or 20 feet?

S2: There's a lot of stories.

Comment: This statement confirms the presence of these stories within the community. It does not say how the stories are used or interpreted, but simply that there are a lot of them.

S2: *Pukalatamu'jk* is definitely the biggest.

S1: Yeah, there's a lot of stories about those. My grandmother used to always tell me them.

S2: We went inside one like two years ago when we went to get clay down the river.

S1: Oh yeah. We went inside one of those caves.

S2: It was small.

S1: We were like....

S2: It was like, "Stay here. We might hear footsteps."

S1: Yeah, it was like a class and we were all like protecting each other. But it was big enough to walk in.

S2: "Three at a time, three at a time." (laughter)

S1: And it was like go right through. It was covered and then there is like another spot at the end and then there's tunnels going through.

S2: But just in case they are real we don't want to be intruders. Like now, when you're going up to _____ (place name), like the men say when you see the signs that say "Deer crossing" and the only reason that [the signs] are out there is because the people are cutting in the woods and stuff and they're destroying their homes. So, when we went down, we were just going to look in there out of curiosity. We weren't going to destroy it or...

This particular description is the display of a mind flickering back and forth in uncertainty ("...just in case they are real...") just as Varela describes "fragile ontologies." Along with this flickering about whether *pukalatamu'jk* are real, are two other concepts: intrusion and respect. The notion of intrusion is then correlated to the situation of the deer losing their habitat to woodcutters, showing their ability to identify with situations in a larger societal context. The woodcutters have intruded upon the deer's habitat, and consequently the deer are now being endangered by coming down to the roadside. This habitat loss has led to posted signs warning about deer crossing. A situation has been created that is dangerous both to the deer and to the drivers.

The difference between the deer habitat and the *pukalatamu'jk* cave is not in the logic of each situation, which is the same – disrespecting or destroying habitats causes negative and dangerous consequence. Rather, one situation, the deer and their habitat, can be empirically validated from a western scientific perspective, and the other situation, the *pukalatamu'jk,* cannot because it is invisible and based on people's belief in whether *pukalatamu'jk* exist. In fact, in the *Science Plus* series used in their science class, these students learn all about ecological zones and animal habitats. This is part of their education to learn the webs of life. But, although *pukalatamu'jk* exist in these students' own culture to a certain extent, and are validated by their own culture, it would not make for viable science as it is taught today. However, the students themselves are making this

link (border crossing) to an observable, empirically validated ecosystem within their area of travel.

TS: You're talking about the *pukalatamu'jk* now? You mean if you just go and look you won't be hurting them or anything. Is that what you're saying?

S1: Some people say about the *pukalatamu'jk*...

S2: ... that they're evil

S1: Yeah, they're evil 'cause they ran away from crosses or they knocked them all down one time when the settlers or something came.

Comment: This is the emergent nature of culture. Some people within the community look at pukalatamu'jk as evil, anti-Christian. However, because they are evil does not mean they are non-existent; it just means the context for thinking about them has changed.

TS: You mean like Christian crosses? Is that what you're saying?

S1: Yeah. And some say they're real nice and they'll help you out of the woods and some say that if you believe in them...

S2: ... that they sit on the side of your bed and they laugh at you while you're sleeping.

TS: Is that good?

S2: That's not good.

TS: If you believe in them that they'll sit inside your bed and laugh at you?

S2: No, if you believe in them, then they are real, or you might be able to see one but if you think it's a myth, and you think that it's just like just something to get your kids scared then it's not real.

TS: What do you think (to S1)?

S1: I think both.

TS: Real and not real?

S1 & S2: Yeah.

TS: That's interesting. Can you say more? How you can say things are real and not real at the same time?

S1: Like when little kids are scared of ghosts and you know that they are not real but some people that believe in them...

A number of layers emerging from this conversation regarding how these students perceive reality and determine truth. First, truth is determined as personally believing in something, which leads to literally seeing aliens or *pukalatamu'jk.* Aliens are seen to be unreal or imaginary by these two students, but real if they are seen by a trustworthy person, not in it for personal gain or publicity. However, *pukalatamu'jk* may be real because they are part of the students' cultural reality.

The cultural reality is that *pukalatamu'jk,* or little people, exist in a place located within the community and the members of a group agree they exist, for evil or for good. They are not considered aliens. What makes this culturally distinct is that some elders would support their view, and this is one way truth is determined. What also makes this unique is that *pukalatamu'jk* are associated with a specific place and feature of the landscape (the caves), extending the student's identity beyond the "human" realm, to an identity inseparable from the landscape.

Even talking about little people or other types of beings in the world as possibly real seems to show that their notions of reality can easily override acceptable western notions of scientific, empirically based reality. These beliefs are not necessarily regarded as false by people in their own communities, and *pukalatamu'jk* have been seen by many community members. By contrast, within our contemporary western society, a child is commonly told at some point that Santa Claus does not really exist but is only a symbol, even though the child may dutifully put out cookies and milk each Christmas as though Santa were real.

This example is also an illustration of strong cultural beliefs that have endured for millennia and are part of the "traditional" aspect of "traditional ecological knowledge" and of how these children relate to their world. The caves within their community are not just made of inanimate rocks and soil, but are the habitat of persons or beings that require respect and awareness of their presence. Even if the children do not choose to believe in them personally, they are possibly real and still part of their identity and way of thinking. Furthermore, they understand that disturbing these caves is no different than woodcutters destroying deer habitat. The students also understand that, as a consequence of disrupting the deer habitat, signs have appeared warning of deer by the roadside.

People not of Aboriginal descent have similar concepts or parallel versions of reality as those voiced by these students (e.g., ghosts in a graveyard), but it is what is socially or culturally accepted as reality that is really at issue here, as well as how these children come to decide what is true for them. Truth is also determined by the meaning ascribed to it by one's culture, and how these meanings are embedded in the myths of that culture, whether they seem to appear as superstitious tales or as scientific theories. Truth then becomes a matter of social consensus, which is why Aboriginal peoples and many other cultural groups may be loath to have their whole cultural way of relating to the world, their basis for meaningfulness, undermined by the ideology of science. The point with respect to science education is not to teach about *pukalatamu'jk,* but to understand basic perceptions about reality and relationships to the landscape as part of the students' inherent identity and to not discount it as an unscientific misconception.

On a more profound level, Varela's concept of fragile ontologies or "virtual self" is demonstrated by the students speaking of things being both real and unreal (Varela

2000:12). The students are straddling seeming dichotomies and bringing them into relation with one another within a larger narrative that accommodates both reality and non-reality. Varela responds as follows to Claus Otto Scharmer's interview question, "So, when you say virtual you mean it doesn't have the center self, it doesn't have substance, and yet it is real?"

> Right. It is real in the sense that it can effectively tackle the world with which it's coping. But that coping is constantly updating itself or renewing itself, submitted to all kinds of changes, both endogenous and exogenous. So virtuality is not just this absence of a central self, it also has that kind of fragile floatation of coming and going, which is where the letting go is. Letting go is an interesting gesture, because in fact it's almost like invoking the virtuality of self, just putting it spontaneously on the table. Usually it's life that makes you let go. (Varela 2000:12)

In other words, whether it is your belief or imagination is irrelevant. If you don't believe in *pukalatamu'jk*, then they become like ghost stories and are used to create fear. If you do believe in them, then they are real. It is mind searching for a meaningful reference point with which to identify and relate to specific contexts.

Implicit in this dialogue are multiple layers of the student's identity at play, as well as their ability to cross borders and connect the layers. Judgments about what is real or not real and how truth is determined is fragile and a matter of trust and personal intuition and decision. Identity is drawn from reflection on cultural identity as Mi'kmaq, including their ability to think of *pukalatamu'jk* as possibly real and to treat them with respect. This cultural identity extends to and is inseparable from the landscape the students and their ancestors inhabit. The *pukalatamu'jk* are inhabitants of the caves within their reserve, and their co-existence is reinforced by the belief and legends of *pukalatamu'jk*. The landscape, in turn, becomes part of the students' psyche. They understand the interdependent and multi-layered nature of their existence, and that

violation of that relationship leads to destruction or disturbance to the landscape. Understanding the interdependent nature of the world implicitly transcends all boundaries of identity to deeper sense of inter-connectedness or relatedness of all things.

The students' border crossing between their culture and what would be acceptable as an empirical ecological study (of the consequences of loss of deer habitat) implies understanding of or connecting to a different way of thinking, and an ability to relate and identify beyond their own cultural roots. This type of border crossing might be what Aikenhead and Jegede term "manageable" (1999:6) and categorize as "simultaneous collateral learning," involving a "situation in which a concept in one domain of knowledge can facilitate the learning a concept in another milieu" (21).

Self Esteem and Cultural Identity: Mi'kmaq or Not Mi'kmaq

A further layer in the real/not real issue came into the interview with S1 and S2 when they discussed figures in popular culture, such as Pamela Anderson and Michael Jackson.

TS: You were saying things like vampires and ghosts are real and not real. Are you saying they don't necessarily exist as things that people can try to become? Are they kind of real in that people think them…?

S2: Like on the talk shows, people say I am a real vampire.

S1: But all you have to do is if you think you're a vampire, then that's what you think, but you're really not. Like I could just close my eyes now and say, "I am a vampire" but I won't be.

TS: What do you think you are?

S1: I'm a person, and, like a regular person can be fake too because some people are just plastic mostly. Like that Pamela Anderson girl. Plastic! Even her lips are fake…All that stuff to make her famous.

Comment: S1 continued on to describe Michael Jackson in the same vein saying, "He's not real cause he's meant to be black and if God wants him to be black, then he has to be black. So he's not real 'cause he's not black anymore." S1 made similar statements about men wanting to be women, and women wanting to be men. S2 then linked this need to change your identity to lack of self esteem.

S2: I think that people can't accept themselves for who they are and they try to change themselves a lot....Like doing all this stuff to their bodies when they can't even accept their own self. So the people must have low self-esteem to do all that stuff just to make themselves look what other people want to see.

Comment: Denial of who you are comes from low self esteem, according to S2, which makes you less than human or plastic. This conversation later evolved into the two students reflecting on their identity, personal and cultural, as Mi'kmaq. The following conversation arose because I had asked S1 and S2 if they were Catholic. I had assumed that S1 was Catholic (as the majority of Mi'kmaq are) because she had made a number of references to God and God's power as an ultimate authority. S2 said she was but S1 replied that although her family believed in God and knew he was real, they were powwow hoppers because her father had been helped by "Indian medicines."

TS: Do you think powwows are different from other dances, like ones you go to in town? Like square dances or other dances?

S2: Powwows, they do everything in a circle. Square dance is a little square. (Laughs)

S1: It's fun. I don't like square dancing so it's fun.

S2: I find when you dance more, like when I dance more with a shawl and stuff,

S1: ...you're not as shy.

S2: You feel more comfortable. You feel like you have more pride in being an Indian and stuff.

S1: That's our background.

S2: Yeah and we know how to dance and stuff. Like those other girls my cousin taught, she had to teach them about half a year. It only took me about half a day to learn how to shawl dance.

TS: The other girls were Mi'kmaq?

S2: Yeah, some of them were half. Like _____(name) and _____(name).

S1: No _____ (name) is...

S2: _____ (name) is full.

TS: So, you're both Mi'kmaq?

S2: I'm full, yeah. She's full.

S1: Yeah. I don't look very Mi'kmaq.

S2: Neither do I cause I'm so pale but when summer comes I look so dark.

S1: I'm light the whole year round so work on an artificial (?) tan (laughs)

What emerges from these interview segments is the way the students hold and negotiate seeming dichotomies, and the fluidity with which they travel back and forth between being or not being Mi'kmaq, where they find their identity in being "Indian" and dancing in a circle with a shawl, and who is and who is not full Mi'kmaq. There are a number of dichotomies they are traversing to explore who they are – square vs. round circles, Mi'kmaq vs. non-Mi'kmaq, light vs. dark skin, and so forth. Even their reflection on their own skin colour, along with their humour about the lightness of their skin, illustrates how they see and identify themselves as Mi'kmaq, and even more broadly, as "Indians," introducing yet another layer of identity – one that is pan-tribal. It also shows the same type of "fragile ontologies" at the cultural level.

Exposure to Cultural Diversity Generates Compassion

The importance of cultural identity surfaced again during an interview segment in which we discussed science. I had been attempting to discover if S1 and S2 could see a relationship between their ancestral knowledge and the learning of science. As was a common occurrence in the interviews, the students took the conversation to where they

found relevance. In this case, S1 immediately went to the larger issue of culture in the school systems tying it to the recent shootings in the school in Columbine, Colorado.

TS: Back to school and science: Would you like to see more of your ancestry brought into the curriculum?

S1: I think that they have to bring culture back into the schools because of that shooting in Colorado. They [*I'm not sure who she is referring to here, but I think she means people in general or her ancestors*] were taught to love everybody no matter what. Just cause they're different doesn't mean you can make fun of them. 'Cause those guys who did the shooting sure were teased since whatever age and they even called them the trench coat mafia because they wore trench coats. So like if I was screwing up, and if I was called stupid everyday, or weird or something, I would've exploded already. I would have been mad at everybody and I would have probably did the same thing. So, I think it has to be brought back in the school and you have to talk about God and tell everybody that God loves everybody no matter who you are and no matter what you are and you should do the same.

TS: What about you (to S2)?

S2: Umm. Like sometimes in Catechism class we talk about what God is and some people think that God is white. But really what I think is that God is already like all the colors that we are. Like Indian, White, Black and Chinese so I think he's a mixture of all this stuff and that he just put it into different sections of the world and people just, you know, they traveled a long time ago...that's why we've got lots of people here like Blacks, Chinese people out in Moncton.

Comment: The shootings at the school in Columbine, Colorado, had an obvious impact on S1. Both students are relating to their own narratives about why these shootings took place, and how they could have been avoided. The narratives are both a way to making sense of the shootings, as well as their way of identifying with the shootings and the alienation of the killers. Both are looking toward a higher meaning to find a compassionate "god" who could have potentially prevented these killings had that meaning been present for the student/killers to find in their lives. S1's compassion, interestingly, is with the students who did the shootings, and with their isolation and anger.

In her first statement, S1 sees bringing culture back into the school as a necessary remedy so students don't feel isolated or marginalized. One meaning she seems to be ascribing to culture is God's love or Christian compassion, which is inclusive. There appears to be some ambivalence between her extreme anger in her identification with the

alienated students to the other extreme concept of God's eternal and all-encompassing love. S2 sees God as multi-cultural and a reflection of all humanity. S2 also connects culture with compassion in her image of God as multi-racial.

S1's personal identification with the persecuted student is filtered through her narrative, which serves as her means to reconcile the conflicting emotions. Narratives appear to be one way people can reconcile conflict. This is an example of Postman's "god" (1996:6-7), Connelly and Clandinin's concept of a "narrative unity" (1988:74-75), and an illustration of spirituality as discussed and defined in Chapter Two. If this is true, then it would have profound repercussions for the learning of science. Students become engaged because narrative is personally meaningful. As will be illustrated in Chapter Five, students can more easily engage in science if they come to it with some meaningful narrative (spiritual) context.

A Cultural/Spiritual Context for Science

How students hold these different layers of reality relates to the learning of science and within a larger narrative occurs in at least two distinct ways that are illustrated in the following interview segment. I had asked the two students, "Can you just tell me, when I say the word science what comes to your mind?"

S2: The world itself (little laugh). And, I don't know, a whole bunch of stuff.

TS Can you tell me more?

S2: Just like everything. In science books you learn everything. Like plants, energy, light, and all that stuff. So, you might as well say science is everything and everywhere.

S1: Yeah. The earth is God's science book.

TS: Huh?

S2: Or chemicals. (They both laugh.) When we were in grade six, that's all we did was science, science, science. You had to eat, sleep and breathe science.

This is a profound interchange for a number of reasons. First, it does not deny science. Second, it simultaneously provides a spiritual context for science. In fact, it appears that these students see a boundary between spirituality and science. On the one hand, they describe the earth as "God's science book"; on the other, the "earth is just a bunch of chemicals." God is the author of the ultimate science text. On yet another level, it illustrates how people do merge what in the West we tend to regard as different spheres – the spiritual and physical – within a larger narrative, or accommodate one (science) within the other (spirituality). This example points to the need for a more holistic and more narrative based approach toward learning.

Later in the conversation, when exploring their ancestral knowledge in relation to science, another dichotomy arose:

TS: What would you say would be the difference between your grandmother teaching you about the medicine, how is that different from science would you say?

S1: I don't know.

S2: Because the medicines they use and all that, are all put together in a bottle.

S1: The medicines today, are like all chemicals and all this stuff. I mean they even have a chemical name for water. Like the purest thing on this earth and they call it – H2O.

Comment: This is a pithy statement in that science seems to be pitted against purity – "the purest thing on this earth and they call it H2O"— bringing into relationship both the natural and the abstract, or the simple and complex, water vs. H2O

What emerged from the interview with S1 and S2 was the fluidity of their thinking, their ability to hold seemingly opposite or conflicting realities, and the ideas

they felt comfortable with or used to develop some sense of identity (dancing at powwows, their spirituality, etc.). Powwows were mentioned a number of times throughout the interviews, and have an obvious role in helping the students identify with "being Indian"; but this "being Indian" identity is also fragile and multi-layered, and shows how the students continually evaluate their reality.

Five basic themes, with a number of sub-themes, were identified in this interview that have also emerged in other student interviews. These five themes are:

1. **Fragile ontologies**

   This theme focuses on the flickering, transitory patterns of personal reference points and dichotomies that are present in the students' descriptions of their realities – real/not real, Mi'kmaq/not Mi'kmaq, spiritual/material, pure/impure, simple/complex, Indian/not-Indian. Varela (2000) calls these patterns "fragile ontologies," a term he uses to describe the insubstantial nature of identity formation and the lack of a central locatable self. Varela views the self as a flickering, transitory pattern that emerges from multiple, interacting levels of experience.

2. **Multiple layers of identity**

   Included in the concept of "fragile ontologies" are the multiple layers of experience that these students draw upon, some stronger than others.

   - Personal identity: this layer involves the development of a personal style and predispositions based on a number of factors influencing each student individually. These factors include personal histories, family situations, and inherited character traits. Each student develops his or her individuality in

terms of conscious and unconscious meaning-making processes as well as personal values that vary from one situation to another. As part of this developmental process each student must decide what is true or real and what criteria (e.g., trust, intuition, situation-specific circumstances) they will use for making such assessments.

- Cultural identity: This layer involves the development of an identity as a Mi'kmaq. This identity is inseparable from the landscape traditionally inhabited by the Mi'kmaq, a landscape also inhabited by other beings (*pukalatamu'jk*). I have also expanded this layer to include a Pan-tribal identity, which involves the development of an identity as an "Indian" through participating in pan-tribal rituals such as powwows, drumming, dances (shawl dancing), and values related to being Aboriginal.
- Societal identity: This layer involves the development of an identity based on an awareness of differences between the Mi'kmaq and pan-tribal realities and the "outside," non-native world. This identity shows up in their understanding of a different way of thinking: about the earth through science concepts (as just a bunch of chemicals); about environmental degradation that leads to loss of deer habitats, about different ways of performing cultural rituals (square dancing vs. circle dancing); about cultural stereotyping based on skin colour, Indian status (full or not full), and general appearance (not looking like a Native); and about the non-real appearance of popular culture icons such as Pamela Anderson and Michael Jackson.

3. **Border crossings** – how the students bring together these different layers of existence, e.g., relating *pukalatamu'jk* with deer crossings, connecting science to spiritual beliefs and cultural traditions, or identifying with both the victims and the attackers in Columbine, Colorado. The students appear to bring together different and often opposing layers of existence to form boundaries that share a mutually dependent border – two sides of the same coin so-to-speak – that appears to be crossed without hesitation or cognitive conflict.

4. **Cultural Continuity/Emerging Culture**

   The students appear to integrate both cultural continuities and emerging cultural beliefs without apparent conflict. This integration can be seen in their beliefs in *pukalatamu'jk* as helpful in the woods and as evil because they knock down crosses. Stories about the *pukalatamu'jk* as helpful comes from continuing cultural beliefs passed on through ancestral knowledge while stories of the *pukalatamu'jk* as evil come from emergent cultural beliefs that are tied to Christianity, a relatively recent addition to Aboriginal beliefs.

5. **Beyond Borders to a Spiritual Narrative**

   In Chapter Two, I defined spirituality as "the student's experience of relatedness, or interdependence". The students I interviewed seemed to have an understanding of the interdependent nature of everything, seen and unseen, tangible and intangible, as witnessed by their various discussions of aliens, *pukalatamu'jk*, God, and their ability to empathize and feel compassion for the students in Columbine, Colorado. They expressed concern about disturbing the caves of the *pukalatamu'jk* although they acknowledge that the *pukalatamu'jk* may not exist.

It is this dimension of being able to unite opposing ideas that extends their identity beyond their own cultural/societal boundaries to some sense of connectedness with the rest of the world. This theme encompasses Postman's (1996) concept of "god"; Hampton's (1995) inclusion of spirituality as an essential component of Indian education; and Connelly and Clandinin's (1988) concept of "narrative unity."

To illustrate these five themes further, I will draw on other student interviews.

Fragile Ontologies and Personal Identity within a Cultural Context

The second interview, with S3 and S4, illustrates some of the themes already outlined and shows the variation of the experiences and the border crossings each one makes or does not make depending on the context or "reality" of their experience. The following conversation occurred after a lengthy dialogue about why S3 had no interest in science

TS: But say, we're going to study the lesson about diversity, like ecology. There's a lot in your own community that you could learn about while learning science as well. Like about the sweet grass and what happened to it and why did it go away. Is that interesting to you?

Comment: The students had already told me about places their grandmother (S4) and mother (S3) had taken them to pick medicines, get clay, and pick sweet grass in a previous interview that was not recorded. They had also talked about pukalatamu'jk and mentioned the caves by the river. They told me that sweet grass was no longer available locally because of a bridge that had been built where it grew. Because we had already talked about these aspects of their life, I was trying to see if they could border cross between their experiences with sweet grass and science.

S3: Mmmm.

TS: I mean would you like to see more of that in science? Do you think that would help you get more interested?

S3 & S4: Yeah.

S3: They talk a lot about that at powwows.

Comment: S3 immediately made the association between powwows and sweet grass thus relating it to a more familiar and concrete framework, and shifting the context from the one to which I was referring. In this moment, I had to drop my own assumption about what I was looking for in the response. I had assumed that S3 would relate to the general concept of environmental degradation, using the loss of the sweet grass picking area when the new bridge was built as an example. Instead, she related sweet grass to something culturally familiar (her Pan-tribal identity) and positive in her life.

TS: Like what?

S3: Like about the sweet grass and mother earth...

S4: Eagles. Mostly eagles.

Comment: S3 makes the association of sweet grass to powwows and Mother Earth. S4 takes the association even further, leaving my question about relating science teaching to something such as the loss of sweet grass, far behind. We are now in a completely different discussion about powwows and what is talked about there. The students have put my question into a larger cultural narrative, showing some important reference points. This conversation is an example of the thread that can connect science with what we term spirituality. From this point, the content of the lesson could continue to discuss eagles, sweet grass, and the concept Mother Earth, which I did in my trial chemistry lesson (See Appendix D). This is a kind of border crossing.

S3: They tell stories.

S4: Usually when the eagle like flies over a powwow ground, they'll start freaking out. I find anyways.

TS: They get excited you mean?

S3: Yeah, the eagle crossing there, and they'll tell a story about it. I really don't know why. I think it's like good luck or something like that.

Comment: This is an example of their process of meaning making. S3 is attempting to understand and speculate why people get so excited when an eagle flies over. She is not just in the narrative; she is also observing and trying to interpret the meaning of the narrative and finding her own personal identity within a cultural context. Part of the meaning making is to understand the emotional investment associated with the eagle sighting – the "freaking out."

S4: I thought it was good luck.

S3: Or when you find an eagle feather, good luck.

S4: Yeah, and if you have an eagle feather and if you drop it on the ground, you can't touch it no more. You have to give it to someone else. Mine's locked in the cupboard.

Comment: Now we have gone from an initial question about relating science to the sweet grass and the ecosystem within the community, to powwows, eagles and eagle feathers as possibly bringing good luck. It is then brought down to the students' own personal eagle feathers. Again, there is some uncertainty or ambiguity about their relationship to these features. The students are simultaneously evaluating and questioning the meaning of the stories about the eagle and the eagle feather, and people's reactions to it, while also going along with it and having their own eagle feathers. This fragile ontology aspect based on both real and not-real qualities is similar to those expressed by the talk between S1 and S2 about puklatamu'kj. They are making meaning by testing reality in the sense of evaluating their experience in different contexts and on the basis of both personal and cultural identities.

There is also an awareness of the protocol involved in how one treats an eagle feather. This type of protocol would be important to note within the teaching of scientific processes.

TS: Do you think that's science. The stories you hear? I remember last time you were telling me about the stories your grandmother told you about the fox.

S4: Oh God, those fox…

TS: Is that right? Why are you laughing?

S3: Your fox stories

S4: Yeah, that's more like social studies.

TS: You think that's more like social studies?

S3: Yeah, the history.

Comment: The students are categorizing the animal stories as not science. This implies the students have some criteria to discriminate what they think science is and is not – science is not history or social studies.

TS: Do you think those stories tell you anything about the animals, or what they're about?

S3: No, just what they were – like stubborn or happy.

S4: I think they are happy.

S3: The fox is stubborn.

S4: The fox was happy.

Comment: It seems here that the students are saying that the stories do not say anything objective about the animals, just what their personalities were like. The students were able to discriminate between the general characteristics of foxes, which is closer to a more objective approach, from the particular personality of a fox discussed in a story.

There is potentially a more profound exploration that could take place which has to do with Mi'kmaw traditional world of reality. This could reflect or stem from a traditional belief in a continuum between the animal spirit and the human spirit. As with the description of the eagle at powwows, we cannot assume that the students' relationship to the animal stories is fantasy or anthropomorphic projection. This aspect of the culture can also be witnessed in the extension of kinship terms to the animal realm in a familial relationship. Many Aboriginal people say: "We are all related."

This interconnectedness between the animal and human realm makes the narrative more powerful (Whitehead 1988:12). The implication for pedagogy is that a teacher should not make an assumption that the stories are just fantasies to students, as previously seen in the dialogue about *pukalatamu'jk.* Yet in the next segment from this interview, it appears the students may see them as fantasy. In other words, a teacher could close down a dialogue by making assumptions about student's relationship to different experiences of reality.

If the curriculum has been developed with sensitivity to alternative cultural perceptions of reality, and the teachers are prepared, then they can enable the border

crossing necessary for the students to be receptive to the scientific perspective. To establish receptivity to western scientific view, it is necessary to acknowledge the narrative and go deeper in our own assumptions about what narrative is and what fantasy or belief is. We need to understand how students experience their world which, as discussed in the previous chapter, is where learning begins.

Once a meaningful relationship to the subject matter is established, for example in the context of the animal stories, then questions can be asked such as: "How would a scientist relate to a fox?" Then scientific questions about overt, observable characteristics and the symbiotic relationship of animals and their environment are no longer regarded as alienating or conflicting points of view but part of the larger dialogue. As a result the scientific approach would have more context for the Aboriginal student.

TS: What do you think when you hear the story of the eagle? Do you think that is social studies?

S3: Mmmm.

TS: A myth?

S3: Yeah, just stories they like to tell and change. Like every time they tell it, they make it sound more exciting every year. And when it does happen, everybody's freaking out.

S4: Freaking out.

Comment: Here the students themselves see people of their own culture, telling stories from their own culture, as a myth, or fantasy in that they change them from year to year just for excitement. This is important in seeing that the overall discussion is not about pitting one cultural view of reality against another, but seeing the underlying view the student has of any experience whatever the culture.

These comments illustrate Varela's core processes of suspension, letting go, and redirection and his concept of fragile ontologies (Varela 2000:12) and represent a deeper level of reflection in terms of how the students experience and attempt to make sense of

the narrative. The student is faced with uncertainty (suspension) because of the dissonance between the eagles and eagle feathers bringing good luck and people "freaking out." She also notes that people keep embellishing the story with the result that they get even more excited when eagles fly over. On another level, S4 is seeing and recognizing the making of myth, and then is able to distinguish that from science for herself. She is not saying one way is right or wrong particularly, but just observing and finding her own meaning about it all in the process. This is the letting go and redirection part of the process and involves a type of border crossing. Part of this meaning is her own uncertainty about whether she believes it to be real or not-real. We also see her recognition of the historical context of the eagle stories and their evolution from year to year, and how knowledge, and hence truth, is reinvented, which is the emerging aspect of culture. This one dialogue is an example of the factors that play in identity formation – personal, cultural, and societal, and the historical context as well as the meaning-making or emergent aspect that occurs.

Cultural Continuity, Pan-tribal Identity and the Sacred

The third interview, with S5 and S6, builds further on the themes already illustrated. In the interview, S6 talked about wanting to teach about his own culture to other people. He drew on his experience as a drummer at powwows. He had learned drumming from one of his neighbors. S5 had learned shawl dancing from her sister. Both had attended powwows. I told the students a story about the first powwow I had attended in 1992 and an intimidating experience I had while filming the dances. I had been warned about not videotaping certain songs and dances, and was dutifully trying to respect that rule, but

was still nervous that I might do something wrong. As I stood videotaping, a group of large, Mohawk dancers in full regalia left the dance circle exiting right where I was set up with my video camera. They broke like a wave around me and my camera, and I was literally afraid of being run over. My camera immediately blipped out and stopped functioning for a few minutes. In response to this story, S6 said:

S6: Were you supposed to be filming on that song?

TS: It was o.k. I wasn't doing anything wrong. It was just that I was still trying to get to know...

S6: I believe in stuff like that because a couple of the powwows I went to...There was one group, they drummed the first day. They went out that night drinking, came back, they were drumming, and their drum cracked (S5: You're not supposed to...) right in half.

TS: Really?

S5: You're supposed to be...

S6: ... four days clean.

S5: ... sober or like not take any drugs or anything for four days before you touch a drum or tobacco or sweet grass

S6: All this sacred stuff.

S5: Yeah.

S6: You're supposed to be clean....

Comment: This message of sacredness, which is prevalent at powwows, again points to a significant guiding theme that there is something sacred (the drum) or pure (water) or objects that bring luck (eagle feathers), that must be respected (pukalatamu'jk, eagle feathers, deer habitats) or there will be consequences to their actions (the drum breaks in half, warning signs go up about deer, crosses are knocked over). Powwows are part of the students' emerging cultural identities in the sense that they are becoming pan-tribal, and different tribal practices are being adopted by the Mi'kmaq (e.g., the shawl dancing that S5 learned from her sister who had learned it out west). But the principles are traditional as seen in the stories about pukalatamu'jk, medicines, sweet grass, etc. Sacredness, natural

purity, luck (chance) all become narrative themes that can be used to create a context for introducing scientific logic.

In this next segment we again see the cultural continuity in the stories that S5 and S6 heard growing up.

TS: Did you grow up hearing about your culture?

S6: Oh yeah.

S5: My aunt, or his aunt.

S6: Like my grandmother and, they all talk about it. Really all the elders. If there was someone to listen to and then there was an elder, I would rather listen to an elder cause I find it more interesting to listen to the elder instead of somebody else.

TS: Have you always felt that way?

S6: Oh Yeah.

S5: My grand poppa, once he starts telling a story he'll never stop.

TS: What kind of a story for instance?

S6: When I was a young lad, all those stuff. When they were young, what they used to do, about Kluskap, a couple stories about that.

S5: Kluskap.

S6: About sweet grass, that story. (Hair? Inaudible) All different ones, you hear them all the time.

Comment: Here again we find cultural continuity, the IEK aspect of their lives, in the stories these students heard growing up. Not only do they recollect stories about sweet grass, they also know places near the community where sweet grass used to be picked prior to the building of the bridge.

My work on developing an Earth Science curriculum, and on Legends as Maps, specifically delved into this association between rock and land formations and Kluskap sites (Sable 1993, 1996). Kluskap stories are often associated with specific sites and rock formations throughout the Maritimes. These legends are embedded in the landscape the

Mi'kmaq traditionally inhabited, and unlike aliens and rock stars, the landscape is an integral part of their cultural narrative.

Border Crossing Between IEK and Science

Unlike S1 and S2, the border crossing between their own cultural knowledge and science proved a bit more difficult due to S6's persistent dislike of science.

TS: Would you consider some of the stories you heard science?

S5: Not really (giggles).

TS: Especially ones that had to do with...

S6: Kluskap and stuff.

S5: Animals.

S6: The ring-tailed racoon.

TS: I never heard that one.

S5: How he got his rings around his tail.

S6: Yeah, I think so, some science.

TS: Like how that might be science?

S5: Has to do with animals, I dunno. Life or something, I guess.

TS: How about you (S6)? This is a serious question. This is what I am working on.

S6: Say the question again.

TS: I started out asking you about things you heard from your parents or grandparents, some of it has to do with animals and the environment...

S6: Say something about science?

TS: Yeah, would you consider that science? What they told you?

S6: Yeah, some of it. Cause like they had to look back and back, (tape inaudible)...they had to go and test stuff out. I don't know really. Ask S5, she knows everything.

S5: No I don't.

TS: This is what I am working on. I'm trying to see if there is actually a way those two things could..

Comment: I am making my purpose explicit here, bringing the students into the actual work I am trying to do.

S5: I guess. (Giggles) Well they used to drink medicines, they didn't know what they were doing they just knew. Like how to get rid of scurvy, I guess... diseases.

S6: I don't know. I don't really like science though. I don't really like science.

Comment: Here is a total disconnect. S6 earlier spoke about his deep interest in learning about his own culture, drumming at powwows, his beliefs regarding the sacredness of the drum, his desire to learn from elders, etc., but his resistance to science as he had experienced it, prevented him from even wanting to bridge the two together at this point.

This exchange seems to be an example of what Aikenhead and Jegede (1999: 19) refer to as "parallel learning" where no interaction among conflicting schemata occurs. S6 is not interested at all in science, even when given the opportunity to bring his cultural background into the learning of it. His grades in science were high (mostly 90s), but his interest in it was waning.

Societal Identity and Border Crossing

Moving beyond the classroom, the following interview highlights social factors influencing these students' life experience.

TS: O.K. One more question. Are there any special places outside the school, here in the community that you consider special?

S6: I think we should get that mill out of here. Move it somewhere else. Put it in the middle of nowhere...It's killing everything.

Comment: My assumption by using the word 'special' was that the student would mention a place with positive associations, but S6 immediately focused on a negative example. The mill is 'special' because it pollutes their environment. Here is a moment where the dissonance between my assumption and his response became a point of possible exploration. We had reached a borderland area, where we could consciously highlight the uncertainty that had arisen and use it as an opportunity for dialogue.

S6: Our beach man…It's polluting all the river.

S5: This water's polluted down there.

S6: We know for a fact it's polluted. Used to be...

S5: Yeah, like dead fish on the shore and everything.

S6: People tell you it used to be clear, nice to swim in. Go down there now, you go swimming you get leeches and stink.

S5: Leeches on your legs...

S6: …brown, you can't see nothing.

S5: Yeah. Once you get in there, and once you get out, you have to watch (*wash? inaudible*).

S6: Sad.

TS: So, where do you go swimming?

S6: Pool. I got a pool, she got a pool.

TS: Really?

S5: Yeah, a lot of people got pools here now.

TS: Are leeches a sign of pollution?

S6: I think so. They suck blood anyway. They're on my driveway sometimes too.

As this conversation unfolds, we begin to see the string of co-emerging relationships. Environmental issues came up in three interviews. S5 and S6 have directly experienced the effects of river pollution and environmental degradation, S1 and S2

discussed the loss of deer habitat, and S3 and S4 talked about the loss of sweet grass sites. Another student made reference to a land claims case against a paper company that wanted to build a processing plant next to land used for traditional practices. Talk of the legal proceedings against the mill was prevalent in the community, and the students themselves had been interviewed by the lawyer handling the claim for the band. Part of the students' identity was being informed by political discussions within the community, and a growing political consciousness was emerging as an important aspect of the students' cultural identity, as can be seen in an interview segment with S3 and S4.

TS: Do you ever think, like when you are doing a lesson, that some of what you know is what they are trying to teach you? Like is there anything that you feel you already know in your science lesson that they are trying to teach you?

S4: Mmm. About what?

Comment: My question was too vague, but I wanted to find out if there was anything they learned in their science classes they felt they already knew from their own experience or learning in their own community.

TS: Is there anything that you've picked up from just being here? With your family or with your friends?

S3: Ummm. Lately they've been talking a lot about the crown land situation and stuff like that and that they want to cut the trees down and stuff like that. It kind of makes you think to respect the forest more than you used to. Especially that guy that interrupted the breakfast one time. He said he's... (inaudible) about crown land and they won't let him take his wood out of the pulp mill or something...

Comment: The notion of respect again comes in, as well as the emotional and social impact of these issues on the students themselves. A bit further in this conversation, S3 talked about this man "freaking out" another student because he was carrying on about the situation at this breakfast.

In teaching environmental science, for example, in determining measures of environmental pollution, a teacher might fail to understand how personal and emotional this subject might be for his or her class. The issue potentially becomes more complex for

Aboriginal students as they enter a provincial school where other students may have parents employed by the local mill. The role of the mill in the community adds to the tension around social relationships. A Mi'kmaw student may come to school with a respect for the natural environment that is not based solely on an economic model of resource use. Rather, the local environment embodies this student's history and culturally inherited world view. This world view has its own natural order and sense of the interdependence of living things which includes *puklatamu'jk* and other beings with whom one relates. The scientific approach could be used to show there is increasing evidence that life forms in a local habitat are indeed interdependent, thereby engaging Mi'kmaw students in "dependent collateral learning" (Aikenhad and Jegede 1999: 21) .

All these factors ultimately affect learning. It is this type of situation where an inter-cultural dialogue in science could assist in increasing students' consciousness and knowledge about different perspectives and possibilities of relating to the situation. They are part of the totality of the student's experience, which the teacher needs to understand to open avenues for dialogue with the student.

Personal, Cultural, and Societal Identity

In this interview, one of the students (S6) had been in the provincial system from Grade 1-7, but had switched to the band school for reasons he articulated in the following conversation. I am inserting this dialogue as an illustration of the multiple factors that are pushing and pulling S6 and to illustrate the different levels of identity at play – personal, cultural, and societal.

TS: Are you going into Newcastle next year? Is that the school?

S6: Yeah, MVHS.

S5: High school

TS: Are you excited about that?

S6: Oh yeah

S5: Yeah.

TS: How come?

S6: It's too small a school. Not enough people in here. I suppose it's good because you get a lot more attention and you do a lot more work and stuff.

TS: Here?

S6: When you go up there, it's going to be a class of thirty. Down here you have a class of five. A lot harder though.

TS: There?

S6: Mmhmm. They don't give you as much breaks as down here. 'Cause I was in Harkins, I was in [provincial] town school since like Grade 1...to like Grade 7.

TS: Is this your first year here?

S6: Second

TS: How does it feel, the difference?

S6: Oh, it's a lot easier. My marks went way up.

TS: Here?

S6: From Fs to like As and Bs. I had straight Fs before I came here.

TS: What do you think about that? Can you tell me?

S6: Like the reason I was getting Fs and stuff was I wouldn't do my work and I didn't want to (inaudible) and I didn't like the teacher. I wouldn't do it. More like stubborn really. I came down here and the teachers are nice, they don't growl at you as much. Plus I can't do nothing because my grandmother's just right there and stuff.

TS: But what do you think is the most important thing about learning in school? Not necessarily a subject but what do you feel is the most important thing about a school that makes you want to learn?

S5: Attention. (*partially inaudible*)

TS: What I'm trying to get at is that you just said your grades went up, and the teachers were nicer here. Would you say that is one of the most important things about getting students to want to learn?

S6: I like starting off [in the community school] because I don't want to repeat a grade or nothing. I want to end up in college somewhere. I want to get the grades. And I think here is going to give me more confidence so I can go on to high school and do it.

Comment: On a personal level, S6 recognizes his stubbornness is an obstacle to learning, but clearly states his desire to succeed. However, the large class sizes, high demands and unfriendly teacher provoked his stubbornness, which undermined his self-confidence and performance. He returned to the community setting where the cultural familiarity, the presence of his grandmother whom he respected, and the friendly relations I observed between him and his teacher, helped him to perform well and rebuild his self-confidence. S3 also came from a broken family, and he spent much of his time at the home of S4, his second cousin, with whom he had a very close relationship. In fact, later in the interview, they engaged in a friendly banter about who got the best grades.

Here, S6 appreciates the closeness and confidence he receives from his own community school, but also sees himself continuing on to succeed within the Canadian educational system. He also recognizes his own stubbornness as part of his failure in provincial school, and the need for boundaries provided by his grandmother. What emerged thematically from this conversation was the interplay of the different layers of his identity – personal identity (stubbornness), cultural identity (his home school and family, e.g. his grandmother, all of which protects him and gives him confidence), and the social identity (who he wants to be within the larger Canadian society).

This dialogue is another example of the "border-crossings" and "fragile ontologies." S6's failure in the provincial school could be attributed to several variables – the teacher's personality, conflicting cultural values and behavioral norms, societal expectations, or individual learning style. Any number of variables might have been identified as the reason for his failure, but the complex reality may have remained

obscure. Without contextualizing it within a web of relationships that S6 is negotiating, and without understanding his internal experience of these relationships, we cannot work towards a pedagogy that would open up new possibilities of learning for him. Aikenhead and Jegede's (1999) border crossing model suggests that S6 felt he had encountered an impossible border-crossing in his attendance at the provincial school.

It is important to note the co-creation or co-emergence of conditions causing S6's alienation from the learning process: the interaction among his inherent nature, the cultural norms he had been raised with, and the impersonal and uninviting classroom culture at the provincial school.

Border Crossing and Cultural Continuity: Literacy in Two Languages

As a final example of fragile ontologies and border crossings, I am including a segment from the interview with S7 and S8. Both these students were in 7th grade and both were in special tutorial sessions in Math and English. Both put science in their least favorite category of subjects, but later stated that math and science were the most important subjects to learn in school to prepare you for life. Of the four interviews, this was the shortest, and S7's attention span was as it was in class–short. In class, S7 often asked for permission to go to the washroom, library, or somewhere other than where he was. What was of interest in the following segment was that it was the longest period of time these two gave to any topic I had introduced. They displayed interest in the topic, and carried the conversation beyond perfunctory responses.

TS: I was just asking S8 whether his parents or anyone in his household spoke Mi'kmaq, the language?

S7. What did he say?

TS: (laughter) I'm asking you now.

S8. _____(name) speaks lots of Mi'kmaq.

S7. Well my mom and my dad speak Mi'kmaq .

TS: Do they speak it to you? I mean do you understand it or speak it?

S7. Some of it 'cause every day I hear they want tea and they want coffee...

TS: *P'tewey.*

S8. *P'tewey na*

S7. Can you pass me the bread...

TS: *Pipinaqn*

S7. You can talk Indian?

TS: A little bit.

S8. Yeah, *pipinaqn.* That's what it is.

S7. What, you looked at this or something? (There are Micmac-Maliseet language papers on the desk)

TS: No, I've been talking to Mi'kmaq people for ten years. I've been studying a bit. But can you understand when someone is speaking to you?

Comment: This was the first time the students took an active interest in what I was saying and crossed a border to find out more about me and how I had come to know the language. Their surprise that I knew something about their language opened up the communication between us for a brief period of time. Reflecting further on this conversation, I realized that it allowed them both to speak about something they knew about, and that I was interested in knowing about as well. It took the conversation out of the "school" realm to the broader "cultural" realm.

S7. Yeah, I say Pat, give me some *samqwan.*

TS: *Jikalasi.* What is "Give me?"

S8. *Jikalai*

TS: What's "Give me?"

S8. Oh, "Give me?" or...

TS: Like, "Give me something."

S7. Bring it here?

S8. That would be *jikuwey* but...

S7. *Jikuwey* means come here, and *jikalai* means "go away."

TS: But can you understand it pretty well?

S8. I can't that much.

(A short while later in the conversation.)

TS: Do you think it's important? The language?

S8. Yeah, I think.

TS: Can you tell me what you think would be important about it?

S8. Umm, I don't know.

TS: (laughs)

S8. I really don't know.

TS: To preserve it? Do you think it's important to have it in school?

S8. Yeah. Or, in between. Should be...We had Mi'kmaq yesterday.

Comment: S8 held his own in response to my leading question. Here I am asking him, in essence, if he thinks it is important to preserve his language and have it in school. He has a mixed reaction, but later (next response) refers to the younger kids in the school knowing all these animal names.

TS: Do you enjoy studying it?

S8. Yeah. The little kids in K-4, they can say all the animals and everything in Mi'kmaq.

Comment: This final reference to the younger children learning Mi'kmaq was poignant. In a later segment of the interview about what interested them in science, S7 pulled out his textbook and wanted to show me a chapter where they studied animals. He then showed me the physical and chemical change

experiment they did a couple of weeks earlier for which I had provided some of the chemicals and had videotaped the session.

TS: So are there science lessons that you've had that have taught you something that you didn't know before?

S7. I'll show you the one right here.

S8. Science book.

(S7 gets out his book and looks through it)

S8. What are you doing (to S7)?

S7. Looking up this science with animals man. We did all kinds of things with animals.

Comment: As noted in the first segment of the interview, S8 had mixed feelings about the importance of having more Mi'kmaq in the school, but was aware of the younger children learning the names of all the animals. In this interview, there are two references to animals—one involving their names in Mi'kmaq, and one involving a science lesson that S7 remembered doing. The first discussion on language had engaged the students beyond the norm exhibited in our interview, and the lesson on animals seemed to have stayed in S7's memory.

There are a number of moments in the interviews that could be used to create a dialogue between science, the student's personal experience, as well as their cultural narratives of the environment, and their language. These relationships already exist within the students' own narratives, and a teacher listening carefully, might begin to bring these relationships into greater awareness. A teacher listening carefully might also begin to understand the conflicts the students experience, such as being raised with a traditional cultural respect for the land while surrounded by environmental degradation. These conflicting influences that shape the students' relationships with the environment are what a culturally sensitive pedagogy attempts to bring into consciousness. What appears as a point of conflict holds the potential for a "teachable moment." Varela (2000) would view nurturing awareness of these moments in terms of his three-fold

process of suspension, letting go, and redirection. This is an expansion of what Duschl has called "speaking together times" in that we are not trying to supplant one way of thinking with another, but rather exploring all ways of thinking and how they relate or do not relate with one another. In placing science within a larger narrative structure, the students can begin to understand what makes science "science" while simultaneously allowing for them to find personal meaning within the learning of science in the first place.

Through the establishment of dialogues or "speaking together times," the webs of meaningful relationships and relevant associations students are making will emerge. Simultaneously, the teacher and students will become aware of where re-accommodating, suspending and redirecting occurs in each other's thought process. As can be seen in the previous dialogues I cited, there are a number of places where the students go back and forth in their minds about what is and isn't science, what is or isn't important, and the ease with which they moved into talking about powwows, eagle feathers, stories, and the like. There are many places I also redirected my own thinking. As a final example, I will return to a conversation with S1 and S2 about the creation of a cross-cultural science curriculum.

TS: You know that I was thinking the other day – one of the things I try to do working with various people always trying to bring what your ancestors into science because they knew so much about land and everything, like you were talking about. Like the other day when you were talking about chemical change right? That same day, you had that canoe making. Remember? You know, just the fact that the person making it…

S1: He knew how to make the wood bend...

Comment: Immediately, once again, this student understood the concept of physical change.

TS: And also the sap, blending the sap and the fat and heating it to the right temperature. You know, it was all about physical change. Would that be interesting to you? That kind of tying that....

S2: Yeah, like Indian people make those kinds of boats. And it's kind of like science too because when you do something with chemicals, you have to make sure it's the right amount, the right temperature, and the right kind, and just like how they were making that sap and the fat and that kind of stuff.

Comment: Here too is a teachable moment. The student is saying it's "kind of" like science, and then goes on to describe how. This is still the "doing of" science and not the theory-building Duschl calls for, but it would be at this juncture that a teacher could encourage the dialogue further about why or why not the examples are similar.

S1: And like dying quills and stuff and... they know how to get them, they know how to cut them so they won't get hurt, they know how to dye them, they know how to put them together.

TS: Do you think that would be interesting. I mean, I'm not trying to say you shouldn't learn science as it is now in the books and stuff, but I think it seems any other cultural stuff is put in social studies or history, but when you look at it there was all this knowledge people had. I don't know, what do you think?

S1: That would be cool cause it would be like part of their culture.

TS: I'm not saying don't learn science but rather create a dialogue.

S1: They're both important.

Comment: Again this clarity comes through in the students' ability to quickly discriminate science from studying culture, while simultaneously understanding they are both important. Their notion that it is cool was said with animation and from my perspective, genuine interest.

What is important here is that a moment of creative exploration occurred. First, both students immediately made the connection of the canoe making to their science lesson on chemical and physical change. Second, S4 is saying it's "kind of" like science,

and then goes on to describe how. Third, the students were also able to discriminate science, or at least their understanding of it, from studying culture, while simultaneously understanding they are both important. It would be at this juncture that a teacher could encourage the dialogue further about why or why not they are similar. Finally, S1's statements that "it would be cool because it would be part of their culture," were said with animation, and from my perspective, genuine interest.

Summary

An analysis of how the students in this study found meaningfulness or relevance within an ambivalent and often contradictory world yielded phenomenological themes (van Manen 1990) or knots within "webs of significance" (Geertz 1973) and narratives or personal stories (Connelly and Clandinin (1988). Five basic themes with a number of sub-themes were identified and were illustrated by segments from interviews with participating students. These five themes are: fragile ontologies, multiple layers of identity (personal, cultural/pan-tribal, and societal), border crossings, the continuing and emerging aspects of culture, and beyond borders to a spiritual narrative.

The interview segments presented in this chapter illustrate the types of narratives already at play within the students' minds, as well as the fragility, as defined by Varela, of their identity formation process. Multiple layers of identity – personal, cultural, pan-tribal, and societal – have emerged in these interviews. The students reflected upon their identities in a number of ways at different times, for example as Christians, powwow hoppers, Mi'kmaq, "Indian," students, and future citizens within Canadian society. But within each identity there was also ambivalence and the need for some overarching

narrative to bridge seeming dichotomies. Examples of this ambivalence are the real-not real aspect of perceived experiences, the Mi'kmaq/not-Mi'kmaq delineation, and the myth vs. science boundary. Varela (1996) describes the insubstantial nature of identity formation and the lack of a central locatable self. Rather he sees the self as a flickering, transitory pattern of figure that emerges from multiple interacting layers of experience.

If we take S6 as an example, the "webs of significance" were his family, his cultural community, both the band and provincial school despite his negative experience, as well as his negative opinion of the environmental degradation brought on by the intruding paper company. The thematic knots included his continuous desire to study his own culture, participate at powwows, get rid of pollution, and not yield up his stubbornness in his personal dealings with the world.

The students described many examples of cultural continuity during their interviews – the ongoing use of the language, the presence of legends, and references to sites associated with legends such as the *pukalatamu'jk* caves and Kluskap legends and resource use such as sweet grass picking areas and the pollution of the swimming beach. In these references, the students demonstrated a respect for their ancestral knowledge and a belief in the values embedded in the stories and their relationship to the land. These stories were associated with their immediate landscape rather than with remote landscapes providing a sense of immediacy in their belief system. These legends are part of each student's identities which are inseparable from the landscape.

Their cultural identity is based on both the Mi'kmaw culture and shared, pan-tribal culture. The latter was often derived from powwows through the learning of

drumming and dancing, through hearing stories about the sacredness of the eagle and seeing the eagle flying overhead.

In contrast to this cultural and pan-tribal identity, the students' also expressed an identity based on larger societal issues involving the degradation of the surrounding landscape – destruction of the deer habitat through over cutting in the forests, pollution of the river by a business that provided economic support to many families, the loss of a traditional sweet grass growing area to accommodate the building of a new bridge. This societal context would eventually include, and already did include for S6, their attendance at a provincial high school; and their general place in history as Aboriginal students in Canada and future citizens of the country.

The students described many instances of border crossings, the process of navigating mutual boundaries between seeming dichotomies. Most of the students, while believing in *pukalatamu'jk* also expressed uncertainty about whether these beings really existed; but just in case they existed, the students described approaching their caves with great respect.

A fifth theme, which I have called "beyond borders to a spiritual narrative" ultimately circles back to the fragile ontologies of the first theme. This theme is based on an intrinsic "decenteredness" (Varela 2000: 14) that involves an understanding of the interrelated aspects of all things. The students expressed a sense of connectedness within some overarching narrative, or a sense of totality that brings them into relationship with one another, their landscape, and the rest of the world. This dimension naturally extends the students' identity beyond their own cultural/societal boundaries to some sense of shared humanity or shared identity. Within this unbounded dimension the students seem

able to reconcile conflict and ambivalence. This aspect of their identity appears similar to the ideas of "narrative unity" (Connelly and Clandinin 1988), "god" (Postman 1996), "spirituality" (Teasdale 1999), and the "unalienated self" (Hampton 1995).

Chapter Five

A Culturally Interactive Pedagogy for Science Education

Introduction

This chapter focuses on narratives and themes that emerged during the field trips conducted with Steven Ginnish, a silviculturist who manages a model forest project within the community; and the trial science lesson I developed and conducted with the teacher in the classroom. These themes continue those derived from the interviews with the students and expand them into the larger setting of the school and the community in which these students are situated.

As in the previous chapter, I present dialogue from the videotape of the field trip interspersed with italicized commentary. In the discussion of the trial lesson, I draw from my notes written during and after the lesson since I was unable to record it. These notes are presented as one reflection piece on my observations and experiences during the teaching session with added commentaries in italics.

The Field Trip: Creating the Narrative

The purpose of the field trip was to bring the environmental knowledge and practices of the Mi'kmaq into dialogue with Western science, and to connect the learning process to a successful model forestry project within the community. Originally, I had proposed that one of the field studies from *Science Plus*, the text being used in the classroom, be incorporated. I had made alterations to one of the field exercises in the unit dealing with the "Diversity of Living Things" in hopes of offering some alternative ways of viewing

and coming to know the landscape. I had also created some of my own exercises, but none of these were introduced during the first field trip because of a shortage of time.

Although my original aspiration to pilot some of the exercises was unfulfilled, in retrospect, what did occur was far more significant than the lessons I had proposed. The brilliance of the field trip lay in the way that Steven created a narrative in which both environmental practices of the Mi'kmaq and science were brought together. This provided a context for the students to relate to the scientific material, which included some of the tenets of silviculture (e.g., forest regeneration, harvesting practices, and forest ecosystems), and introduced specific skills, such as how to determine the age of trees using a tree borer or counting the whorls. The field trip created the potential for introducing lessons on taxonomy, ecosystems, and the diversity of life from different cultural perspectives.

The following excerpts were chosen from the field trip to illustrate the effectiveness of narrative in creating a learning context with which the students can identify. These excerpts also show how science could be integrated into a larger narrative and be regarded as one part of a web of relationships, without losing the integrity of the discipline itself:

SG: Do you know what this tree right here is called?

(A number of students call out cedar.)

The tree behind you is called eastern white cedar. That particular tree there is one of the most important medicinal plants of all Native cultures. If you go, like here where we're from we're known as Micmac people, that tree there (points to the tree) is very important to us. If you go out to the west coast and talk to what they call the Haida Indians, that tree there is very important to them. Anywhere you go you'll see a lot of our elders have a bowl that has four medicines in it and this one's one of the most important ones. There are three other medicines that are very important. You've got the cedar of course. You've got sage. Sage grows here somewhat but it isn't the real good sage, but I'll show you what it looks like. It's called "pearly everlasting," and I'll show you that plant if we see it. Tobacco's very important. The problem is tobacco is commercially produced so you get it in a package. But in the wild you get native tobacco from a dogwood tree and I'll show you what a dogwood tree looks like. That's where you actually get the Indian tobacco from, it's from dogwood trees. The other medicine that's really important is what Trudy gave me in the classroom, sweet grass. Those are the four, very important medicines

Comment: What immediately struck me about Steven's narrative is how he set the context of learning about the forest within First Nations' traditional use of trees for medicines, and invoked the lineage of their ancestral knowledge by reference to other tribal groups. He also brought together past and current uses of these medicines within First Nations cultures, as well as tied it to the land on the reserve by showing what plants could be found in the students' own environment. He further brought together contemporary issues regarding commercial tobacco, contrasting it with the wild native tobacco, saying "Indian tobacco" comes from dogwood trees. Everything in this presentation seemed to situate the students within a larger, national Pan-Tribal identity, while also tying the lesson to their immediate community and their own elders. He also situated the students within the larger Canadian society through reference to the use of these plants in the commercial packaging of tobacco and to pharmaceutical medicines in the next segment.

SG: I'm going to show you how to stop bleeding in the woods. If you cut your hand or scrape your hand say, if your hand won't stop bleeding, what you do?

(Steven walks over to a tree behind him.)

This tree right here, this is a typical Christmas tree...and see these little blisters? Pinch that. See the sap that comes out? Smells real nice. You just put it where your cut is, it will stop the bleeding. I tried it once and I heard [about it from] one lady tried it once. But you got to be very careful; you got to know what you're allergic to. Like when your doctor asks you, "Are you allergic to any medicines?" you say, "Oh yeah, I'm allergic to aspirin." But nine out of ten people aren't allergic to [this tree]. It works really well. Good for cold sores too.

Comment: This is an example of the emerging culture and cultural continuity theme introduced in Chapter Four. Contemporary and traditional uses are brought into one continuum. Steven relates the traditional use of medicines to contemporary use of medicines, and finds a common theme – allergies. While discussing the sap, he draws on the use of a number of senses – sight, smell, and touch – to expand the students' experiential connection to the material. The students are also learning something immediately practical – if they cut themselves in the woods, they can use the pitch from the tree. Later in the field trip, some students began experimenting with the sap blisters on the trees.

SG: Other medicine you can see right here on the ground.... This plant is called Golden Thread. Usually before you pick it...

(One student is digging into the earth. Steven says jokingly to him, "You can't see it, your big head is in the way.")

... you offer tobacco; that's the belief. You see ------ (name) did it wrong 'cause you're supposed to offer tobacco before you pick it. And a lot of the elders, and a lot of the people, before you go out and pick it, they'll put a little bit of tobacco beside it and make an offering before you take any medicine out of the woods. And the way you pick it, you don't grab it like ---- (name) just did and haul it right out of the ground. You just clean a little bit of the dirt away from it so you can see a lot of it, you kind of work along the root right here so you can peel it up. (Steven demonstrates.) See it here? And it's just right below the surface and this medicine our elders, or whoever needs it, will collect it. You collect about a handful of it, and they take it home with them, put it in a little bit of water and they'll boil it, just making a tea out of it. And once the tea is done, you get a little strainer and you just pour the tea in the cup. You never throw these roots in the garbage. What you do after you finish with the roots...the next time you're in the woods, you put it back. You don't have to put it back where you find it, you just put it back in the woods where it came from. That's like for any medicine that you use.

Teacher: It's to show respect eh?

SG: Yeah, it's to show Mother Earth respect. Because there's so much out here that she gives us and it's just to show her that we respect her for her medicine.

Comment: Respect for the land is emphasized here. Furthermore, there are specific actions taken to show respect – offering tobacco before picking and returning the roots to the woods once finished with making the tea. Re-cycling is an important lesson within science text books, but here we are entering into the more "spiritual" realm and acknowledging a personal relationship with "Mother Earth." Earth is not just an inanimate substance – it is regarded as an aspect of one's total being. This reflects the fifth theme identified in Chapter Four –Beyond borders toward a spiritual narrative.

If you talk to your regular doctors, this is where they get penicillin from. They call them non-timber forest products, or products that aren't considered lumber. Other products – blueberries, raspberries, ground pine – a lot people go out and collect this stuff and they sell it to their pharmaceuticals or your drugstores and your medicine places, and they make medicines out of that, too.

But this is called Golden Thread. It's only found in wet areas or areas that are considered to be more wet than other places. Some places you go you'll never find this plant but if you go into areas where you see cedar trees, or fir and spruce trees you usually find this stuff but there are other places that you don't. And these plants are big (indicating the ones he is showing the students), they're doing very good.... Sometimes they're real tiny, but they're all over the place.

What's unique about this is the fact that it's still here. You see all this brush on the ground all around you, all the trees that look like they've been cut. I don't know, about four or five years ago, we had a big machine in here like the one you see at the saw mill....That was all through this ground. And you wouldn't think because it doesn't look like that much damage...but what the workers will do, the workers will come in and we do a silviculture treatment. Anybody know what the word silviculture means?

Comment: Again Steven has tied in both traditional use of plants with contemporary uses, which exemplifies theme 4, cultural continuity and emerging culture. He points out this is where penicillin and other medicines have come from, and that people sell these plants for medicinal use to companies. The dichotomy is implied between the commercial and pharmaceutical and the Native uses of these plants, which he points out, are simply Golden Thread.

Steven has also introduced the category, "non-timber" products used by silviculturalists as a means to classify potential products within the forest ecosystem. He is introducing a different perception of the forest from the silviculturists' point of view. Further, he has made students' aware of the ecosystem where these golden thread plants can be found, and what nurtures their strong growth. He discusses the fact that they have survived environmental degradation from previous clear cutting, a reference to external, societal practices and influences that have affected the reserve and their medicines. His own model forestry project is referenced in terms of the work they are trying to do to restore the forest through "silviculture treatments," alluding to the medicinal or healing process he has been discussing. He seamlessly incorporates a number of thematic layers – personal (his own role in restoring the forest), cultural (the use of variety of medicines by Mi'kmaq), and societal (silviculture as a discipline he has learned at university, and the environmental degradation that has come from clear cutting) – synthesizing (border-crossing and emerging culture) these layers into a description about healing the forest (beyond borders to spirituality).

(Students don't respond.)

SG: No! What silviculture means is just like a farmer. If you know anybody who has a garden and who grows carrots and potatoes and corn and all that stuff and every so often they'll go out in the garden and they'll either pick some of the plants out because they're growing too close together and they don't grow as fast and they pick them out just to give them more room to grow. Silviculture is the same thing – it's just like a big farm. You cut out some trees to give the others a chance grow faster and by growing faster you end up with more wood for fires, or lumber to build your home, or just to make the stand more healthier, because what happened in the woods in the past is that everyone just cut trees down and took all the good wood out and never put nothing back, never respected Mother Earth. After a while they found out when they were getting nice big trees like this (rounds his arms out to show) they weren't finding them any more because they were cutting all the big ones and they never left anything in place to grow more big ones. That's what we're trying to do here in Eel Ground. We're trying to make these trees get big again, so when you guys grow up, you'll have all the resources you need to build your homes or make a nice chair, or make a drum. If that cedar tree gets a chance to grow real big, and you use the medicine out of it, you could use the stalk on it to build a drum (inaudible).

Comment: Again, we see the same fluidity between all the spheres of the student's experience as Steven discusses the forest from many different aspects, including the students' future use of the forest. A sub-theme of healing is emerging in Steven's reference to making the forest healthier. This is tied to a larger spiritual narrative (theme # 5) that could be described as taking care of "Mother Earth." Within this framework he is presenting a wide array of needs that can be fulfilled if the forest grows healthy, e.g., daily (houses, firewood), as well as for medicine and drums. He also encourages cultural pride in the sense that this healing is happening in the community under the guidance of a Native leader.

SG: These sticks here (hemlock), if you look to my Uncle ---- he has [sticks like these] all over his house. And you see how they curve up? They're called weather sticks. You take the bark off, and take a little branch off close and put it on the side of your house, and when rain comes, the stick will bend downward. When it's real sunny out, the tree will point upward. So it tells you if it's going to be a nice day or a real rainy day. In the morning, when you first look outside, you see that stick level or bending down a little bit, you know it's going to be a rainy day so you can put on the proper clothes. If it's pointing right up, you know it's going to be a nice day. So instead of putting boots on, you put sneakers on.

Another medicine is right here – spruce gum. You don't see it used much right here but out on the west coast you see it used a lot. But if you smell it, it smells good. If you want your car [to smell good], some of your parents, instead of

buying some of those smell packages, just collect a little of that and rub it on something, and set it in your car. You get the same smell and it doesn't cost you anything. Instead of paying four dollars, you can get it for free. But this Spruce gum, what people do with it, I remember my father – he used to work in the woods, he used to chew it. It kind of tastes unpleasant at first but it's almost like bubble gum once you chew it a little bit.

Teacher: My mum chews it

Comment: Steven is relating these practices of using the weather sticks and the spruce gum to members of their community known to the students. In so doing, he is showing an example of the cultural continuity (theme #4), as well as providing a cultural identity with the forest itself (theme #3: cultural/Pan-tribal identity). Their teacher reinforces Steven's story. He also brings in economics by telling students that they can pay $4.00 for essentially the same thing in the store tying it to the larger societal context (theme #3: societal identity).

SG: Yeah? Another thing people will do is the same thing as the Golden Thread…

(Steven continues on to discuss how to make tea from Golden Thread for medicine, and how the students have to make sure to let their mother or father decide how much to use or they could become allergic by drinking too much).

You've got make sure you respect it; you don't grab the bottle and drink the whole thing. It's not good for you when you do it like that.

(Steven then shifts to how to determine the age of a tree and what conditions prevent trees from growing strong and tall, just like children.)

This particular tree is a young tree but I'm going to show you how to age a tree. I'm going to show you a real small tree that's about 100 years old and I'm going to show you…. If ------ (name) wasn't allowed to grow, say if these big trees were always over the top of him like this (Steven bends over the student), he's not going to grow, he's going to stunt himself and look really deformed when he gets [older]. But if I give him the room to grow, he's going to grow to be a big man when he grows up hopefully and be real healthy. It's the same thing with a tree. If there are all these big trees shadowing small trees, the small trees won't grow and so you [have to] give them the room to grow.

Comment: In the previous chapter, in considering the pukalatmu'jk caves, I discussed how a student's identity is inseparable from the landscape associated with Mi'kmaw legends and resource use. Here we see a similar relationship. Steven is likening the trees growth to the students', metaphorically tying the health of the environment to their own health. This idea illustrates the interdependent nature of their existence (theme #5) and the inseparability of their personal and cultural identities with the landscape. Steven is border crossing

between the students' personal wellbeing on the one hand and the larger context of the health of the forest and between the present to the future.

(The group moves to next tree.)

SG: When we do forest management, one thing we like to do is to make sure that the big trees that we're trying to grow for the mill and for our own use at home, that when we're growing our big trees that we make sure the young trees will grow. If you look around you, there's a lot of people they have the tendency, they like to look at whatever they see at their eye level. For a forester, it's important to look at the ground, there are all young trees, and its important to protect those. Before we take these big trees out, that we'll have a bunch of little trees ready to grow. So you'll never have to bring in new trees, you'll always have trees here. What did you ask me earlier ------ (name)?

Comment: Again, Steven is tying present responsibilities for the forest to its future wellness. He is also discussing the specific perception a forester has of the forest. For the second field trip, I developed a role playing exercise for the students to experience perceptions about the forest from the point of view of people in different roles (e.g., artist, doctor, fireman, etc.) and of different animals (deer, snake, bird, etc.).

Student: How do you tell between a hard wood and a soft wood?

SG: Did you ever notice in the winter time how some trees lose their leaves?

(Steven talks about this and discusses the needles of a Balsam Fir and the difference in their shape with and without sun. The group walks on to find a spruce tree and fir tree. Steven shows how to age a tree with a tree borer and then how to age a tree by counting the whorls. He explains you won't see the mark the borer made in the tree in four or five years, and how you can age the tree without hurting it by counting the whorls.)

I'm going to show you another tree that is younger but it is bigger than this one. (He goes to another tree). It's only some of the soft woods that you can count [the whorls] like this. With the hard wood trees it is much harder. Anyone know this type of tree? (Puts in the borer.)

Student: A balsam.

SG: Nope.

Student: A pine.

SG: What kind of pine.

Student: A green pine.

SG: There are three types of pine in this area. One is called a white pine, [one is called a] jack pine.... When the trees get older, see how they start getting these cracks.

Student: It gets wrinkled.

SG: (laughs) Just like when you get older you get wrinkled. This one is called a white pine (the one he is boring). It has medicinal qualities – they'll use it for aroma. [Other] medicines are [made] from berries on the ground [that] I'll show you. Some cosmetic products our young ladies used in the olden days [came from these trees]. You couldn't go to the store [in those days]. You had to get makeup somewhere.

Student: Where's the candy leaves?

(This student is referring to teaberry which they later find on the walk back home.)

SG: We'll get to those

(The borer is stuck in tree. Steven explains that's what white pine will do because it's sticky. He pulls the borer out. The sample is broken so he has to put it together with the students helping. Three students go over to another tree to take some of the sap bubbles off the tree. Steven shows the rest of the students how to count rings and how much the tree has grown each year.)

SG: The white mark is called spring growth in the sample and the brown mark is called summer growth.

(One of the three students gathering sap goes over to Steven and asks: AWhen you bust those things and it comes out red, what does that mean?@)

SG: It's just the minerals in the ground that will sometimes dye the sap red. But don't get that all over you. It will take you all day to get that pitch off.

One of the students who have been playing with the sap says, "We're already sticky."

SG: Don't take any more than that. You don't pick that stuff unless you're actually going to use it for medicine. This is what I referred to as not respecting Mother Earth. You're just taking the medicine out and not respecting it. That's enough! The teacher's going to make you write 150 lines on the board.

Teacher: Never abuse Mother Earth.

Comment: The overarching narrative of Mother Earth is brought in again, tying the student to an interdependent network of relationships.

SG: See it's hard to believe this tree's older than that one. You'd think that one was much older. But if you check certain trees as you're going through the woods, sometimes you'll get a real small tree that's real old. Right below me, right here, they found a new medicine to treat cancer. You always hear them talking about it out in Calgary and places like that where they first discovered it. That there's a plant in the wild that actually creates new medicine that can fight cancers like leukemia. Does anyone know what leukemia is? It's cancer of the blood.

Student: It makes your hair fall out.

SG: But the medicine comes from this shrub. This is called Ground Hemlock, and sometimes when you see this hemlock, it has a little berry on it. You collect the berries to make that medicine. I don't even know what it's called – it's got about 500 letters to it. But that's where they get it from; they get it from the ground hemlock.

Comment: As in the interview with S1 and S2 in which S2 contrasts water to its complex scientific formula ("The purest thing on this earth and they call it – H2O"). Steven has brought up a similar dichotomy between the hemlock berry and the chemical compound derived from it ("It's got about 500 letters").

Science is a way of thinking about the world, but it does not necessarily clarify our relationship to each other and to the physical world in a way that is meaningful to Aboriginal students. In this dialogue Steven accomplishes a number of things, and offers several avenues for the students to relate the material to their personal experience. This narrative integrates both indigenous knowledge and Western science.

First, Steven connects the use of medicinal plants to Mi'kmaw culture and knowledge and to other Aboriginal cultures in general, and further shows the contemporary uses of the plants he is discussing. First, he goes from the personal level (citing people in the community who use the medicines, weather sticks, etc., his uncle, the teacher's mother); to the community level (the forestry project within the Eel Ground community and the knowledge of the medicines taken from the land on which they are

walking); to the Pan-tribal level (the use of medicines to other tribal practices and the need to respect Mother Earth); to the societal level (silviculture and forestry in general, and also about the clear cutting that has gone on within the forest). These shifts illustrate theme #2, multiple layers of identity. He finds common themes (borders) between chemically manufactured medicines, cosmetics, gum, and scented products on the one hand and the Mi'kmaw plants and plant products (e.g., resin) used for similar purposes on the other (theme #4, border crossings). He notes that any medicine must be respected and that students could be either allergic to or healed by these medicines (theme #5, beyond borders).

Second, he provides a multi-sensory approach to the lesson. The students are able to see, touch, and smell the medicines within their natural ecosystems. Third, Steven frames the lesson with an overarching narrative to respect the medicines as a gift from Mother Earth. This view of medicine draws on Mi'kmaw traditional cosmology that sees the inter-related nature of living things. Relationships are framed in terms of offerings, gifts, and healing, which signal a reciprocity and acknowledgment of humans and the land as equal partners living in symbiosis (theme #5, beyond borders).

The concept of Mother Earth as an active entity worthy of receiving respect and offerings could be viewed an emerging Pan-tribal cultural identity (theme #3). Many of the students are already familiar with rituals created to recognize the generosity of the land during annual powwows. But, the language, legends, songs, and dances of the Mi'kmaq also convey this relatedness to the landscape.[1] The Mi'kmaw language itself is relational, and points to a system of relationships with the environment.

Creating Webs of Significance: Using Mi'kmaw Language

Further engagement of Mi'kmaw students in a culturally interactive pedagogy for science education could be achieved through the inclusion of the Mi'kmaw language in the curriculum. The Mi'kmaw language captures the five themes identified from the individual interviews and trial lesson. Evidence of the students' relationship to their environment has already been pointed out in the interviews in Chapter Four (e.g., the *pukalatamu'jk* caves, eagle feathers, animal stories, etc.). But the Mi'kmaq relation to their physical world can also be seen in the extension of kinship terms to animals, stars, and other beings. The language implies that some animate beings are, or have the potential to be, one's relatives and can take human shape. A Kluskap story recounted by a Mi'kmaw, Jerry Lonecloud, and documented in the 1920s, demonstrates this:

> On the Island of Sighignish, Glooscup's [Kluskap's] niece (the animals and birds were human then) was in the woods [with] bow and arrow shooting small game, such as squirrels, rabbits, and other small animals. When she returned she found the people in the encampment had left in their canoes to go to the mainland when Glooscup required them. She didn't know how to get to the mainland. Finally, she saw a whale passing by. She said to the whale, "Uncle, will you be so kind as to take me to the mainland? I am here all alone." So he said, "Yes, I will take you but I can't take you on dry land." But, she said, "Well take me as near as you can." (Dennis 1923: (2) 11)

The Mi'kmaw language reflects a view of the world as interdependent and in constant motion (Smith 1994). This form of language relates particularly to theme #1 (fragile ontologies) as well as theme #5 (beyond borders). In the words for colours, for example, except for the four main colours – red, black, white and yellow – all colours are associative, or "analogised" (Francis 1995). For example, the words used to describe the colours blue and green mean "like the sky" (blue) and "like the fir trees" (forest green) (Hewson 1996; Francis and Johnson 1995; Whitehead 1982:71). Thus there is no way to

describe the colour of blue and green rocks, or even a dream of blue and green rocks, without ascribing to them a connection, or relationship, to the sky and fir trees. Even the four main colours are thought to have derived from Proto-Algonquian words that associated them with blood (red), light/sunlight/dawn (yellow and white), and ash (black). All colours are intransitive verbs that can be conjugated. The translation of *maqtew'k* (black) means "in the process of being black," implying that there is no fixed state of blackness, but rather a stage in a process that could change (Francis 1994). Thus, the language itself reflects theme #1, "fragile ontologies," and theme #5, beyond borders to a spiritual narrative.

This also means that the profundity of Mi'kmaq is often lost when translated into English. Furthermore, conventional assumptions of objective and subjective experience are inherent in English, and translation distorts the dynamic and interdependent world view offered by the Mi'kmaw language. There is no absolute split between the "inner" and "outer" worlds, or the spiritual and physical in the Mi'kmaw worldview; things are understood only in relation to one another.

Language traditions therefore parallel current calls for environmental awareness and stewardship. In a science curriculum, Mi'kmaw views of the earth could be coupled with an examination of the values within science itself regarding the conservation and care of the environment. A culturally interactive pedagogy would allow the students to establish meaningful relationships to the subject matter.

During the interviews, I asked the students their views on integrating their language into science education. I believe that bringing the students into dialogue about these ideas regarding curriculum development assists in making them more conscious of

the learning process in which they are involved.

TS: Would you like to see it (the Mi'kmaw language) as part of science?

S6: Yeah.

TS: Do you think it might work?

S6: Like do the language, like science in Mi'kmaq?

TS: Yeah, or at least have some of the terminology anyway, say you study about the environment.

S6: You'd have to learn a little more Mi'kmaq to do that. Science words in English are already pretty hard.

TS: I know. That's what I'm working on. I'm trying to figure out how the two can work together. Mi'kmaw culture and the way science is taught. Does that sound like something that might be interesting to you?

S6: Yeah, I'd like to try it.

The difficulty of learning scientific vocabulary was mentioned in other interviews with the students as well, and this student is aware of the challenge of introducing Mi'kmaw vocabulary into the process as well. Yet, he is willing to try because he is interested in his culture.

There are many ways the language can be incorporated into the teaching of science. In the 1993 earth science lesson I developed, I used place names, each of which have their own meaning and tell a story (Andrews 1990; Sable 1993), as well as the names of the minerals and rocks, again each of which have their own translations and story. The research was painstaking and involved working with elders and linguists. It involved understanding the meaning for the Mi'kmaw terms for different animals, plants, rocks, and minerals, etc., not just the English translation of the term. This led to the realization that some 'nouns' in the English language were actually verbs in the

Mi'kmaw language, which in turn led into a whole discussion on world view, concepts of animacy and inanimacy, relationships to the natural world, and so forth.

In the chemistry lesson, I attempted to do the same with various terminology, as well as have the students contemplate the meaning of the word earth in Mi'kmaq (*wskitqamu)* and the way scientists define the term. Again, the overall aim in doing so was to heighten students' awareness of their own environmental knowledge as well as seeing where it meets or diverges from scientific practice.

The Trial Lesson

The trial lesson was designed to teach the students about physical and chemical change using materials familiar to them and readily available in their environment; and to help them extend their knowledge of the Mi'kmaw and (English) science words and symbols for the materials and the change processes. The trial lesson was a demonstration of the themes already discussed in Chapter Four: border-crossing between scientific language and Mi'kmaq; emerging culture, incorporating scientific thinking alongside traditional culture; and respect for fragile ontologies, a flow of inquiry that would not prejudice the students against the framework of their traditional culture.

Although circumstances prevented me from measuring student performance on standardized science tests, I can attest to the students' engagement during the lesson and the support for the lesson that came from the Chief of the community, the teacher, and the principal of the school. These individuals, plus others on the Education Committee, reviewed the lesson plan and found it exciting, educational, culturally relevant, and in keeping with the direction the community was aspiring to take with their educational

curriculum.

At the time I introduced the trial lesson (2001), the Chief and Band Council had formed a committee to develop a strong Mi'kmaw language curriculum to preserve the language and to reverse its growing disuse. The loss of language was exemplified in the lives of the students themselves – all live in a home with at least one Mi'kmaw speaker but use English as their primary language. At school, the students had two, one-half hour lessons in the Mi'kmaw language each week, but had French every day.

Scientific Literacy in Two Languages

The content of the trial lesson included learning the words for various materials and processes in two languages – Mi'kmaq and (English) Science. I hoped to reinforce both the learning of comparable words in both languages and to give students a deeper understanding of the meaning and world view embedded within each. Tewa Pueblo educator, Gregory Cajete, argues that such learning "along with a resurgence of cultural identity, will have a direct effect on perceptions and attitudes students have toward science" (Cajete 1999:146). I also hoped that their exploration of language would lead them to do further research within their community by asking the elders, their parents or other Mi'kmaq speakers about words that are connected to their lessons. Understanding the meanings in two languages and their symbolic forms allows the students to understand cross-cultural issues about bio-diversity and cultural diversity that are being discussed around the world.[2]

Herbert states that literacy is "the ability to use symbolic systems that are culturally valued [enabling] us to make a distinction between resources, understandings,

and underlying assumptions that constitute social reality in a literate world" (Hebert 2000:55). Scientific literacy involves understanding and using the symbol systems that are valued in the scientific community.

The importance of this trial lesson is that the content establishes one of the pillars of scientific thinking in general, the use of notational representation or symbols. In Chapter Two, I discussed Duschl's framework for scientific thinking, and his three domains of criteria for relating evidence and explanation: (1) assigning data, (2) identifying and representing patterns/models in selected data, and (3) generating theories or explanations to account for the patterns/models (Duschl 2000: 190). I discussed the first of these domains in some detail in that chapter. Here, I turn to the matter of identifying and representing selected data by using symbols.

Duschl supports instructional sequences that involve students both in investigations and in conversations about the investigation or "speaking together opportunities" (2000:195). These conversations allow students to reflect upon and assess the data, to share data and their different perspectives of the data, and to work together on the presentation and display of the data for further discussion. Instruction needs to be designed to provide diverse experiences and diverse outcomes with the overall goal of helping students learn scientific language and ways of thinking about physical and chemical change. Duschl goes on to state that: "Over time the goal of these discussions is to promote the refinement and extension of scientific language and thinking along three cognitive dimensions: metacognitive/conceptual, notational/ representational and epistemological" (2000:195). Gardener states: "Scientific knowledge arises from the fundamental capacity to know and symbolize, but strives toward explanatory models that

can be expressed in translatable languages" (1994:14).

The notational-representational dimension crucial to the scientific process can be introduced in a much wider context to promote a culturally interactive dialogue. There is now a scientific language that goes beyond coding in ordinary language. This is a new language, rife with symbols that are supposed to be universal, non-localized and translatable. In using this language, students are seen as moving toward recognition of "criteria for identifying and representing patterns/models in selected data" (Duschl 2000:190). But there are many ways to get students to think about the basic principles of identifying patterns and coding them, and of learning how people of other cultures did this. If the students understand the basic principles of identifying patterns, they will be able to discuss how they see and express patterns, and how their ancestors saw and expressed similar patterns. The fact that science has its own criteria for expressing patterns could be looked at as learning about a different culture.

Some of the questions addressed in the trial lesson were: What important patterns can we identify in physical and chemical change? How can we display this information? How do scientists display this information? How did our ancestors display such information? The trial lesson attempted to weave together scientific and Mi'kmaw language and symbols as representative of two particular ways of knowing and to allow the dialogue or "speaking together opportunities" between the teacher and the students to demonstrate interactions between these two languages and ways of knowing. The best possible outcome from the trial lesson would be: first, that students' could consciously hold different views of reality and apply them according to the context they are in; and second, that students could find translatable and common themes – border crossings. For

example, in some cases, explanations about physical and chemical change might be translatable from science into Mi'kmaq and from Mi'kmaq into science, but learning where they are not easily translatable could be equally important.

Gregory Cajete, proposes that, within the teaching of science, the analysis of symbols should be introduced only after students have learned the basic scientific skills of observing, collecting, categorizing, and generalizing their findings. Then they can be presented with "a comparison of the way in which science as a thought process is exemplified in both their particular culture and that of the larger society" (Cajete 1999:142):

> In every culture, the thought process inherent in science attempts to relate derived symbols of phenomena to each other to develop a pattern of thought. An analysis of symbols as they relate to the explanation of natural phenomena in both Native American culture and that of Western science should be undertaken. The model or symbolic map of concepts representing what is important in a particular culture's natural reality is vital in forming the way members of that culture apply [a scientific] process and develop their mind set .... That is, information and communication concerning natural phenomena are presented in the context most appropriate to their purpose or through the use of symbolic vehicles such as art, myth or ritual. (Cajete 1999:140 & 142)

To develop the trial lesson I used, as an exemplar, educational activities developed by the Yup'ik of Alaska, who use a variety of traditional symbols and activities for teaching math and science in their schools. For example, the geometric patterns on the traditional parkas are used to teach fractions, tangrams, geometry, pre-algebra, estimation, symmetry, and other factors while simultaneously teaching the students about their culture. The shapes used to decorate parkas tell stories of legendary people and traditional resource areas used by specific families (Lipka 1998:155). The individual geometric shapes have

different terms associated with them with the same symbol having "multiple meanings depending on its orientation and its relationship to the action" (Lipka 1998:156).

This approach is supported by research conducted by the U.S. Department of Education that concluded that "schools that acknowledge, accept, and teach a child's cultural heritage have significantly better success in educating these students" (as cited in Cleary and Peacock 1998:108). A student grounded in his or her culture is less likely to be absent and drop out, and more likely to achieve higher test scores and continue on to higher education (108). Part of teaching about culture is to provide a means for students to identify with the subject, an important aspect in creating a narrative framework.

I had originally developed three projects. The teacher in the grade 7/8 classroom chose the lesson that used red ochre – a mineral traditionally used by Mi'kmaq for paint, medicine, and ceremonial use – to discuss and demonstrate physical and chemical change.[3] In brief, the lesson involved showing slides of Mi'kmaq in traditional clothing within a variety of settings (e.g., hunting, celebrating, unrolling birch bark, etc.). The students were asked to look at the symbols painted on clothing, *wi'kuoml*, and canoes with paints made from ochres. During the slide show, students discussed what they were seeing. They were then introduced to the concept of scientific symbols when the chemical symbol for iron oxide (red ochre) was written. Samples of rocks and minerals traditionally used by Mi'kmaq were then passed around. The places where these were found in the Maritimes were shown on a wall map. Next they were asked to heat both the red and yellow ochre over a flame and report any physical or chemical changes. They made their own paint from red ochre and drew their own symbols on scraps of leather.

The lesson plan called for students to discuss their use of symbols at the end, but time ran out before we could complete this task.[4]

Data from the Trial Lesson

As preparation, the teacher hung up the map the Native Council of Nova Scotia's map of traditional, pre-contact Mi'kmaw territories next to a current map of the Maritimes. This was to illustrate different perceptions of the landscape, as well as show different Mi'kmaw place names. The following account of the lesson is taken from my field notes which were written as the lesson progressed. As I reported in Chapter Three, I had to stop recording the lesson on audiotape because one student objected and I felt the only ethical thing to do was to continue with written notes only:

> I showed up with the bundles of leather scraps, red and yellow ochre, the slides and slide projector, the map, and a host of other accessories. The teacher and I worked to set up for the lesson with the help of some students who had finished their other work. When everyone was ready, the teacher grouped the students in two groups of four and one of three (two students were absent that day). The four girls were in one group, the other two groups were boys. The groups pushed their four desks together to make a big square for doing the painting project.
>
> The teacher went to the Mi'kmaw map and talked about how the land looked before the coming of Europeans, and how all the place names were in Mi'kmaq. She pointed to a few names on the map and told the students they would be referring back to these names as they went along. She then drew a chart on the board with the columns headed: "English term", "Micmac term", "Micmac meaning", "Chemical description", and "Chemical symbol". She told the students to copy it in their science scribblers, which they all did. She told them that if they didn't know the meaning of some of the Mi'kmaw words, they could ask someone in the community.
>
> Next, I played a tape of the Mi'kmaw Honour Song. Everyone stood and the boys all took off their caps. The boys in one group joked around and talked some of the time during the song. After the song, they sat back down and the teacher asked if they knew the meaning of the song. Most said they didn't really know; one said it was about honouring and being proud of why they were here. The teacher asked

them about being at powwows and hearing it at the Grand Entry which begins powwows. Some said they had missed it.

The teacher then asked about the word *wskitqamu* in the song. She wrote the word earth on the chart under the English term column and then *wskitqamu* under the Mi'kmaq term column. The students wrote it down. She asked the students what they think of when they use the word "earth." One student said, "everything on top." Another said, "just what's visible." The teacher explained that the word meant the surface of the earth and included the atmosphere around the earth.

She then told the students about another term, *lamqamu* which meant under the earth and asked what chemical term might correspond. Since no one else spoke, I answered "chemical compounds" because their science textbook tells them that all substances are chemicals. She and the students wrote that on the chart.

The teacher then, unexpectedly, launched into asking the students, "What is science?" As was common when students were asked this question in my interviews, they first responded: "chemicals" and "experiments." She said they didn't have to limit themselves just to the indoors, but could think outdoors as well. The students then responded that science was about nature and everything outdoors, and that when they think of scientists, they think of labs and microscopes. One student mentioned scientists sometimes wear isolation gowns when working with chemicals. The teacher also said she envisions people with lab coats when she hears the term scientist.

Then she told the students to think back 500 years ago before Christopher Columbus first discovered America. "Were there any scientists?" One student responded, "Indian ones" and explained that early "Indians" experimented with different things and conducted their own experiments. Another student (boy) facetiously said something to the effect of, "Yeah right. They had microscopes back then."

Comment: This dialogue between the students and the teacher is the type of "speaking together" is what I envisage happening in a culturally interactive science curriculum. Two students had different perceptions about whether or not their ancestors were scientists. One student made the connection between experimenting with different "things," while the other student can't envision science without microscopes. The teacher has also framed the question as pre-Columbus, a significant historical reference point for a time when Aboriginal peoples still had their own "science."

The teacher asked what their ancestors' lab would have been like. A student said "Nature." The teacher asked, "Would the lab be outdoors in nature?" and the student said "Yup. Native people were scientists." The teacher said, "Science is all these things. Ancestors had their own kind of science. One of their scientific

discoveries was paint." She then explained how their ancestors needed paint to decorate their faces, shelters, and clothes. She asked the students if they remembered the Beothuk, an extinct Newfoundland tribe, who painted their whole face with red ochre. She asked, "How can we make paint out of red ochre? Making paint is science."

Comment: This is a poignant presentation. The teacher is expanding the students' conceptions about the definition of a "lab". One student is able to border-cross to think of their Mi'kmaw ancestors as scientists with their own lab (Nature) and own kind of science. The making and using of paint is something the students can easily relate to in contemporary culture, again allowing for border-crossing (theme #3) and illustrating connections between emerging and continuous aspects of culture (theme #4).

By mentioning the extinction of the Beothuk, the teacher brings in the legacy of Aboriginal people, while connecting it to the ongoing science lesson. This broad sweep between the past extinction of the Aboriginal peoples of Newfoundland who used ochre extensively, to the present day science class on chemical change, encapsulates the legacy spoken of in Chapter One. The emerging culture here is one that is emerging with a legacy of pain.

Although the statement "Making paint is science," would be disputed from the point of view of Duschl's criteria domains, turning the statement into a question, "Is making paint science?" would allow for a valuable exploration. The statement, however, is valuable from the point of view that the teacher is creating a cultural identity for the students as scientist, and offering a border-crossing opportunity.

I then showed the slides of a reproduction of pre-contact Mi'kmaw culture. Because I was at the front of the room, I asked some questions and discussed some of the resources seen in the picture, such as the copper beads and arm bands, shell ornamentation, how black and white paints were made, etc.

The teacher had mentioned earlier that some of the petroglyphs shown on the slides were painted by Alan Syliboy, a contemporary Mi'kmaw artist, as decoration on tee shirts. A picture of this artist appears in the Maritimes Studies text book, thus connecting the past with the emerging culture.

The students all seemed attentive during the slide presentation, and asked questions or made comments, not silly ones. The girls were as involved in the discussion as the boys, some even more so. I pointed out a tinkler cone made from copper and tied onto a woman's outfit, and one of the girls immediately made the connection to a jingle dress used in present day powwow dances. At another slide, I mentioned how the Yupi'k of Alaska used the geometric patterns on their clothes to teach math to students. I asked if they could understand how. One girl

replied because of the repeating patterns and the measuring of distances, and the shapes. I also mentioned the geometry.

Comment: This girl's immediate connection gave some confirmation of the use of cultural symbols as a way to use the cultural heritage of Aboriginal peoples in the teaching of math and sciences.

I next brought the students' attention to the symbols in the slides and how scientists had their own set of symbols. I do not know if they got this connection or not, but I also mentioned the chemical symbol for Copper is "Cu."

The slides of the petroglyphs were interesting for a number of reasons. One student mentioned how talented the people were. We discussed the dating of the petroglyphs, what each one might be especially the double curved motif found in many Mi'kmaw designs. One student made a wise crack about the cow with the chain saw on his head (a moose.) One student asked me if I was Native. I said "No." He said "You know more than me and I'm Native."

Comment: This is a moment of personal identity formation for the student, where he is seeing himself as Native, but also reflecting on himself as not knowing as much as me. Because I seemed to know so much, he assumed I must have had some Native background.

I also had some samples of native copper from Cap d'Or,[5] samples of jasper collected from the Minas Basin area to show material used for stone tool making, and a stone with limonite on it with which I could draw yellow streaks. Two boys mockingly stole the copper from me. The students were all very interested in these samples. The girls looked at them more closely, felt them, and made comments about them. I showed them on the Mi'kmaw map where they came from. I also had a rock with ochre on it, which one of the boys mockingly tried to steal from me saying I could get another one. The boys also punched each other around in play fighting.

After the slides, we began to get ready to use the ochre for making paint, mixing it with egg yolks. Both the teacher and I had explained, and re-explained how they had to be really careful not to spill the ochre because it spreads all over the place and you can't get it out of your clothes. Before the class, one girl student voluntarily went to another teacher who gave her some plastic aprons used in other science classes. This was an unexpected surprise since I had been prepared to use garbage bags. The girls were the only ones who did the experiment of heating the red and yellow ochre up to see if there was a color change and to determine whether the colour change represented a chemical or a physical change.

The girls stayed with the heating experiment for about 10 minutes. None of the boys joined in. One girl reported that the red ochre was beginning to darken; the

edge turned a browner red. Another told me that the yellow was starting to turn color a bit to a browner yellow. They were doing the experiment on tin can tops and a bottle top held with a clothes pin over a candle flame. They also thought they had detected a slight change in smell, another sign of chemical change. I had told them before the experiment that they were helping the researchers at the Nova Scotia museum because no one there had tried this yet.

After about ten minutes the metal of the can tops and the burning candle began to smell too much. The girls then turned to mixing paints and painting on the leather scraps. Each table had both red and yellow ochre. Some of the boys started horsing around with some leather tongs that were in the heap, making whips out of them. Gradually, the students settled down to do their projects, chattering away. By the end of the lesson, only one student had not finished. At this point, the lesson had lasted two hours and the students were near their lunch break.

I had written four questions on the board for them to answer as a quick evaluation. The students recorded their answers on a slip of paper and turned these into me before going to their lunch.

What did you like most?

- The slides, it was learning me things I didn't know.
- Painting and learning more about how natives used to paint
- I liked the painting the most; it was fun but hard with the sticks
- Because we got to paint
- Making my arm band (boy)
- The painting because it was fun using it
- I liked playing with the paint the most (2)
- When I was painting
- I liked the painting because we had fun and it was cool
- The painting 'cus it was fun

What did you learn?

- To make paint
- That the Micmacs are really talented
- I learned how to make paint (3)
- How to make paint
- I learned some things about Native Arts
- The learn how to make paint and how Indians made paint
- How to make painting
- I learned how the natives used to live and how to make paint
- Lots like the meanings of words

What was the most challenging?

- Getting the ochre to change colour
- Not getting paint all over you

- It was hard not to get the paint all over yourself
- Not getting paint on my clothes (3)
- Trying to staple my arm band
- The most challenging was trying not to get dirty or paint all over you.
- Nothing
- Not getting paint all over your clothes or they will stain
- The chart because I had to write stuff

Would you like to do more projects like this?

- I would love to do projects like this.
- Yes, because it was fun
- Yes I would like to do many other projects. It was a lot of fun
- Maybe
- Yes, because I think that Native Art is fun
- Maybe. It was fun but it was too dirty. Maybe, maybe
- Yes
- Yes, I would like to do this again 'cus you get out of school
- When we were painting
- Yes because we get to have fun and get out of class
- Yes, because it was fun

The children left then for lunch. The teacher explained that eating is a very big deal to the students. In response to the lesson, she mentioned something to the effect that perhaps I had tried to cover too much material. More time was definitely needed, and to evaluate the success or lack of it would be inappropriate without a longer duration of time to test what had been learned.

As can be seen by their responses, doing the painting was the predominant favorite, although a few responses showed engagement with the slides, the experiment with the ochre, and the word chart. It is also evident that the word "science" is lacking in their responses, but this is not a surprise for a number of reasons. First, the lesson was not presented the way a science lesson was normally presented. In the science lessons I had witnessed, the text was open to a lesson, and an experiment was set up to illustrate the lesson, and give the students hands on experience. Second, science is not usually associated with doing art or seeing slides about one's culture. The lesson, therefore, was outside the usual context and format normally used for teaching science. Third, we were

not so much doing science as building a context for teaching science, although I related the lesson to what the students were currently studying in their science text (Duschl 2000).

More interesting to my research was the students' response to the lesson and level of engagement. I was surprised by the animation shown by the students and the teacher during the discussion about whether Native people did or did not do science. Having students identifying their ancestors as scientists (whether or not others agreed) was a major border-crossing (*theme #4*). Most students in their interviews saw scientists as people wearing white coats, doing experiments, and using complex vocabulary. Others gave more thought and deeper responses, but this general image of the white-coated scientist was pervasive, a perception the teacher also shared.

The teacher's idea to span the centuries and place the students' attention within a pre-contact period was very interesting. By framing the lesson in a pre-European time, the teacher highlighted the students' cultural identity as First Nations people (*theme #2*), and took them back in time to when their ancestors were the scientists and the holders of knowledge. This was a very poignant moment for me to see science framed historically. I was forcibly struck by the fact that the First Nations students had to go back to a time before Columbus to understand their heritage in the field of science.

This level of engagement on the part of the students continued throughout the slides and while looking at the various rock samples. The symbols shown on the slide were of interest to them, as evidenced by their responses to the discussion of the Yupi'k geometric patterns and their ability to connect the symbols in the art work with mathematical patterns. The petroglyph slides had originally been collected to teach about

sedimentary rock in my 1993 Earth Sciences curriculum design (Sable 1993). However, the teacher also pointed out that the drawings spanned two centuries and were connected to the work of the contemporary Mi'kmaw artist, Alan Syliboy, who the students had read about in their "Maritime Studies" text book. Syliboy uses these symbols in his artwork and on his well known tee-shirts, which are sold internationally (*theme #2*). This interest in connecting their cultural heritage and knowledge lineage was also expressed by the Chief, members of the education committee, the teacher, and the principal of the school.

The Five Themes in the Trial Lesson

Returning to the five themes introduced in Chapter Four, we can see each one illustrated at different points in the trial lesson. Theme #1, fragile ontologies, underlies the entire lesson with the students grappling with the question of whether or not their ancestors were scientists.

We can also see evidence of theme #2, the different layers of identity – personal, cultural/pan-tribal, and societal. The student's question to me about whether I was "Native" and his statement about how I knew more about his own traditions than he did was a moment of self reflection for him. Cultural identity ran throughout a great deal of the lesson since the entire topic was based on Mi'kmaw ancestral knowledge and use of resources. Specific examples include: the student who said the *Honour Song* was about honouring and being proud of why they were here; the girl who made the connection between the jingle dress used in present day powwow dances and the tinkler cone I was displaying; the teacher highlighting the students' cultural identity as First Nations people

by getting them to think back before the arrival of Columbus; and the teacher's reference to the Beothuk. Some students also identified with doing "Native arts" and how talented Mi'kmaq were, as can be seen in the answers to the questions. Societal identity can also be seen in the discussion of what scientists are and are not, what labs are and are not, and of the distinction between Mi'kmaq and people of European descent.

A number of examples of border crossing (theme #3) can be noted in this lesson. Some students could identify with their ancestors as scientists, one girl connected the repeating patterns and the measuring of distances, and the shapes of the Yupik parka to mathematics, and many could relate to the making and using of paint through time. This example of the paint also shows the continuous and emerging nature of culture (theme #4). Other examples are the contemporary Mi'kmaw artist, Alan Syliboy's use of petroglyph images on tee-shirts, the wearing of jingle dresses at pow wows, and the way the teacher herself presented the lesson to the students. Finally, theme #5, Beyond borders to a spiritual narrative, can be seen in the overall connecting of the lesson to a larger narrative to which the students' could relate.

Conclusion

In this chapter I have presented five themes as key elements in a culturally interactive pedagogy for science education: fragile ontologies, multiple layers of identity that include the personal, cultural/pan-tribal, and societal layers; border crossings; cultural continuity and emerging culture; and beyond borders to a spiritual narrative. These themes can be identified in the student interviews, the field trip and the trial lesson. These themes can be used to develop lessons that engage students within their own cultural landscape. The students begin to discover that there is "science" within their own

heritage, not only looking back at the technology of their traditional culture, but recognizing the current connections of their natural resources to medicine and other branches of science.

Working with language and symbols increases border crossings and cultural continuity, two of the themes identified in the interviews. By finding equivalent terms in Mi'kmaq and English the students discovered that the criteria for selecting data from their natural observations shifted with their language. For example, scientific language is primarily utilitarian and explicit in its detailed descriptions. The Mi'kmaw language can also be utilitarian, but almost always suggests multiple and implicit meanings. Both languages permit assigning data, identifying and then representing patterns in selected data. In science the next step is generating theories or explanations to account for the patterns/models; but the Mi'kmaw language points to a larger, symbiotic, interdependent and more integrative narrative rich in multiple meanings. Engagement in learning that is based on Mi'kmaw reference points has been largely disregarded within the educational system, although their heritage and language pre-date the coming of Europeans to North America.

The teaching questions asked during a lesson can be used to explore insights in either language and both avenues need to be treated with equal value (e.g., What important patterns can we identify in physical and chemical change? How can we display this information? How do scientists display this information? How did our ancestors display such information?). It is through "speaking together" opportunities that alienation and obstacles to learning can be overcome. Both the students and the teachers made connections between seemingly unrelated knowledge fields (e.g., the traditional Mi'kmaq

use of golden thread, hemlock, spruce gum and modern medical discoveries). Working through language and symbols assisted in border crossing and cultural continuity, and could be used to promote a spiritual narrative in the sense that it has been defined in this thesis. Further, content could be included that draws from the cultural heritage of the students, giving them an historical context with which to identify.

Endnotes

1. My Master's thesis, Another Look in the Mirror: Research into the Foundations for Developing an Alternative Science Curriculum for Mi'kmaw Children looked at Mi'kmaw legends, songs, dances, and the language as ways of conceiving of and expressing the world (Sable 1996:207-220; see also Sable 1998).

2. The obligation to protect and include Aboriginal communities as part of environmental and sustainable development initiatives is enshrined in several international declarations: the Rio Declaration and the Convention of Biological Diversity (CBD), as well as Canadian legislation and declarations (Canadian Environmental Protection Act 1999).

3. The reason for selecting the "Chemical changes" unit was because of practical issues concerning the availability of the teacher and what she was teaching at that time, as well as the availability of the Education Committee and the principal to meet and approve the lesson. I had initially adapted lesson plans for the "Diversity of Living Things" unit in the *Science Plus* text to complement the field trips organized in cooperation with Steven Ginnish. However, any unit in the text book could be designed for a culturally interactive dialogue and "speaking together."

4. In preparing the lesson on "Chemical Changes," I drew on research I conducted over the past fifteen years, specifically from a Mi'kmaw Earth Science curriculum I had designed for the Department of Energy, Mines and Resources in 1993 in cooperation with the Mi'kmaq Education Authority (now Mi'kmaw Kina'matnewey). A number of scholars in a variety of disciplines (archaeology, ethnology, science, and linguistics) were also consulted in the preparation of both lessons.

These scholars included: David Christianson, provincial archaeologist at the Nova Scotia Museum who provided important information regarding the activity of copper in burial sites, the use of shells in ceramics during the ceramic period, as well as information on shell middens; Ruth Holmes Whitehead, ethnologist and author of many books on Mi'kmaw culture, who also assisted me with the chemistry involved in various processes such as annealing copper and the general use of various materials such as different sea shells, copper, and the making of paints; Alan Moore, author of the chemical changes chapter in Science Plus text book, who supplied me with specific answers regarding chemical processes I was discussing in my lesson (e.g., how and why copper is toxic and combines to make copper sulphate which has preservative properties), the

nature of calcium carbonate in neutralizing soils thus also preserving organic substances within the soil, and the nature of iron oxide. The language exercises were drawn from years of questioning Elder Margaret Johnson and Elder Wilfred Prosper of Eskasoni, and linguists Bernie Francis, Doug Smith, and John Hewson. Dr. Charles McFadden, project director for the Science Plus series reviewed curriculum design, made comments and connected me with Dr. Moore.

5. The copper samples were given to me by Dr. David Keenlyside, archaeologist for the Canadian Museum of Civilization, Ottawa.

Chapter Six

A Culturally Interactive Model for Learning

Introduction

This chapter proposes a model for visualizing the learning process of the participating students as it has emerged from this research. I discuss the model in stages, and ground the discussion in the research presented in previous chapters. I propose that this model can be used as a pedagogical tool for the development of a culturally interactive science curriculum. I then compare other pedagogical models with my own, particularly models of Aboriginal Education such as those offered by Arlene Stairs, Eber Hampton and Gregory Cajete, and suggest where the models are complementary. Finally, I address the potential of traditional Mi'kmaw culture and spirituality as an appropriate narrative for teaching science.

A Culturally Interactive Model for Learning

The model depicted in Figure 1 emerged as the culmination of the research reported in this study as well as work done in past projects with First Nations groups (Sable, 1996 2000). The underlying design of the model is also in agreement with ancient principles depicted in medicine wheels seen throughout different North American Aboriginal cultures and *mandalas* seen in Asian cultures. Applied to education in general, the medicine wheel illustrates the necessity of balancing the physical, emotional, intellectual and spiritual dimensions of learning and personal development (Castellano, Davis and Lahache 2000: xii). The key features of the model are described one feature at a time, beginning with the fundamental and pervasive concept of fragile ontologies.

Fragile Ontologies

Varela's concept of fragile ontologies is inherent within all aspects of my proposed model. The features of the model were chosen to reflect the dynamic and fluid nature of identity formation. Varela posits that there is no central, stable, locatable self: "since it is not within the head, since it is not just in language. It's none of those dimensions, it's somehow in a figure of multiple levels of emergence, but it is always fragile....These emergences occur within the social emergence of human life" (Varela 2000: 12-13). Or, one could say, self co-emerges with social life. Varela compares this emergent, multi-layered, fragile process of identity formation to a cloud or turbulence, which he describes as similar to the arising of a pattern. Self, in this case, is a transitory, emerging pattern with which we then identify (Varela 1996: 6). Although we can acknowledge the individual aspect of life, it is also historically determined by many conditions. "It is essentially a pattern of life – the entire biosphere" (Varela 2000: 13).

The creation of an *individual identity* is a constant generative process. At the core of the experience is a three-fold process that involves a continual cycle of "suspension, letting go, and redirection" (Varela 2000: 10). This cycle is an ongoing, moment to moment occurrence of the "fragile self" continually forming a network or pattern of identity, one we mistakenly take as locatable and stable, and ongoing within the finite space of our bodies. Instead,

> ... the subject, not being a locatable being, can only be this transitory movement. And so you follow certain trails that are given by conditioning in the past. But inevitably it's bound to be stopped by surprise, by change, by accommodation, whatever. Life is constantly in the process of re-accommodation and therefore, this kind of cycle is at the very core of what life is about. (Varela 2000: 10)

Although each feature of the interactive model will be discussed in its own right, all features reflect this fragile, fluid, and emergent aspect of identity formation. It is represented by the use of broken, rather than solid, lines between identity layers (Figure 1); by broken arrows weaving among the concentric circles (Figure 2); and the cultural spiral running vertically through them (Figure 3). Circles and spheres are used to depict that there is no beginning or end to the process. The learner is constantly re-generating identity.

The broken lines symbolize the fragile aspect and fluid nature of identity formation, as well as the border crossings that students continually make (or don't make) between frames of reference. Some students, as Aikenhead and Jegede (1999) point out, manage border crossings easily, while others, such as S6 and his experience at the provincial school, get stuck and retreat to a space or place that offers more comfort or safety. Respecting the all-pervasive characteristic of fragile ontologies provides educators with a universal context for understanding the conflicts and problems that students bring to their education.

The Identity Sphere

The sphere in Figure 1 represents the students' whole field of experience, both conscious and unconscious, from which they draw meaning and derive their identity. It includes both the totality of the students' experience and the multiple layers of identity that are brought to the learning process. These layers need to be understood by educators in holistic terms as interrelated aspects of the students' experiences.

Around the sphere, the label "Historical Context" signifies the historical influences and legacy that affect the learning process. The sphere itself consists of three

layers, which are shown in a cross-section in Figure 1, of identity and meaning-making. The cross-section enables us to visualize boundaries between self or individual identity; the community, including the school, within which the learner exists and forms a cultural or pan-tribal identity; and the world outside the community within which the learner forms of societal or national identity. These layers are synonymous with the three levels of identity discussed in Chapters Four and Five – individual/personal, cultural/pan-tribal, and societal/national; all exist within a larger historical context.

Because of the interrelated nature of these layers, it is difficult to discuss them separately. The cross-cut reveals all layers of the students' experience from which they develop their webs of significant meaning within a culture situated within the larger Canadian social context. Educators need to understand as much as possible about each layer. At the same time, it is within the individual/personal layer that learners form and re-form their own particular patterns that determine what is meaningful and worth learning for them. I will consider each layer separately.

The Individual/Personal Identity Layer

The innermost layer represents individual or personal identity. As noted in the interviews, there are a number of examples in which the students have their own criteria about what is real or unreal, what can be trusted or not trusted, who is telling the truth, and so forth. Specific examples were cited in S1 and S2's discussion about determining what is true, and the emphasis they placed on personal trust of people talking to them. What is true, meaningful, and trustworthy refers back to their personal experience.

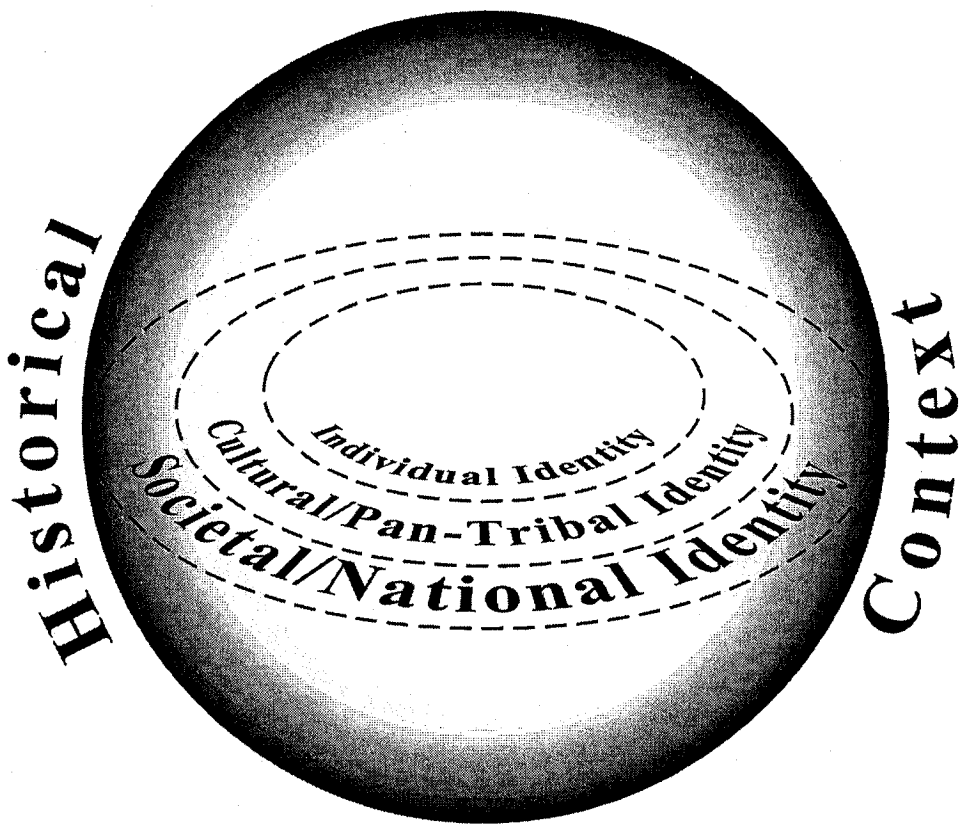

Figure 1: The Identity Sphere

Another example was given in the discussion with S3 who was attempting to understand why people became so excited at powwows when an eagle flew over. Her personal, unique interpretation of what was occurring involved suspending herself at least momentarily from others' emotional investment in the event. Yet another example of a primarily personal response can be seen in S6's description of himself as stubborn and disinterested in learning.

Personal identity includes the unique experience of each individual, family situations, and inherited character traits. Each student develops his or her individuality in terms of conscious and unconscious meaning-making processes as well as personal values that vary from one situation to another. As part of this development, each student must decide what is true or real and what criteria (e.g., trust, intuition, situation-specific circumstances) they will use for making such assessments.

Each student I interviewed had their own aspirations for what they hope to be when they grow up – artist, marine biologist, lawyer, dancer, RCMP officer. They also had their own personalities and individual ways of working within their world. While this observation may seem obvious, I am emphasizing it in light of stereotyping that still exists in the education system regarding Aboriginal students.

The Cultural/Pan-Tribal Layer

The second layer in the cross-cut of the identity sphere indicates cultural/pan-tribal identity. Although these two could be distinguished separately, I have put them together because they both relate to being Aboriginal as distinct from Canadian or other nationality or ethnicity. This layer includes the community, family, and school as well as pan-tribal identity with other Aboriginal people. Powwows are an obvious place where

the pan-tribal identity is learned, but many examples were provided in the data from the field trip as well as the trial lesson. Steven Ginnish spoke of people within the community who used plants and forest products for different medicines, dyes, gum, make-up, and tools. The classroom teacher distinguished between the pre-Columbus inhabitants of the land, and the later Europeans, and raised the students' awareness of their ancestors as Aboriginal scientists. The interviews were also filled with examples of the students' Mi'kmaw identity through their discussions of legends, *pukalatmu'jk*, the use of sweet grass, and the continuation of their language.

This cultural/pan-tribal layer also includes consciousness of and identification with narratives and forms of energy/beings embedded in their physical environment. The landscape, therefore, is included in their cultural identity.

The Societal/National Layer

This outermost layer involves the students' interaction within the surrounding, non-Aboriginal Canadian society. It includes the community, in which the reserve is situated, as well as general Canadian and global society. In the interviews we saw the development of an identity based on an awareness of differences between the Mi'kmaq and the "outside," non-native world. This identity shows up in their understanding of a different way of thinking about such things as: the earth as understood through science concepts as just a bunch of chemicals; environmental degradation that leads to loss of deer habitat; different ways of performing cultural rituals (square dancing vs. circle dancing); cultural stereotyping based on skin colour; Indian status as it is conferred by the federal government (full or not-full); general appearance (not looking like a Native); and the non-real appearance of popular culture icons such as Pamela Anderson and Michael Jackson.

Border Crossings

The boundaries between the identity layers are broken to signify the porous nature of the borders between identities, and the fluidity with which students can draw from these different layers of experience (see Figure 2). However, the solid parts of the broken lines are equally important to indicate where students encountered obstacles, had difficulties, got stuck, or were unable to relate to a situation or learning context, such as S6's experience in the provincial school.

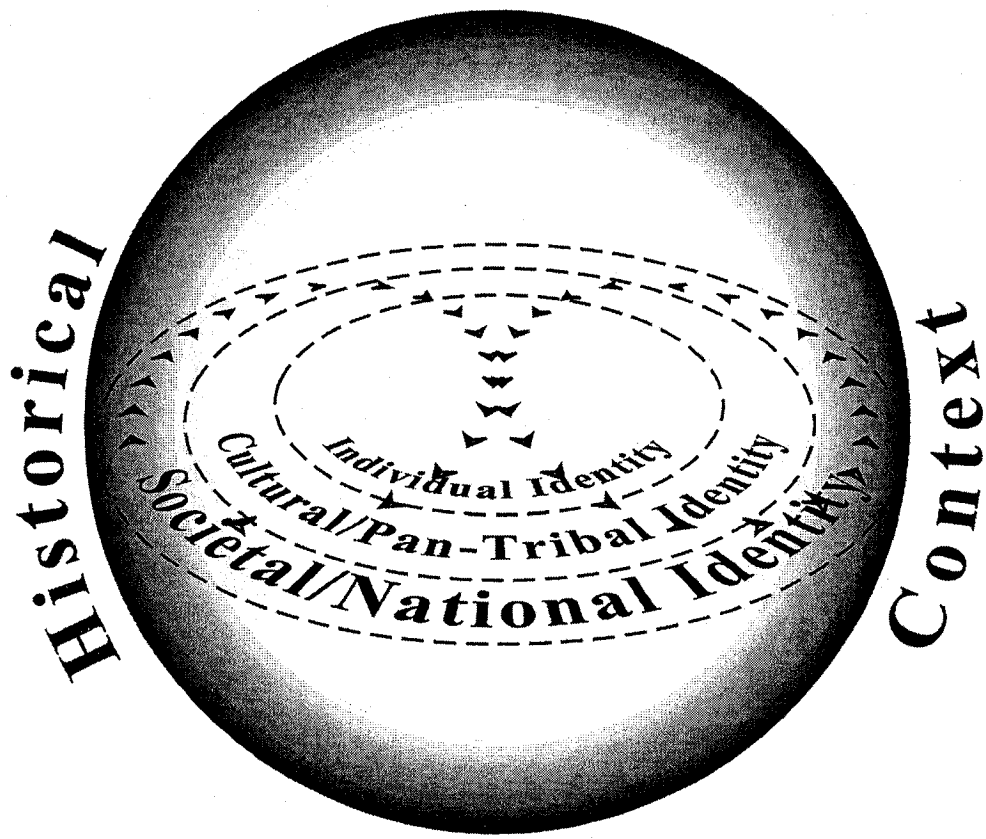

Figure 2: Border Crossings

The small, circulating *arrows* signify that an *outward and inward flow* exists among these circles and the continual journey each individual makes to form an identity in the world. Even when a student is stuck, or unable to cross a border, the associated influences are still present in his or her psyche, and affect behavior. For example, S6 describes himself as stubborn – a personal identity that derives from his family (e.g. his grandmother) and that protects him and gives him confidence. That same identity, however, also made it difficult for him to succeed in the provincial school. Other examples can be found in the interviews, as well as during the field trip in which Steven Ginnish continually wove into the discussion the community's uses for plants and their personal relevance to the students' lives (e.g., allergies to medicines, make-up, candy).

The Spiral of Culture

Through the vertical dimension of the model winds a spiral to represent both *cultural continuity and the emerging nature of culture* (see Figure 3). The spiral, a symbol found in many cultures, conveys the impression that we continually cycle through nature, much like the seasons, yet we never are exactly where we were before. Realities shift, as do our relationships to that reality. This vertical dimension also conveys a sense of time. It provides a collective well of past experience that transcends personal identity, feeds into the present moment, and is part of the momentum for forging ahead into the future.

I have used the image of a spiral, and have labeled this spiral, "cultural continuity/emergent culture" to indicate the way we draw from our cultural heritage while meeting and adapting to new and emerging realities. The spiral itself weaves through and around the identity sphere ad infinitum to show the interrelated nature of the

various influences on identity formation and to indicate the fluid and ongoing nature of identity formation.

A number of examples of both cultural continuity and the emergent nature of culture can be found in the data. Cultural continuity can be seen in the *puklatmu'jk* stories, the continued use of the Mi'kmaw language, Steven Ginnish's teaching about plants and medicines used in the Native culture, the use of sweet grass, and the ongoing presence of legends and stories within the community. More examples can be seen in the trial lesson when the teacher referred back to pre-Columbus times, discussed the uses of various resources to make paint, and referred to the work of Alan Syliboy. Other examples were provided as part of the students' experiences at powwows especially their accounts of changes in the stories told from year to year.

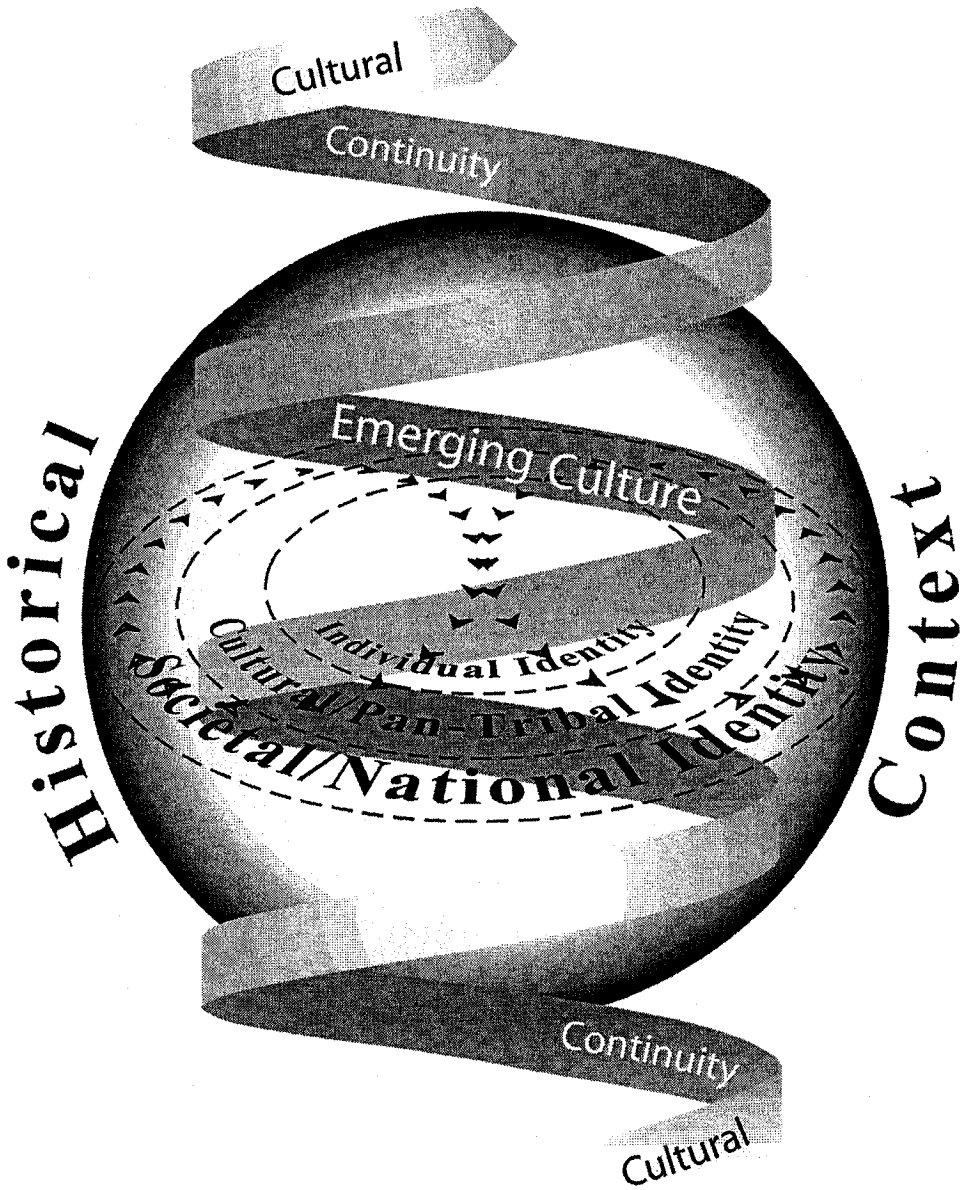

Figure 3: The Spiral of Culture

Beyond Boundaries to the Spiritual

I purposely extended the spiral beyond the sphere to indicate that the cultural influences reach beyond time to the spiritual dimension in the final component of the model (Figure 4). The first dimension is the movement between personal, cultural, and societal identity. The second dimension is cultural continuity with the past and emergence of new cultural identity. The third dimension, depicted as the extension in space that creates the sphere, can be thought of as the sense of relatedness, or interdependence of all phenomena that can be brought together into a narrative unity. I have included illustrations of animals and the landscape to depict the students' own sense of connectedness with their environment.

Ultimately, the foundation for meaningful learning occurs beyond the boundaries of self and society, past and future, in the space of fragile ontologies where everything is in some sense interdependent and co-emerging. This dimension allows the students to reach beyond their personal, cultural or societal identity, to a larger sense of compassion, as can be seen in the discussion by S1 and S2 of the Columbine shootings, and in Steven Ginnish's continual reference to respect for "Mother Earth" and his use of the metaphor of "healing." In the case of the Mi'kmaw students, I have used images from their interviews, and their connection to the landscape to depict this larger, cultural psyche that gives them narrative unity in their lives and connects them to a large sense of being in the world.

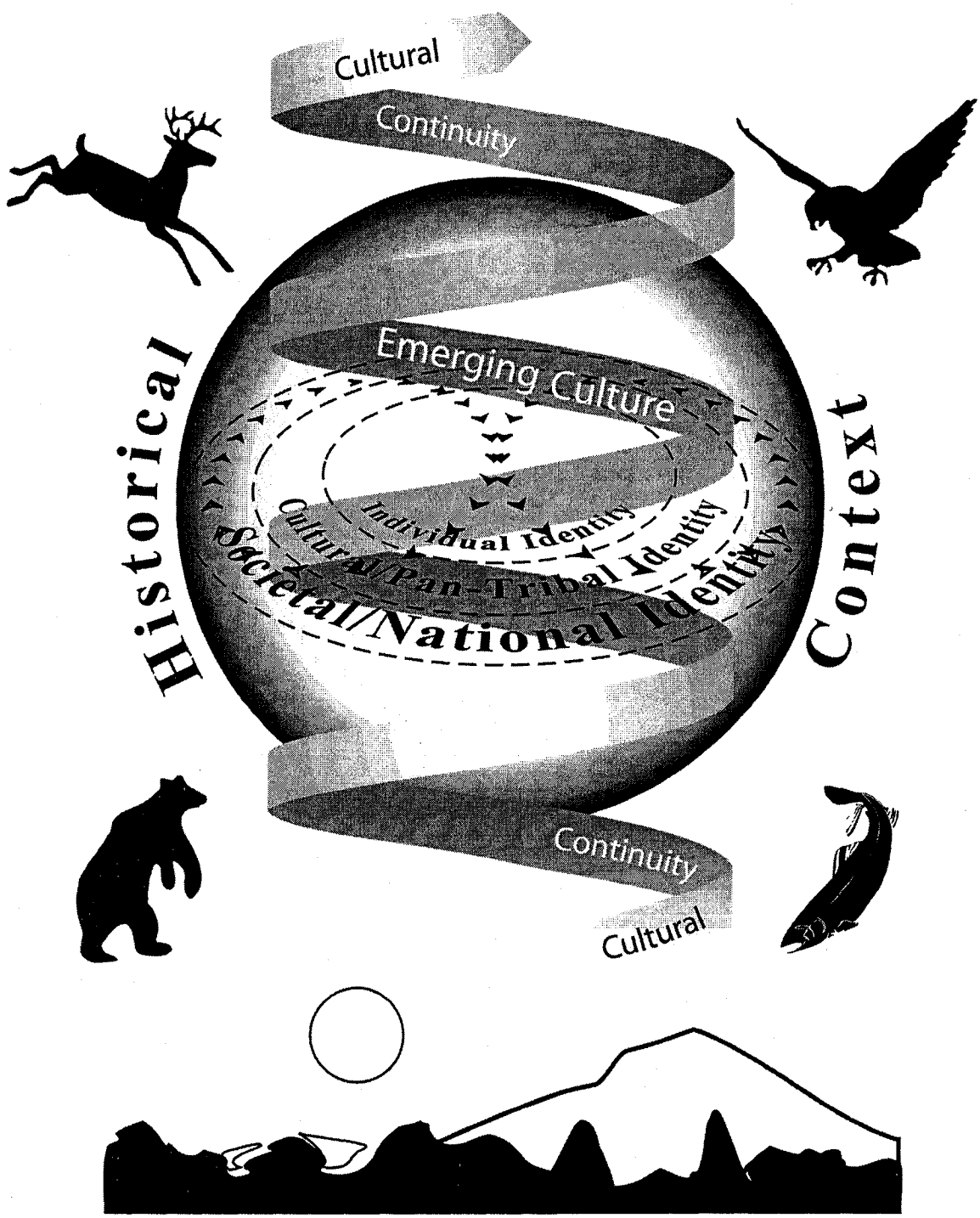

Figure 4: Beyond Boundaries to the Spiritual

Using the Model

This model demonstrates both the different aspects of identity formation, and the range of contextual influences within a student's life – personal life, cultural background, local, national and international cultures, as well as the historical legacy – that affect their learning. It offers a way to think holistically about the students, and a way to think about places where they are having difficulty, or conversely, where they are able to make connections. For instance, if we accept the concept of border-crossing as an aspect of the model, then any solid piece of the broken lines within any layer could be viewed as an obstacle in the student's learning. Conversely, this same dash/line could be viewed as a positive place to build on in terms of transforming the obstacle into an entry way to understanding through dialogue with students.

For example, the general lack of cultural content for First Nations students in science education has been identified as an obstacle for them when they try to connect to the curriculum. They do not "see" themselves in the books, although a number of efforts are being made to address this. If we contemplate this obstacle and work with it consciously then that same line in the figure becomes a stepping stone, in turn, an opening for students into a wider dialogue in which they can explore what science is or is not, as shown in my trial lesson.

By looking at the borders that we ask students to cross and what obstacles arise at these borders, we can begin to speak together to identify difficulties. Both the emergent and continuous aspects of culture are vital components for building a curriculum. Incorporating both the continuous and emergent aspects of culture into pedagogy can provide students with a solid foundation from which they can connect to material that is

often alienating to them.

The model could also be used to look at the school within the community or the community within the larger society, in a similar exercise to identify what obstacles or openings are present for working under certain conditions. For instance, many dialogues are occurring throughout the world regarding Global Science and Local Science. (cf., Bicker, Sillitoe, and Pottier 2004).

The model can also be used to look at science education in general, and how it does or does not relate to different cultural groups. Generally, students are instructed to pay attention to what a society, via the curriculum, deems relevant and important. The introduction of scientific thinking generally excludes other knowledge systems that are not deemed relevant, and yet we know, on a personal level, that students learn more easily those things that they deem relevant to their inner world, their identity and how they would like to be able to relate to the larger world. Aboriginal peoples as a whole have been saying similar things about their cultural identity and the relevance of their way of knowing within the global context.

It is possible to adapt this model to different grade levels because the principles are the same for any situation and the same five themes, I believe, can be seen in any situation. In this case, I was working with Grade 7/8 students to try and understand what a transitional year is for a number of the students. The following year, approximately half the class would be attending provincial school, and entering a larger, exciting, and challenging new world.

Other models can also be used in a complementary fashion and incorporated into my model. For instance, the medicine wheel used by Aboriginal peoples could be used

alongside this model. Standards or outcomes for learning, whether from the provincial curriculum (e.g., *Common Framework of Science Learning Outcomes*, CMEC 1997) or standards such as those articulated by Eber Hampton and adapted by Madeline MacIvor for science education could also be applied within this model, as will be discussed in the next section. In other words, this model is about speaking together, generating dialogue between different world views, and coming to know the layers of identity and engagement at play within a learning situation. Given that science is an essential body of knowledge to understand, while recognizing it as a way of thinking and a culture in and of itself, my model accommodates the narrative of science (the story), its contents, as well as other cultural ways of knowing.

Other Models for Learning

A number of models have been put forward regarding Aboriginal Education, although few relate directly to the teaching of science. Many features described in my model are similar to and complement those found in other models. For example, the use of *mandalas* and medicine wheels as a means for depicting relationships between inner and outer, subjective and objective, the parts and the whole, enable the viewer to grasp the integrated and interactive aspects of learning. The Coalition for the Advancement of Aboriginal Studies has adopted the medicine wheel model as the basis for its approach to teaching and learning (Coalition for the Advancement of Aboriginal Studies 2001).

I have chosen to compare my model to three models used for science education: (1) a general model for Aboriginal education by Arlene Stairs; (2) a model of education by Eber Hampton and adapted for science education by Madeline MacIvor; and (3) two

models developed by Gregory Cajete for an Aboriginal science education.

Stairs Model

Arlene Stairs, in her article "The Cultural Negotiation of Indigenous Education: Between Microethnography and Model-Building" (1994), contrasts the multidimensionality of her model to the uni-dimensionality of other models of Aboriginal education (Stairs 1994: 154). The premise of her model is that "school is a cultural phenomenon" bounded by history and current contexts. Stairs maintains that schools must serve as "agents of negotiation among cultures in contact" and not simply as transmitters of subject material needed for success in the world (155). Stairs also views learning as dynamic and participatory, and as a meaning-making, narrative endeavor (156-157). Cultural negotiation includes a view of education as "culture in the making" on many levels. Schools are considered as sites where negotiation between the surrounding cultures, the school, the students and their own culture is an ongoing process of construction and reconstruction of identity (156).

Stairs depicts her three-dimensions by the use of rectangular cubes side by side (See Figure 5). The horizontal dimension represents the wide range of contexts from the classroom out to the values and culture of the larger system. The vertical dimension signifies the "level of meaning, progressing from the 'what' of language and content, to the 'how' of ecological and social relationships, to the 'why' of worldview and cultural value systems as the focus of indigenous schooling" (Stairs 1994: 154).

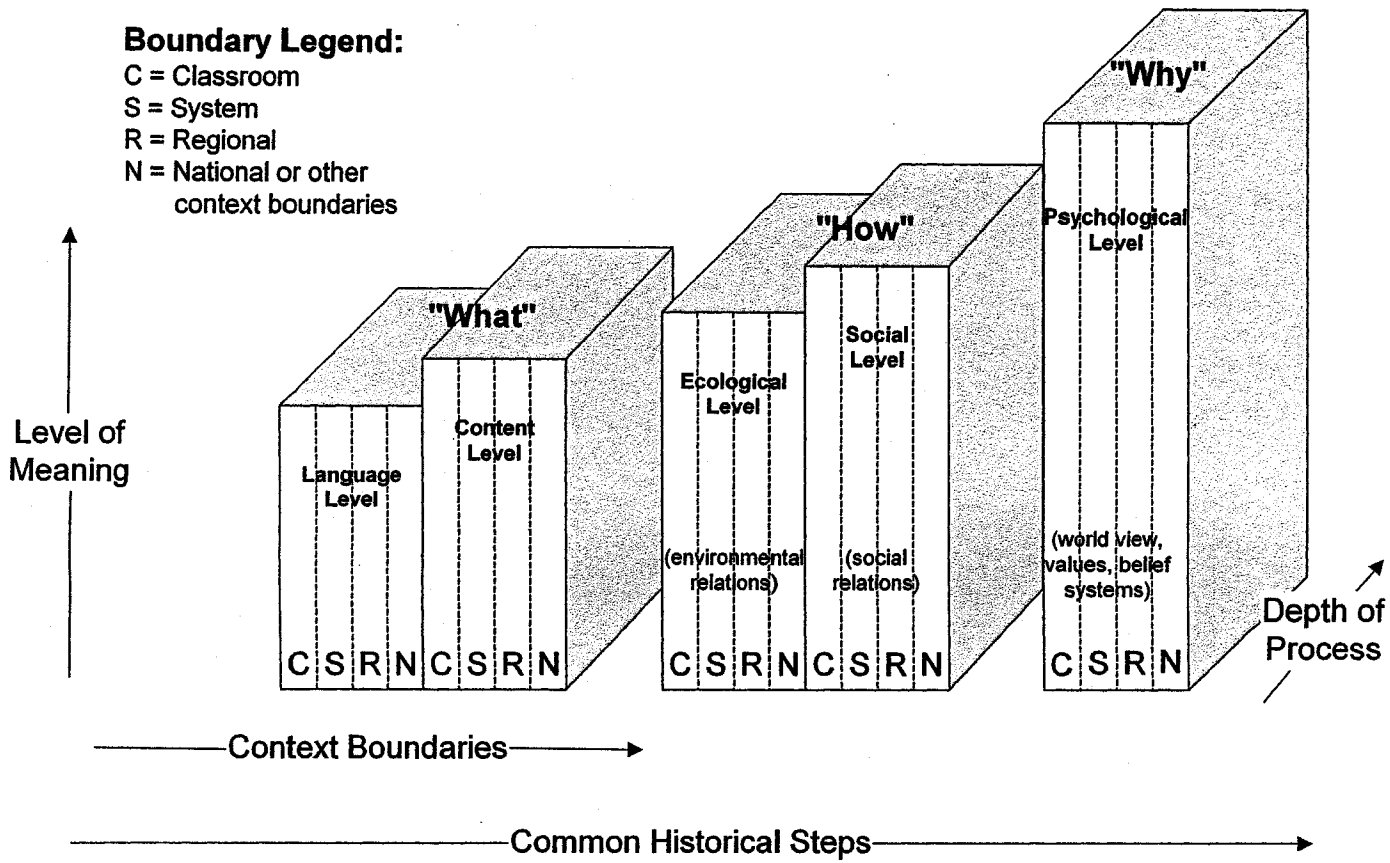

Figure 5: Stairs' Model of the School as a Cultural Phenomenon

Adapted from: A. Stairs (1994) The Cultural Negotiation of Indigenous Education: Between Microethnography and Model-Building. Peabody Journal of Education, 69 (2), 154-171

Stairs describes the third dimension as the "degree of engagement and participation at any level of meaning" (154) and relates this to constructivist directions in education. She considers this third dimension as largely invisible yet most important in the meaning-making process required for Aboriginal students to engage in learning and find their identity.

Stairs sees the "how" of education as lacking in depth, even if the content of lessons seems culturally relevant and meaningful. If students do not find their own meaning within any context, they will not be engaged in the learning process. She describes the "why" of learning as being about the depth of meaning-making for the students, and the place where they negotiate their identity: "...we see that the cultural negotiation of education is in fact the negotiation of identity as it evolves through interactions of individual and surrounding culture(s), and between cultures" (167).

Stairs concludes her discussion by presenting the Inuit model of identity in which participation – deep process – is the essence of integrating all levels of meaning. She introduces the Inuit ideal of *inummarik*, the process of becoming a "most genuine person. [Through] a lifelong process of developing correct interaction with humans, animals, and the non-living environment, one maintains connection to all aspects of the world with tolerant, quiet distance" (168). Stairs speaks of cycling throughout all layers and contexts as "active building and rebuilding of relationships" (168).

The graphic model presented by Stairs (Figure 5) is a work in progress that does not convey the dynamism and cycling aspects that she describes. While border crossing is more implicit than explicit in her discussion, Stairs' work validates the components of my model (Figure 4) with the exception of fragile ontologies. Stairs also does not use the

term spiritual, but it could be interpreted as being present in the third dimension of her model – the deep process of engagement and meaning-making aspect – and her discussion of the Inuit term, *inummarik.*

Hampton/McIvor Model

Madeline MacIvor reflects on and adapts Eber Hampton's twelve standards of Aboriginal education (discussed in Chapter Two) to develop a model for science education (MacIvor 1995: 75). These twelve standards arose from Hampton's research to answer the question: "What is Indian education?" (Hampton 1995: 7). The twelve standards that arose from this research are: spirituality, service, diversity, culture, tradition, respect, history, relentlessness, vitality, conflict, place, and transformation.

Hampton's key concept relates to how Aboriginal students' come to find their "place" or identity within the scientific world. In Hampton's vision, students first have to feel who they are and connect to their identity, which also involves connecting to their culture and their history and to find how to bring the strength of their traditions into the present. Hampton attaches great importance to identity and its connection to culture and history. This foundation for learning was confirmed in my own research interviews and is accounted for in the "Cultural/Pan-Tribal" layer of my model.

MacIvor, a Metis and member of the Canadian Aboriginal Science and Engineering Society, takes Hampton's twelve standards and relates them to science education. She argues that the first standard, spirituality or the "centrality of the sacred," is especially relevant to science education because of the interwoven nature of Indigenous knowledge and their ceremonial or religious traditions (MacIvor 1995: 75). This standard

relates to the "Beyond Borders to the Spiritual" component in my model. She also cautions that to bring these traditions into the classroom requires great care and respect, and suggests educators can facilitate this by inviting Indigenous parents or community members to participate.

The second standard, "service," MacIvor suggests could be applied by making science relevant to Aboriginal community concerns, and incorporating local knowledge into curriculum (76). The third standard, "diversity," could be addressed by recognizing the many languages and cultural differences among Aboriginal peoples, and allowing for local community input in respecting these differences (77). The fourth standard, "culture" involves culturally appropriate teaching methodologies and understanding of and respect for traditional beliefs and practices (78). Some of the methods used and skills taught in science may be at odds with local cultural practices, and these need to be explored and discussed. The second through fourth standards correspond to the cultural/pan-tribal layer of my model.

The fifth standard, "tradition" relates to the cultural continuity of a people and the identity derived from that continuity (80). This standard corresponds to the spiral in my model associated with cultural continuity. MacIvor suggests that Aboriginal traditions can be incorporated by looking at how science and technology have been used by Aboriginal peoples through time, as well as Aboriginal peoples' contributions to sciences. The sixth standard of "respect" is related the students' sense of personal autonomy and power as a value inherent to Aboriginal peoples. MacIvor suggests teachers need to respect the knowledge students bring with them and build on it as a means to both validate and include the student in the learning process (81). This

inclusivity is implied in the whole purpose of my model. My suggestion regarding "speaking together" opportunities is a means toward accomplishing inclusivity within the teaching of science.

The seventh standard, "history" relates to the history of colonization, and its toll on Aboriginal cultures. This history could be looked at in terms of the development of science and technology and its influence on society and cultures (82). This seventh standard relates to the overall "Historical Context" around the identity sphere, as well as the spiral labeled "Cultural Continuity" going through the sphere in my model.

The eighth standard," relentlessness," refers to Aboriginal peoples themselves being committed to bringing science education to their own people and communities (84). This effort includes creating new approaches to science education, better mentoring and counseling of Aboriginal students, upgrading facilities and materials for teaching science, science camps, and so forth. The ninth standard, "vitality," refers to the continuing life and relevance of Indigenous knowledge, its strength and continuity, despite the history of suffering and denial of Aboriginal ways of knowing (85). MacIvor suggests that respecting this vitality involves learning proper protocol for approaching elders with whom we wish to work to understand this knowledge, and new research frameworks for working in partnership with Aboriginal communities (85). The eighth and ninth standards relate to both the cultural identity of the Aboriginal students, and the spiral of cultural continuity/emerging culture in my model. These standards were reflected in both the interviews in which students spoke about aspects of their culture, including the importance of the language, and in the field trip led by Steven Ginnish. His presentation continually emphasized the contemporary relevance of Mi'kmaw and

Aboriginal environmental knowledge.

Standard ten, "conflict" has to do with the alienation many Aboriginal students feel from a Western scientific way of thinking, and having their own way of thinking dismissed as "unscientific" (86). This disjuncture can be addressed by creating an opening to look at different perspectives through language, symbol, lesson content, etc. and show how this knowledge can be complementary to science. This "conflict" relates to unsuccessful border-crossing, which can occur at the different layers of identity and are depicted by the solid dashes in my broken lines.

Standard eleven, "place" again has to do with Aboriginal students not having a way to relate with Western science given the scarcity of role models or course content with which to relate (88). Giving a place to indigenous science in the classroom, as well as discussing how science can assist in protecting traditional territories, resource use areas, and so forth would give the students a way to identify with the "story of science." This corresponds to the "Cultural Identity" layer of my model, as well as the spiral of "Cultural Continuity" and "Emerging Culture."

By contemplating all the standards, the twelfth standard, "transformation," refers to the transformation that can begin to occur within the science curriculum, moving from an assimilationist model to one of respect, inclusion, learning, and expanding how different peoples experience and come to know the world (90). Ultimately, my model is about this process of transformation.

Cajete Model

Gregory Cajete (1994 & 1999) is specific and comprehensive in his proposed models for

science education and curriculum development for Aboriginal students. Figure 6 outlines his model for creative process instruction. The model is based on four groups of processes: (1) perceptions, paradigms, and components; (2) principles, forms and classification structures; (3) processing creatively, experientially and holistically; and (4) reflecting symbolic orientations. Figure 6 presents these components as parts of a holistic model for understanding science education. Cajete views the learning process as beginning with the students' personal identity and the educative process as connecting personal and cultural mythology (Cajete 1994: 117). He describes personal mythology as forming a "dynamic web that informs the very essence of our lives" (117).

Cajete states that a key to understanding indigenous education is mythic language and the deeply embedded mythological complexes through which we shape our lives. I believe these mythological complexes are similar to the "webs of significance" I have presented in previous chapters. Cajete's discussion of personal and cultural mythology aligns with my discussion of the personal and cultural identity component of my model. This personal and cultural identity was seen to be embedded in the local landscape, and repeatedly re-created and reinforced through the legends, songs, and dances that transmitted this web or mythological complex through time, as shown with the *pukalatamu'jk*, Kluskap, and other legends mentioned by the students.

Cajete views teaching as the transmission of systems of cultural symbols. Scientific thinking itself is a culturally conditioned, "logical-rational-thematical" style of thinking (112). He characterizes Native Americans as representing and communicating about natural processes symbolically, a creative and artistic process. He views the artistic and scientific thought processes as complementary in Native American Cultures – art

being the creative representation of natural processes, and science being the explanatory aspect (112):

> Based on these foundations, the strategy of the curriculum model is to provide the presentation of the basic principles of general science by first introducing students to the ways in which these principles are communicated, utilized, or otherwise exemplified in Native American culture. Students are then presented with a comparison of these cultural examples with similar elements in Western science. The idea is to illustrate that these principles are the result of the creative thought process and to establish this as a point of commonality between both cultural perspectives. Finally, the students are provided with a variety of opportunities to review and apply the basic principles. (Cajete 1999: 112)

Art, in Cajete's opinion, becomes a means for learning science from a "socio-cultural and affective/creative process" (112). Cajete views this creative aspect as a means for orienting students to underlying patterns of thinking that influence both Native American and Western science (113). He includes the use of art as an integral process to learning. While I have not made the use of art explicit in my model, it is included in all curricula I have developed to date, and discussed at length in my other publications and research documents (Sable 1996, 1998).

In Cajete's Creative Process Instructional Model (Figure 6), the journey begins in the center with each student finding their inherent creativity and cultural identity as a way to connect with the basic principles or "underlying patterns of thought" of science through their own cultural background; or what he terms "First Insight" in the first quadrant or stage of his model (top, right quadrant). The students then begin to work with myths and metaphors and other cultural content which assist them in forming "perceptions, paradigms of thinking, and a sense for the essential components of what they are about to learn" (Cajete 1999: 170).

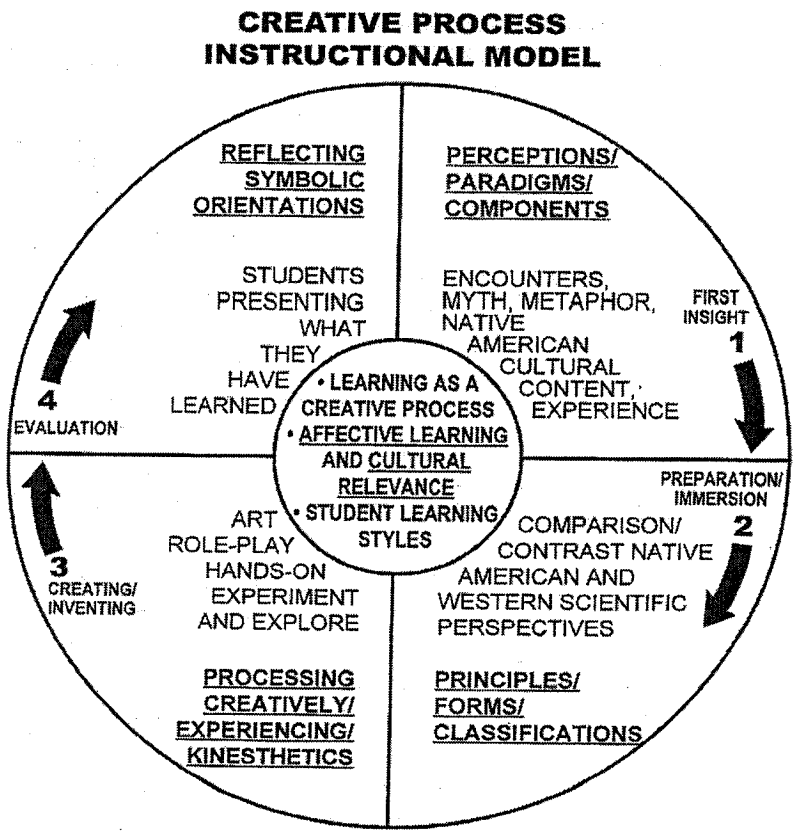

Figure 6: Cajete's Creative Process Instructional Model

From: Cajete, Gregory A. (1999) Igniting the Sparkle: An Indigenous Science Education Model. Skyland, N.C.: Kivaki Press, p. 171.

In the second quadrant or stage, "Preparation/Immersion," the students engage in comparisons of Native American and Western scientific perspectives, facilitated by the teacher and are introduced to the classification systems and principles of Western science. In the third stage, "Creating/Inventing," students engage in artistic exercises, role playing, and other hands-on activities to process what they have learned creatively and through direct experience. In the fourth stage, "Evaluation," students reflect on the "symbolic nature of their learning" through presentations and discussions about what they have learned. During this final stage, students can develop what Cajete terms an "affective connection," in which they develop a deeper sense of the meaning or significance of what has been learned (Cajete 1999: 171).

In reflecting on my trial lessons, much of what Cajete suggests in his instructional model is included in both the approach and the content of the lesson. At the very beginning of my trial lesson, I hung the Mi'kmaw map of the Atlantic Provinces alongside the map of the Atlantic Provinces issued by the Government of Canada. This display immediately illustrated two cultural perspectives of the landscape, and provided visual support for the students to border-cross between different cultural perceptions of the landscape. The Mi'kmaw map also depicts a variety of animals with their Mi'kmaw names around the edges of the map signifying the Mi'kmaq close relationship to the earth and interdependence with living beings. This relates well to the first stage of Cajete's model, "Perceptions/Pardigm/Components" in which he includes myth, metaphor, and Native American cultural content experience. The animals depicted on the map are integral to the many Mi'kmaw myths and mythological complex. In my model, the animals are around the sphere indicating both the cultural connectedness to the world

view of the students, as well as the "Beyond Boundaries to the Spiritual" dimension in their awareness of the interdependence and relatedness of their lives to the environment.

The students could also see that the Mi'kmaw map contains only Mi'kmaw toponymns, while the Government of Canada map is pre-dominantly in English with post-contact European names, with only a few exceptions. Each of these toponymns, when translated, describes some aspect of Mi'kmaw land use, history, or mythological beliefs. There are no provincial boundaries on the Mi'kmaw map, just the names of Mi'kmaw traditional territories, again illustrating different perceptions of the landscape.

I next included a discussion on the definition of the Mi'kmaw word for earth and a Western scientific definition to stimulate a linguistic discussion of terms. The teacher made further comparisons between the "Indian" scientists in pre-Columbus times and scientists as we know them today, and asked what the students' ancestors would have used as labs. I also included a comparative chart to present western symbols with Mi'kmaw words for different elements and substances, such as copper and iron oxide. This was followed by the hands on experimentation with the ochre, heating it and mixing it with egg yolk to look for physical change. These activities compare to Cajete's second stage, "Preparation/Immersion" in which he includes comparisons, contrasts of Native American and western scientific perspectives.

Next, my lesson provided opportunities for the students to use the ochres for making paints as their ancestors once did, having first understood its properties in the experimentation part. They cut leather strips for arm, wrist, or head bands to paint their own designs and symbols, in a fashion similar to their ancestor's clothing as shown on the slides viewed earlier in the lesson. This activity corresponds to Cajete's third stage,

"Processing Creatively/Experiencing Kinesthetics" in which he includes art, role playing, hands-on experiments and exploration.

Finally, the students were asked to design their own symbols for painting their leather scraps for arm and wrist bands. The lesson was designed to include a discussion of this project and the students' symbols, and their learning process, but time ran out. These activities compare to Cajete's fourth stage, "Reflecting Symbolic Orientations" in which he includes an evaluative process in which students present and discuss what they have learned.

Cajete specifically includes both western and Aboriginal science in his discussion of curriculum development (Figure 6). The model is helpful to visualizing and understanding the respect science is being given as a component of an Aboriginal curriculum while putting it within a holistic perspective. From the students' point of view, science is not being alienated; rather it is being respected and integrated in hopes of healing the alienation many Aboriginal students have felt toward science and science-related fields of study.

Summary

In this chapter, I have discussed models specifically relevant to Aboriginal students and their learning of science. In the first section, I introduced the various layers of my model as they have emerged from my research. The model I have proposed is a way of contemplating the various layers and conditions affecting the students' learning experience, and how they travel or don't travel between these layers depending on their experience. These layers are further influenced by a larger historical context within

which each student's personal journey is situated at any one point in time. The model is infused with the moment to moment emergence of identity (fragile ontologies). Furthermore, each student has a larger narrative that brings all the layers into relationship with one another, and assists them in mediating between seeming paradoxes, and in finding a common humanity.

In the second part of the chapter I compared my model with other models, specifically ones relating to the learning process of Aboriginal students. I discussed Arlene Stairs multi-dimensional, constructivist based, model of the school as a cultural phenomenon. This was followed MacIvor's adaptation of Hampton's twelve standards for Aborignal education for the teaching of science. Cajete's model was then introduced as a comprehensive and complex model that specifically integrates Indigenous science and Western Science within an Aboriginal model for science education. My model, as well as those of Stairs, Hampton, MacIvor, and Cajete, refers to a need for a more phenomenological and fluid framework for thinking about Aboriginal science education.

Chapter Seven

Conclusion

The purpose of this research was to explore an alternative pedagogy for teaching science to Aboriginal students incorporating alternative ways of knowing and systems of knowledge. I looked at the conditions necessary for developing what I term a "culturally interactive science curriculum." The term "culturally interactive" refers to the border crossings Aboriginal students must make to live and learn with different world views (or sets of values and beliefs) within their own culture and that of provincial schools (Aikenhead and Jegede 1999). A culturally interactive science curriculum recognizes that many Aboriginal students must live, learn and study in different science cultures – their home and community culture in which Indigenous Ecological Knowledge is used and informally taught and their school culture in which Euro-American scientific knowledge is used and formally taught.

This study investigated the basic relationship between learning in general and the meaning making processes engaged in by the grade 7/8 Mi'kmaw students involved in the research. This approach was taken in the belief that learning science must begin with the students' personal experiences, and must provide avenues to help them find their identity within the learning process. I examined how these Mi'kmaw students perceived themselves in different contexts and how their sense of identity established the meaningfulness of particular educational content. I also assessed how personal, community/cultural and social contexts affected the students' learning. As a result of the study I identified conditions and contexts necessary to help the students cross cultural borders in science studies. To provide a context for their experiences as Mi'kmaq within

the current educational system of Atlantic Canada, I first looked at the legacy of science and scientific thinking in relation to Aboriginal peoples. I then followed the legacy with a discussion on past and current research regarding Aboriginal peoples, specifically in education. This context was provided to assist readers in understanding the current academic performance gap that exists in our educational system between Aboriginal and non-Aboriginal students, and why Aboriginal peoples are calling for self-determination and the development of their own research tools and educational philosophy. In so doing, I have identified a complex web of factors that affect the full participation of Mi'kmaw students in scientific fields of study.

Through interviews with the students, my research has shown that Mi'kmaw Grade 7/8 students hold multiple world views and move back and forth between these views to suit the context in which they find themselves. Mi'kmaw students face a complexity of personal, cultural, and social conditions within contemporary educational systems that often affect their continued participation in the learning process. I have also shown the powerful, underlying cultural identity and its relationship to the landscape that is a major thematic reference point for the students; and the importance of acknowledging this cultural identity as a guide to the students' perceptions of their lived experiences.

For educators to understand how this complexity of issues relates to grade 7/8 Mi'kmaw student achievement of scientific literacy requires a theoretical framework that allows the students' lived experiences to emerge. The view underlying my proposed framework is the acknowledgement of fragile ontologies – the ongoing, moment to moment, multi-layered process of meaning making and identity formation. In so doing, educators can come to understand the larger narrative that gives shape to the students'

identities and ways of relating to the world and to recognize the boundaries that both obstruct and open a path to meaningful learning experiences. I presented this concept of fragile ontologies as a web of relationships and networks of meaning that form the basis for personal, cultural and social identity.

I have also shown through both the field trips and the trial lesson, that a culturally interactive science curriculum needs to include content that reflects Mi'kmaw environmental knowledge, along with their language as the symbolic means of expressing and communicating that knowledge. Five themes emerged from the student interviews, the field trip, and the trial lesson as the foundation for a culturally interactive model of learning and a culturally interactive science curriculum. These themes were:

1. fragile ontologies;
2. multiple layers of identity comprising personal, cultural/pan-tribal, and societal features;
3. border-crossings;
4. cultural continuity/emerging culture; and
5. a greater spiritual narrative.

The most striking realization that arose from the interviews was the continued connection of the students' identity to the landscape of their community, which was reinforced by the perpetuation of legends, the continued use of their language, and the beliefs of the Elders. All the students envision themselves in Canada's future, but they also carry with them their unique culture tied to the landscape of the Maritimes with a language that reflects the complexity of that landscape and inhabits it with *pukalatamu'jk* and other beings. Their language therefore continues to be essential to their identity.

Using their language in science education becomes a profound way to engage Mi'kmaw students in new meaning-making. Knowledge itself, I noted, is about identity.

This relationship to the landscape, along with the presence of powwows and the emerging pan-tribal consciousness of Aboriginal peoples, provided penetrating evidence of what some Aboriginal peoples have been saying for decades – it's time for a new story in education. This new story emerges in combination with a sense of Canadian identity and brings with it the need to learn science as part of being Canadian. In the proposed culturally interactive curriculum, these identities can be brought into dialogue and respected in order for essential border-crossings to occur in learning. If science is a way of coming to know our universe, then the teaching of science must also be a way for students to come to know who they are within that universe. In a culturally interactive science curriculum, Aboriginal students can begin to discover science in its own right and not as something culturally alien.

The Learning Model

The learning model, or the process by which students come to engage new knowledge and ways of knowing as meaningful, is a way of seeing at once the various layers and conditions at play in the students' experiences. It offers a visualization for understanding the relationship of the layers, assists educators in mediating paradoxes, and helps them find the spirituality that lies beyond the boundaries of the model. The many layers of the model are all features in how the students become engaged in inquiry and motivated to learn.

The culturally interactive science education model brings Indigenous science and Western science within a shared sphere of learning. With the approaches to learning

discussed throughout the thesis, educators can begin to look at science education as a holistic activity that engages students within a wider context of their experiences. The content of the curriculum can be drawn from the cultural heritage of the students, giving them an historical context with which to identify. As examples, I presented the results of a trial lesson on "Chemical Changes" and a field trip project adapted from the "Diversity of Living Things" lessons in the *Science Plus* text used in the school. I then looked at ways to open avenues for creative learning and cultural interaction.

Taken into the classroom, this interactive paradigm could be adapted to pedagogical methods as "speaking together" times (Duschl 2000), in which students could explore the processes of doing science while appreciating their own cultural traditions. Working with the language and notational representation of the students' own culture has been shown in this study and by other Aboriginal educators to help the students learn to cross cultural borders and understand the cultural continuity of their own heritage.

Recommendations for Further Research

The research presented in this thesis is limited to a small group of Grade 7/8 Mi'kmaw students within a reserve school in the Maritimes. Further research is needed into the other grade levels, within both reserve and provincial schools and at post-secondary levels to create a comprehensive data base. I recommend that a consistent research methodology be agreed upon among Aboriginal educators and educators concerned with Aboriginal education provincially and nationally. I further recommend that this method involve a phenomenological approach as a means to understand the lived experiences of

the students.

Research is needed to track students as they leave reserve schools and enter provincial schools. Their experiences need to be compared to those of Aboriginal students who attend either provincial school or reserve schools throughout their education. Since my time in the community, the local, provincial school has initiated a program in which their students do some of their studies with the classrooms of the reserve school. This type of initiative opens communications between reserve and provincial schools, and is a stepping stone to cooperation in curriculum development.

This thesis has not included a discussion of Aboriginal teachers and their teacher education, a vital topic in terms of "the new story" that Aboriginal educators are trying to find. Most Aboriginal teachers have had to rely on traditional education programs as taught in Canadian universities from which they received their degrees.

More work is required in curriculum development, and in pedagogical methods for teaching Aboriginal students. Numerous Aboriginal educational curricula, including indigenous science curricula now exist; examples from around the world include Maori, Hawaii'an, Inuit, Cree, Sami, and Yupii't, science studies. These can be used as models to help educators revise science curriculum for use within reserve schools in Atlantic Canada.

Conclusion

Science does not stand in history solely as a "western" phenomenon. The history of science is also part of the history of Aboriginal peoples. Science has affected Aboriginal communities deeply and continues to affect them through its pervasiveness in every

aspect of life. Part of the STS vision is that science education should connect to the environment and larger society in which it takes place.

If we combine the definition of science proposed in Chapter One as "a rational perceiving of reality where perceiving means both the action [of] constructing reality and the construct of reality" (Ogawa n.d.: 2) with the concept of "speaking together opportunities" (Duschl 2000), I believe we can come closer to the definition of scientific literacy articulated in *Benchmarks for Scientific Literacy*: "to become thoughtful human beings who understand science as a way of knowing and [who can] follow the 'story' of science" (AAAS 1993: 3). If we can foster a culturally interactive and inclusive science curriculum, we have the potential for a broader narrative that would allow Aboriginal students to identify with the story of science. A culturally interactive science curriculum would enrich, not compromise, the understanding of science for all rather than continue the legacy of alienation and drop out. We have seen that within the students' learning process and identity formation there are overarching narratives at play that can connect the students to a larger humanity as a whole, accommodate paradoxes, and create opportunities specifically for learning science.

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Appendix A

EEL GROUND FIRST NATIONS SCHOOL PRINCIPAL'S CONSENT FORM

Researcher: Trudy Sable

Title of project: Development of a Culturally Appropriate Pedagogy and Science Curriculum for Mi'kmaw Students

Location of Project: Eel Ground First Nations School, Eel Ground, New Brunswick

I have been fully informed about the nature of the project and its requirements and I,_____ give my consent for Trudy Sable to: (please check AYes@ or ANo@ following each request.)

Participate in the Grade 7/8 class from March-May/June, 1999	Yes___ No___
Interview students and tape record these interviews;	Yes___ No___
Videotape some of the Grade 7/8 classes	Yes___ No___

I understand that no audio or videotaped material will be used for any other purpose beyond this project without my consent, and that tapes of interviews with my Grade 7/8 students will be erased if requested. I also understand that no names will be used in written material, and that any of the Grade 7/8 students, or the teacher can withdraw from the project at any time.

Signature of Principal_____ **Date**_____

To be filled out by Researcher

To the best of my abilities, I, Trudy Sable, have explained the purposes, benefits, risks and inconveniences of this study to Peter MacDonald and have answered all his questions. I have also agreed that if the nature or purpose of the research changes, he, and all participating parties, will be informed for consent.

Signature of Researcher_____ **Date**_____

(A copy of this form will be returned to you.)

Appendix B

TEACHER'S CONSENT FORM

Researcher: Trudy Sable

Title of project: Development of a Culturally Appropriate Pedagogy and Science Curriculum for Mi'kmaw Students

Location of Project: Eel Ground First Nations School, Eel Ground, New Brunswick

I have been fully informed about the nature of the project and its requirements and I,_____ give my consent for Trudy Sable to: (please check AYes@ or ANo@ following each request.)

Participate in the Grade 7/8 class from March-May/June, 1999. Yes___ No___

Interview my students and have the interview(s) tape recorded: Yes___ No___

Videotape some of the Grade 7/8 classes Yes___ No___

I understand that no audio or videotaped material will be used for any other purpose beyond this project without my consent, and that tapes of interviews with my Grade 7/8 students will be erased if requested. I also understand that no names will be used in written material, and that a I, or any of my students, can withdraw from the project at any time.

Signature of Teacher_____

Date_____

To be filled out by Researcher

To the best of my abilities, I, Trudy Sable, have explained the purposes, benefits, risks and inconveniences of this study to Anne Ward and have answered all her questions. I have also agreed that if the nature or purpose of the research changes, all participating parties will be informed for consent.

Signature of Researcher_____ **Date**_____

(A copy of this form will be returned to you.)

Appendix C

STUDENTS CONSENT FORM AND LETTER

February 10, 1999

Dear Students,

My name is Trudy Sable and I am a graduate student in education at the University of New Brunswick. I would like to come to your class to do research with you from March-May (maybe June) 1999 to watch how you learn and what interests you, especially in science. If it's okay with you I would like to ask you questions and videotape your class. Your teacher, Anne Ward, also thinks this could be helpful and will make learning easier for you and students next year.

To do this, I need your help. I would like to talk with you about your ideas and feelings about science, and education in general. I would like to interview each of you, and possibly do some activities with you. It would help me to tape record what you say so that I don't forget, and so I can review the material later when I am thinking about how to create a science curriculum. Hopefully, you will have some ideas too. I will erase the tapes when the research is finished, or give you your own copy for your own use. I promise I won't let anyone else listen to these tapes unless you and your parent(s) or guardian(s) say I can.

I would also like your permission to videotape some of the classes, especially some of the science classes. This also helps me learn what you like to do, and what interests you. We can watch these videotapes together after they are done, if you and your classmates want to.

I will tell you more about what I am doing when I come there in March and sit in on your classroom. You can ask me any questions you have about what I am doing with this project. I'll do my best to tell you. In the meantime, if you feel ready, please fill out this form giving your permission to me to come be in your classroom, interview you, and videotape some of the classes. Your name will not be used in anything I write about the project unless you and your parent(s) or guardian(s) wish me to. You can also choose not to participate at any time, and I will understand. I don't want anyone to feel pressured about being part of this project, and I am hoping it will be fun. At the end of the project, I will treat you and your classmates to a feast to thank you and to celebrate what we all learned. I will also try to find a nice gift for the classroom.

Thank you for your help. I look forward to meeting you all.

Sincerely,

Trudy Sable

STUDENT CONSENT FORM

**(Please return this form to your teacher, Anne Ward.
I will give you your own copy)**

Researcher: Trudy Sable

Title of project: Development of a Culturally Appropriate Pedagogy and Science Curriculum for Micmac Students

Location of Project: Eel Ground First Nations School, Eel Ground, New Brunswick

Name of Student_____

I have read the above description of the project and I,_____ give my consent for Trudy Sable to: (please check AYes@ or ANo@ following each request)

participate in the Grade 7/8 class from March-May/June, 1999; Yes___ No___

Interview my child and have the interview(s) tape recorded; Yes___ No___

Videotape some of the classes in which my child may be present. Yes___ No___

I understand that

I understand that no audio or videotaped material will be used for any other purpose beyond this project without my consent, and that tapes of interviews of me will be erased if requested. I also understand that no names will be used in written material, and that I can withdraw from the project at any time.

Signature of Student_____ **Date**_____

(This next section to be filled out by the researcher)

To the best of my abilities, I, Trudy Sable, have explained the purposes, benefits, risks and inconveniences of this study to_____ and will answer all his/her questions. I have also agreed that if the nature or purpose of the research changes, all participating parties will be informed for consent.

Signature of Researcher_____ **Date**_____

I_____ give my permission to Trudy Sable to interview me and tape record what I say. I understand that this material will not be used by anyone else, and

that the tape will be erased if I request it. If the tape is not erased, it will not be used for any other purpose without the consent of myself and my parent(s) or legal guardian(s). A copy of the tape will be given to me if I wish.

I also agree to allow Trudy Sable to videotape some of the sessions in our classroom. I understand that these videotapes will not be used for any purpose other than this project without the consent of myself and my parent(s) or legal guardian(s). I understand that we will be able to watch these videotapes after they are made and copies given to our school if we wish.

I also understand that my name will not be used in the written thesis about this project unless I request it and have permission from my parent(s) or legal guardian(s). I understand that I can choose not to participate in this research and can withdraw from it at any time.

SIGNATURE OF STUDENT _____

DATE _____

(This section will be filled out by the researcher. A copy will be given to each student once the form is completed.)

I, Trudy Sable, have informed the students and answered their questions to the best of my ability about this research project, its' intended results, and any inconvenience it may cause to them.

SIGNATURE OF RESEARCHER _____

DATE_____

Appendix D

PARENTS CONSENT FORM AND LETTER

Dear Parent(s) or Guardian(s),

I am a graduate student in education and have served on the faculty at the University of New Brunswick. I have spoken with Anne Ward and Peter MacDonald a number of times about research I would like to do in cooperation with them and the Grade 7/8 students in the Eel Ground School. The research will help design a more culturally sensitive science curriculum for Mi'kmaw children.

Over the last nine years, it has come to my attention through various research projects and involvement with the Mi'kmaw community, that many Mi'kmaw students have difficulty connecting with science as it is taught in the provincial schools. The problem is not the students' lack of ability. It is my belief that this is due to how science is taught, and the lack of material that is meaningful, interesting and relevant to the student's history, culture and everyday lives. It is my hope that I can work with Anne Ward, the students in the class, a team of educators and scientists from the University of New Brunswick, and Native representatives in a partnership where we can begin to look at what could be done to make science more culturally meaningful to the students. Part of the research is to see if there are ways to bring Mi'kmaw history, culture and use of the physical environment into the curriculum content. To undertake this project it is important for me to participate in the Grade 7/8 classroom activities so I can talk and be with the students and see how a curriculum could be designed or altered to best meet their educational needs. Anne Ward has agreed to my participation in the classroom Monday and Tuesdays from March to May, 1999, and possibly June.

I am requesting your permission by way of this Consent Form to do taped interviews your Grade 7/8 child, as well as to videotape some sessions in the Grade 7/8 classroom at the Eel Ground School. The interviews I would like to conduct with each student will not be done during regular school hours C no class time will be missed. These tapes (both video and audio) will only be used for this research and not for any other public or commercial use. Copies of the tapes will be returned to each student, or erased if requested. No names will be mentioned in the research and children can withdraw from the project any time they wish.

I have offered to assist Anne Ward in some of the class activities in order to not take energy away from her responsibilities as a teacher, and in an effort to give something back to the classroom. I also intend to present the class with a gift at the end of the project and host a dinner for them to thank them for their participation. As well, the school will have use of any curriculum materials that result from the research done at the school, and receive a copy of my final written thesis.

I will gladly answer any questions or concerns you may have and I am willing to

come to Eel Ground to meet with you to discuss this project further if you would like to know more. You are welcome to call or correspond by e-mail as well. Thank you for your cooperation. I look forward to meeting you and working with your children.

Sincerely,

Trudy Sable
University of New Brunswick, Dept. Of Education.
Phone: 506-454-2021
e-mail: tsable@nb.sympatico.ca

PARENT/GUARDIAN CONSENT FORM

Researcher: Trudy Sable

Title of project: Development of a Culturally Appropriate Pedagogy and Science Curriculum for Mi'kmaw Students

Location of Project: Eel Ground First Nations School, Eel Ground, New Brunswick

Name of Parent _____

Name of Child _____

I have read the above description of the project and I, _____ give my consent for Trudy Sable to: (please check one of the answers)

Attend and assist in the Grade 7/8 class beginning in March, 1999. Yes___ No___

Interview my child and have the interview tape recorded. Yes___ No___

Videotape some of the classes in which my child may be present Yes___ No___

I would like to meet with Trudy Sable and discuss this project further. _____

I understand that no taped material will be used for any other use beyond this project without my consent, and that tapes of interviews with my child will be erased if requested. I also understand that no names will be used in written material, and that my child can withdraw from the project at any time.

Signature of Parent or Legal Guardian_____

Date_____

To the best of my abilities, I _____ have explained the purposes, benefits, risks and inconvenience of this study to_____ and have answered all his/her questions. I have also agreed that if the nature or purpose of the research changes, all participating parties will be informed for consent.

Signature of Researcher_____ **Date**_____

Appendix E

STUDENT QUESTIONNAIRE

Name/code: _____

Grade:_____

Age:_____

Date of Interview_____

Location:_____

Attended Provincial School. Yes No

Years of Attendance_____

1. Can you tell me what you like to do most in school?

    a) What is your favourite subject(s)? Can you tell me what you like about it?

    b) Is that the subject do you do the best in?

2. Can you tell me what your least favourite subject is? What don't you like about it?

3. Are there things about school that are helpful to you or important in your life? Can you tell me about these?

    a) What do you feel is the most important thing about going to school?

    b) Can you tell me if there is anything you are learning in school that you feel will be important when you get older?

    a) Can you tell me what you imagine you will be doing in 10 years?

4. Can you discuss what you do not like about school? Are there things you consider a waste of time?

5. Can you tell me what the most important things are in your life?

6. Can you tell me what types of activities you like to do most in your life? Is there something you really love to do? Can you tell me how you feel when you do this?

   a) Do you like to spend time outdoors? Can you tell me what you like to do most outdoors?
   b) Do you like to make things? Do you like to fix things or take things apart?
   c) Do you like to do art? Singing? Dancing? When do you do these?

7. Do you like to hear stories? What kind of stories do you like? Can you share one with me?

   a) Are there things you like to write about? Read about? Do you enjoy writing and reading? Can you tell me about something you have written that you really liked?

8. Do you have a favourite book or type of book? Can you tell me what you liked about it? Was there anything you didn't like very much about the story?

9. What kind of things do you like to do on your own at school? Can you describe a project that you did on your own?

   a) Are there time you like to be quiet and be left alone?

10. Are there times you like to work in a group? Tell me about a project you enjoyed doing with other people. Describe how you decided who did what?

11. Can you tell me how you feel about answering questions in class?

12. Do you like to have discussions about things in class? Can you tell me about things you like to talk about in class?

13. Do you do your school work because you want to pass or because you like to learn?

14. Can you tell me what the best way is to tell if something is true?

15. Do you think everything you read in your textbooks is true?

16. Can you tell me what you think of, or what comes to mind, when you hear the word science? math? technology?

17. Can you tell me how you feel when you have to do science in school? math?

18. What is your image of a scientist? (Can you draw a picture of a scientist?)

19. Tell me about a particular project or lesson you have done in a science class that has

been fun or interesting?

20. Can you think of any science project or lesson that has taught you something you did not know?

21. What do you think of your science textbook? Are there things you like about it? Don't like about it?

    a) Is your science textbook easy to understand?
    b) Do you like the pictures? Which ones?
    c) Have you ever learned something in a science lesson that you can use in your daily life?

22. Do you think science is important now? Will be important when you grow up?

23. Do you think there are things you know about animals and plants or anything in nature (fish, stars, water) that are not in your science textbook?

24. Are there things in your daily life you feel you could bring into the science lessons?

25. Do you know any stories about animals, plants or nature in general?
    a) Do you like stories? Do you hear them often? What kind?

26. Can you tell me what comes to mind when you hear the word earth? The sky? The water? Does any particular image come to mind?

27. Can you tell me what you feel is most important in the way you live your life?

28. Is there anything you feel is not going well in the world today, or something that you would like to see done better?

29. Are there ways you think you can affect the world or make things better?

30. Can you describe how you think of yourself? Can you draw a picture of how you think of yourself?

31. (If the child has gone to the provincial school) Can you tell me what it was like in the provincial school in town?

32. Do you like to learn about your own history, or the history of your Mi'kmaw ancestors? Is there anything particular that interests you?

33. Do people at home or in your family speak Mi'kmaq. Do you speak it? Do you understand it when people speak in Mi'kmaq?

34. Are there special places outside the school that are special to you? Do you think those places are special to Mi'kmaw people or to all people? Can you tell me what is special?

35. Are there things that you think are special or different about being a Mi'kmaw?

36. Are there activities that you do in your community that you think are different from what other children do outside your community? Are they important to you?

NEW QUESTIONS

1. Show a picture of a landscape. Ask the children to describe what they see. What do they think is most important in the picture?

2. Show a picture of a village. Ask them to tell you what they see?

3. Do they know anything special about nature that they have learned from their parents, elders, etc.? Have they learned to pick medicines, fix a motor, or any other tasks?

Collect a group of items, and ask the children to sort them. Ask the kids how they feel about these.

What does the word life mean to you? What does the word spirit mean to you?

Questions for Story:

How did you feel about the various beings in the story?

What's the most important thing in that story and how does it make you feel?

When you see a real beaver, does it have anything to do with this story?

Is it just make believe? Does it have any meaning in real life?

What do you think is true about this story?

Appendix F

Grade 7/8 Science Curriculum Design Pilot Lesson
Chemical Change:
Entering Science through the Language
Developed by Trudy Sable

Comment:
This pilot lesson was submitted to Chief George Ginnish and the Eel Ground Education Committee on April 20, 2001. It was revised in accordance with the wishes and input of members of the Eel Ground First Nations band, as well as those of the Grade 7/8 teacher and her students. This lesson attempts to use an integrative approach to help students deepen their understanding of science and the nature of science while simultaneously fostering an appreciation of traditional knowledge within their culture.

I have used different orthographies in the text below. Most of my work has been in the Smith/Francis orthography; the lesson should be taught using the orthography preferred by the Eel Group community.

Rationale:
The fundamental question in preparing any educational curriculum should be: Why should we care about this? In other words: What is the purpose of being in school and learning the material that has been deemed important by educators and policy makers? Does it help students work with others and work with changes in the environment? Does it help students reach a deeper understanding of who they are, where they have come from, and how they can genuinely care for others in the world and the environment that sustains us? Can they think individually, communally and globally for the benefit of everyone? Does the lesson contribute to preparing students for establishing a livelihood later in their life?

Often, education has become concerned primarily with teaching students how to survive economically by competing in the marketplace. As educator and well known author Neil Postman notes, students are often viewed as economic units. As a result they often do not have a fundamental purpose for learning what they are required to learn in school. Education becomes a training ground for getting future employment. Unfortunately, even this is often not the case for marginalized or minority students, or even for students in "mainstream" society. This sample lesson attempts to address the broader and deeper issues of identity and social well-being as well as the practical skills necessary for physical and economic survival.

Teaching Strategy
These lessons are designed to work with the chapter on "**Chemical Changes**" in the "***Science Plus***" textbook used in the Eel Ground First Nations school, while also tying the content to the students' own cultural background and history. It is intended to create a dialogue between different perceptions of the world, and how these serve(d) peoples needs – physical, emotional, intellectual and spiritual. Other lessons could be designed to complement other chapters in the text book, e.g. Diversity of Life and Geology.

This lesson is designed to:

- illustrate the different ways people come to know and work within the world;
- begin a reflective process whereby students become engaged in understanding the process of coming to know the world, and why science itself is one way people have done that;
- help contextualize the scientific material and experiments presented to make it accessible, interesting, and relevant to the wider context of students' lives, past, present and future;
- guide students into deeper levels of reflecting on their observations;
- integrate various subject matters to reinforce learning in different learning contexts; and
- provide various ways students can express their knowledge (e.g., written, artistic, verbal) as a means to increase their own understanding and to communicate their knowledge to others.

Theme: Shape Changing

The world is constantly changing. Things take on new forms, transform into new materials or other forms of energy. As the traditional Micmac language shows, everything was/is in a process. Even colors are verbs, such as ***maqtewe'k*** which translates as "he or she is in the process of being black" [*wape'k* (white), *wataptek* (yellow), *aq mekwe'k* (red)]. In some cultures, such as the Micmac culture, experience is described with an emphasis on verbs that focus on relationships or the relatedness of things. This is different from the subject-object structure commonly found in the English language. Some Micmac words that were once verbs are now nouns due to contact with other cultures that came to this land.

> **NOTE:** This lesson can refer to or complement the students' language arts lesson to introduce parts of speech – nouns and verbs, sentence structure, etc. *maqtewei*, *maqtewein* or *maqtewe'k*. The "i," "n," and "k" endings mean first person singular, second person singular, and third person singular. It is like any other verb because it can be conjugated. It is an intransitive verb because it doesn't take an object.

Scientists also talk about processes and changes such as chemical and physical changes, life cycles, and evolution but they use a specific way of studying and expressing these changes, and they have their own language for doing so as well.

> **The teacher could write a sentence on the board using the word black or another colour term to show how it is used in English as a part of speech.**

Whether we see the world as a verb or noun, something solid or in constant flux, every culture has had to learn to live and survive within their environmental conditions. Each culture developed certain ways of relating to and describing their environment, and determining their needs as a people. The students can be encouraged to think about

change in any lesson they do, and how different peoples describe change. In the lessons described below, the subject is focused on physical and chemical changes to complement their current scientific unit.

Objectives:
Students will:

- learn how people of different cultures, including scientists, approach, experiment with and relate to coming to know our natural world.
- be able to discuss different uses of resources (copper, red ochre/hematite and sea shells in this particular lesson).
- gain insight into the inter-relationships of these substances with other aspects of their culture, and connect their historical use with present day uses.
- be able to explain chemical and physical change as described in their science lessons.
- demonstrate their ability to use cultural symbols and language to communicate.
- identify and write chemical symbols or molecular formula of common elements and compounds

Entering Science through the Language
Background:
Language is a system of symbols that different peoples have developed over time to articulate and communicate about their world. Science, a discipline with a tradition of its own (quite short in the long span of history), also has its own language and system of symbols. The language of science itself is often a stumbling block to students' learning of science. The following exercise is intended to show the students how words from different cultures have different meanings depending on their view of their relationship to their natural world. This is not meant to prove one as better than another, but to broaden the student's thinking about how people perceive(d) and articulate(d) the world as well as to give them a deeper appreciation of their own ancient language.

> **It might also be mentioned that 3,000 languages have become extinct over the last 30 years due, in part, to globalization and past colonization of lands. When they think about diversity (as in the "Diversity of Life" chapter in their science texts) they could also be made aware that there is cultural diversity and languages were also a means of adaptation that is rapidly being lost.**

Activity 1
Preparation:

1. Hang the Native Council Micmac map of traditional territories on the wall next to a current map of the Maritimes.
2. Draw a chart on the blackboard. Have the students do the same on pieces of paper. They will be using this throughout the lesson. Across the top, put the following headings.

English Term	Micmac Term	Micmac Meaning	Chemical Description	Chemical Symbol

Brainstorming and Reflecting

If appropriate, the lesson could begin with the Honour Song, or another song that mentions the earth, ***wskitqamu***. The teacher should discuss: What is this song about? What is it honouring? What is the drum about? The answers can be written on the board by the teacher or one of the students. Write the Micmac and English words under the appropriate heading on the board. The students write it on their own papers.

What does the word ***wskitaqamu*** actually mean?

In my questioning of Micmac linguists, I was told it means "the surface of the earth" or "surface sphere." I was also told the word ***wskitqamu*** takes in more than just the tangible ground or the tangible earth. It takes in the atmosphere, the ***qamu*** part which implies that the entire atmosphere is included. This could be researched further. Another word, ***lamqamu*** means "under sphere," "beneath the earth" or "underground"

The students could also be encouraged to look the word "earth" up in the dictionary and write these meanings on their charts.

Students can also be asked to think about metaphors for the earth – e.g. Mother Earth, Spaceship Earth, and other usages to get a wide view of the many things implied within this one term.

Legend

A legend from their culture (yet to be selected) could be told or read which includes some of the substances – ochre, copper, sea shells – that relate to the science lesson they are currently studying on chemical and physical changes. The students will discuss their thoughts about the legend. Do they recall anything about how people related with their world? Is that different from how they think or behave today?

After discussing the legend, the students could break into small groups (3 or 4 students per group) (Note: this could also be done without breaking into groups if the teacher prefers). Each group opens to the chapter on Chemical Changes on page 82 and reads Exploration #1. They will be asked to answer the question, "What do scientists call all common substances such as water, table salt, chalk, etc.?" **(Science says all common substances are made of chemicals.)** One or two students could look up the word chemistry and chemicals in the dictionary and read the definition to their group. (Sometimes children think of chemicals as special substances that are added to things like medicine or food.) One student could also be asked to record the answers they come up with in the group.

Ask the students to try to name something that isn't a chemical or made of what scientists define as chemicals. Give examples of some things that are chemicals. Then list some things that are not chemicals. Is the earth more than chemicals? Each group can make a list of things that are not chemicals. How is this different or similar from the way the legend talks about substances? Are all things in the world made of chemicals?

Students could then regroup and each group representative could read their outcomes. These responses could be written on the board, as well as recorded by students on their own paper.

Activity 2

In this activity, copper, ochre and sea shells are used as a means to tie into the lesson on chemical change. Any number of aspects of Micmac culture could be tied into these lessons, both past and present, since the lesson is concerned with the processes of change in natural products found in the world.

The objectives for this activity are:

- The students will be able to recognize and discuss cultural symbols in their lives, including scientific symbols, and to illustrate how words are symbols imbued with cultural meaning.
- The students will contemplate two different ways of describing something.
- Language study will be strengthened.

Slides to Show the Use of Symbols

Slides will be shown of traditional Micmac shelter, dress, and ornamentation. Students will be asked to think about the many symbols they see in the slides and to discuss the concept of **symbols.** The teacher might explain the definition of symbol, and that symbols are whole collections of meaning just as science is also a collection of symbols and meanings. Scientists have a system of symbols for telling about the world. These often seem very complicated, but, like a language, they can be learned over time.

> **Have the students turn to page 114 of Science Plus and look at the table of elements and look at the symbols for elements. Also have them read over page 115 about symbols and their origins.**

Following the discussion on symbols, the students could then be asked to name all the materials that were used for clothing, shelter, cooking, and ornamentation in the slides. They will be encouraged to write down their observations. This could also be an opportunity to review more Micmac words for objects seen in the slides, if known. These can also be written on the board.

Students will be asked about how they think their ancestors, living hundreds of years ago, made the clothes and ornaments they wore. **Was that science? Was that technology?**

- Did their ancestors use these words for what they did?
- How could we find out what words they may have used to describe the way they made and used different resources?
- Are there people in their community still using materials in the same way?
- What type of materials do people use today for clothes, jewelry, shelter, cosmetics, etc. in their community?

Again, the students could take a few minutes to think about how things have changed over the course of history, and what is still the same.

Students can now refer back to their language charts and write the following words down the side column (see sample chart below). **Copper, ochre, Surf or Bar clam, scallops, periwinkles, Northern quahog, mussel, egg, calcium (others can be added).** As the students go through the following lessons (or one or two of them), they can begin to fill in the chart.

NOTE: I am using the spelling of Micmac words as used in the "*Mi'kmaq Fisheries Netukulimk: Towards a Better Understanding*" publication put out by the Native Council of Nova Scotia. Perhaps both or either of the Smith/Francis and Pacifique orthographies could be used to show the students different systems of writing used by people within their own culture.

Later in the lesson, the students could each take one type of shell or other substance such as ochre, copper, calcium, or egg yolk and try to find out some of the chemical properties that make it up. They don't have to get into the complicated formulas but just look for the basic chemicals that make up these substances. This is similar to the exercise on page 115 of the text book where they investigate different elements. These could be written on the chart at a later date. They could also expand this to talk with members of their community who are involved with the fishery about where these shell fish can be found, their habitat, etc. This could also just be done in class as a discussion with the teacher.

Sample Chart

English Term	Micmac Term	Micmac Meaning	Chemical Description	Chemical Symbol(s)
Copper			Element	Cu
Ochre	Wiaqakj – place near Margaree, NS where ochre is found		iron oxide – iron and oxygen compound	Fe, O
Surf or Bar clam	e's		carbon, hydrogen, oxygen compound	C, H, O
Clam shells			compound	Ca +
Scallops	saqkale's			

Periwinkles	jik'jij			
Oyster	mntmu'k			
Northern quahog	pukanamowe			
Mussel	nkata'laq			
Egg	wow		compound	
Calcium			element	Ca

Alternatives:
This lesson could become a project for the students to research, asking elders or people within their community for help with what these words meant to Micmac before English was introduced as another language with its own definitions. This is an important lesson to explain carefully.

> **Example:** I have spent many hours with two elders, Dr. Margaret Johnson and Wilfred Prosper, from Eskasoni as well as Micmac linguists, going over different Micmac words, trying to understand how they would be translated literally instead of how they are now translated into English. Some examples:
>
> **aqmoq – ash (English translation) or "snowshoe tree" (literal translation from Micmac)**
> **muin – bear (English) or "berry picker" (literal translation)**

Students could also begin to find place names associated with where the resources might be harvested or found. Place names are another way to see how people of this area related to and used the land. What is the Micmac name for Eel Ground? What does it mean and why is it called that?

Sea Shells, Copper and Red Ochre
These three substances were chosen for study because they are substances used in pre-contact and early contact Micmac culture, and also are used in the present day for varying reasons and in varying forms. Each one has within it a lesson not only about the culture, but about physical and chemical changes that can be related to their science lesson. Any one of these could be used as a launch pad for research projects, e.g. the fisheries, traditional cultural practices, current affairs, political conflicts around resource use, uses for art, poetry, stories, etc.

Sea Shells
Resources needed

-
- slides or pictures of shell work, shell middens, and ceramics done by Micmac in traditional culture (if available)
- slide projector
- egg shells and chalk

- vinegar
- a basket showing **jik'jij or periwinkle** – this term is used in Eskasoni for the curly cue type ornamentation on baskets. The objective here is to show how natural occurrences of shapes are mirrored in artistic works.

Traditional uses

As food: Shell fish were an important part of the Micmac diet. They are still harvested today by fishermen and are an important part of the local and international economy.

As ornamentation: Shells from different shell fish, such as quahogs, mussels, and whelks, were used as ornamentation on clothing and as jewelry. For instance, a woman dressed in a white robe for her marriage feast might have mussel shells and copper dangles sewn on the front of her robe. Men might use shells, bone beads and copper tubes to decorate a headband (Whitehead & McGee 1983: 24). The outer chamber of a whelk was broken off to get to the central core of the shell, which is like a rod of calcium carbonate. These central cores would be rubbed over and over against sandstone until perfectly circular and then cut in cross sections to form discs. These would then be bored through with a stone drill to make holes for stringing them.

For wampum: Shells were also important trade items among people. Quahogs were highly valued for wampum. It is not certain whether these were used for wampum after contact or in the pre-contact period. Busycon, or whelks, were used for wampum as well, definitely in the pre-contact period. The ones used for wampum may have come to this area through trade from the south of Cape Cod.

The Europeans who came to the east coast of the U.S. began to manufacture these highly valued quahog shells for currency to trade with Native people. They swamped the market so to speak and upset the traditional balance of trade among the Indigenous peoples of the east coast of North America.

As paint: Chalky white shells were ground up and mixed with egg yolk for white paint.

(The next two uses can be tied into the actual science lesson.)

For ceramics - the Ceramic period in Maritime indigenous cultures occurred between approximately 2000 to 500 years ago. Pottery found from this period show that shells were often used as a temper in the pottery being made. The marine shells contain salts, which, when fired oxidizes and makes the clay more elastic, less brittle and harder to break. Soft shelled clam shells were often used for shell tempering in pottery but other shells may also have been used. Question: How did the people know this about sea shells? How would scientists study this? For reference, see pages 84-85 in the text.

Shell middens: Mounds of discarded shells found near shores, are evidence of Micmac peoples use of marine shell fish throughout the Maritimes. These middens are of interest to people studying early Micmac culture because the shells help preserve artifacts or tools used by Micmac hundreds of years ago that may have accidentally been dropped or broken near or in these middens. Sometimes middens were on top of older sites that contained material objects from an earlier time. As the shells degrade, the **calcium carbonate** in the shells neutralizes the acidity in the soil. Maritime soil is quite acidic. Bacteria can not survive in soils with a lot of calcium because of the neutralizing effect of the calcium. Limestone has the same effect.

Science experiment

The students can now conduct the experiments in their text book on pages 83 and 96. On page 83, a dropper-full of vinegar is dropped on chalk. On page 96, a dropper-full of vinegar is added to a piece of eggshell. Egg shells and chalk are made up of limestone or **calcium carbonate**. Blackboard chalk contains calcium sulphate. Calcium carbonate or limestone is used to neutralize the acidity of soil, for instance, in gardening. This fact can be tied into the section on acids and bases on pages 116-117 of the text.

These experiments show the chemical reaction between vinegar (acid) and the egg shell and chalk (alkaline substance or calcium carbonate which reacts with the acid to neutralize it. This will give the students a visible example of the chemical reaction between the two types of substances – calcium (alkaline) and vinegar (acidic). The students should discuss whether this is a physical or a chemical change.

Students should record the results they observe.

The students could also be encouraged to think about what "antacids" – tums, rolaids, or alka seltzer – are used for. They could read the ingredients on the label of a sample of these products. The basic concept is the same. One substance reacts with the other to cause a chemical change. Were there any traditional medicines that did this within their own culture?

Copper

NOTE: I recognize that this section includes the discussion of copper in burial sites, and that some members of the community may think this is inappropriate or offensive. From my own discussions with Micmac friends and acquaintances, I have heard varying opinions about archaeological research into Micmac burial sites, some people against it and others interested in the history it unearths for a variety of reasons (legal, artistic, cultural etc.).

Depending on the feelings of the committee, this lesson could be altered or deleted. It could be used to stimulate discussion about the ethics and values involved in scientific

research. This would also be in keeping with the science standards set out by the provincial science education guidelines. For instance, learning outcome #113-2, from *Common Framework of Science Learning Outcomes* (p.69) (Council of Ministers of Education, Canada, 1993), states that students in grades 7-9 should be able to "describe possible positive and negative effects of a particular scientific or technological development, and explain how different groups in society may have different needs and desires in relation to it."

Resources Needed

- Sample of native copper from Cape d'Or where copper was found.
- Slides showing the use of copper in arm bands, tinkler cones, tube beads, gorges (fish hooks), and other ornaments.
- Pictures of Cape d'Or for the students to see and contemplate Micmac canoeing to this site to procure the copper.
- Copper foil from a hobby shop.

History

Across from Port Royal in Nova Scotia, Cape d'Or is the first place French people created a long term settlement in the Maritimes in 1604. This was part of the territory of *Kespukwitk* of the great headman/chief Membertou who assisted the French in many ways to survive in this unfamiliar land. Cape d'Or (meaning gold in French) is a place where copper is found easily after the spring run off. Pieces of native copper can be found lying on the ground washed out in the spring after the snow melts and the rains come. Micmac would canoe over to the Cape and bring back copper. It was then "cold hammered" into sheets or shapes for arm bands, tinkler cones, fish hooks, and copper needles. When heated, the copper is easy to shape, an example of physical change. Copper from as far away as Lake Superior is also thought to have been used in the Maritimes. Grand Manaan Island and Isle Haute are other known sources of Native copper within the Maritimes. Copper was also used for trade when Micmac travelled to other bands or tribes. It is thought by people studying this area, that there were larger pieces of copper available than can be found today.

Copper kettles were introduced by early Europeans and used by Micmac beginning in the 1500s. Large numbers of copper kettles came into this area at this time. Copper is still valued in cooking pots. Many have been found in burial sites, perhaps as valued items. Early accounts tell of these pots being ceremonially punctured to release the spirit of the pot to accompany its owner after death. (If this topic is appropriate for introduction to the students, it could also be tied into a discussion on the language about animacy and inanimacy).

Archaeologist studying these sites, found that the presence of copper in these sites helped preserve the other materials such as clothing, birchbark, fur, bone, and feathers that would normally decay because of the bacteria in the soil. There are a number of copper burial sites in New Brunswick.

Traditional technology

Copper was "cold hammered" and possibly heated over fire which made it easier to shape into arm bands, tinkler cones, gorges (a kind of fish hook), sewing needles, and a number of other forms for use in daily life and ceremonies.
Question: Would cold hammering or heating copper cause a physical or chemical change?

The tinkler cones were shaped from copper and sewn or tied onto Micmac women's outfits and would make sounds when they danced and moved.
Question: Are there any dances that they have seen that do this, e.g. the j**ingle** dance?

Activity.
The students can take a few minutes to take the copper sheets to make simple copper tinkler cones. They can tie them onto leather strips and shake them to get a sense of the sound they would make when a woman moved with these on her outfit.

Science experiment

Copper alone is toxic (poisonous) to the bacteria that commonly causes the decay of organic substances such as fur, bark, feathers, bone and wood.

It also can combine with other chemicals. Maritime soil is highly acidic and acid combining with the copper would create copper salts. These salts made the soil unfavourable to bacteria and fungus that cause decay. (This ties in with the experiment with aluminum and copper sulfate in the science textbook page108) Copper sulfate is a type of copper salt caused by the process of oxidation, or the combining of copper with oxygen in the air.

After discussing the historical use of copper, the experiment in the text book (p.108) could be done, showing how **copper sulfide** interacts with **aluminum** to produce chemical change.

For the Teacher's Information:
Two reactions are happening here –**Aluminium** is replacing the copper in copper chloride and forming metallic copper. The solution is becoming acidic and the acid reacts with the aluminum producing **hydrogen gas**, which causes all of the bubbles.

This reaction could be used to illustrate that copper compounds can be formed relatively easily and these compounds have **preservative abilities,** which is why the copper in ancient Micamc sites helped preserve part of the Micmac material culture that would normally have been destroyed by bacteria or fungus. Copper in contact with other elements **changes** and creates different compounds.

Current Uses:
Copper compounds are found in many preservatives - e.g. wood preservative. Copper sulphate, because of its fungicidal and bactericidal properties, has been employed as a disinfectant on farms against storage rots and for the control and prevention of certain animal diseases, such as foot rot of sheep and cattle. Other obvious uses are for copper pots, copper wiring, and copper coins. Copper is a very good conductor of heat which is why it is used in copper pots.

Web sites for further information:
http://www.copper.org/compounds/ukcomp.htm#generaluse or just type "copper" into the search engine and a host of subject areas come up.

Science History
The greatest breakthrough for copper salts came in the 1880's when the French scientist Millardet, while looking for a cure for downy mildew disease of vines in the Bordeaux district of France, chanced to notice that those vines, bordering the highways and which had been daubed with a paste of copper sulphate and lime in water in order to make the grapes unattractive to passers-by, appeared freer of downy mildew. This chance observation led to experiments with mixtures of copper sulphate, lime and water. In 1885 Millardet announced to the world that he had found a cure for the dreaded mildew. This mixture became known as Bordeaux mixture and saw the commencement of protective crop spraying.

Additional Projects
Students could be encouraged to surf the web for references on copper. It was used in ancient civilizations and one of the earliest forms of metal working, and it is used for a variety of uses in current society. Copper mining is a large industry. Students could surf the web to see all the ways copper is used.

Students could also find people within their community who work with copper or any copper products. They could also write to the provincial archaeologists, Pat Allen and Chris Turnbull, to find out more about copper in early Micmac sites within New Brunswick. Both worked extensively on many sites throughout New Brunswick, and would be able to supply the students with information or lead them to information that might interest them.

Students could also connect through the Internet with other Native Canadian/American students asking about their traditional use of copper in their culture, or investigate its use in other cultures in the world.

Red Ochre (hematite or iron oxide)

Resources needed
- Red ochre, yellow ochre
- Eggs for mixing with ochre to make paint

- Leather scraps
- Popsicle sticks for using to paint

There were four main colors used in traditional Micmac culture, all taken from minerals in the ground – red, white, black and yellow. These have also been associated with the four directions.

Red and yellow were made from hematite and limonite, black from manganese, and white from ground up sea shells.

Red Ochre (hematite/iron oxide) was used for paint as well as ceremonial and medicinal purposes. Today, for instance, it is what makes red bricks red. The reddish color of the earth seen in some areas is caused by the presence of iron oxide. People could get red ochre from clumps of clay that were then dried out. Some red ochre could be found on rocks and scraped off.

Traditional use

Red Ochre was mixed with egg yolk or fish roe as a medium for paint. People would paint symbols or figures on leather clothes, wigwams, boats etc. as well as on their faces for different ceremonies such as marriage, feasts and war.

Red ochre was/is thought to have very powerful properties, and is often associated in Micmac legends with the ***jipijka'm***, the horned serpent seen in many legends all across Canada and into Siberia.

Heating red ochre makes it an even deeper colour of red

Question: Does heating the red ochre (iron oxide) cause physical or chemical change?

Does mixing it with egg yolk cause physical or chemical change?

Activity

Students will grind the ochre (iron oxide) and mix it with egg yolk. Leather scraps will be provided so the students can make their own designs or symbols or copy ones they saw in the slides.

> Why egg yolk? What is the Micmac term for egg? What is in egg yolk that makes it stick to the leather? Is that a chemical or physical change?

> What happens when the ochre is mixed with water? Is it a different texture? Does it make a good paint?

Students can take time at the end of their activity to discuss the symbols they chose to draw. Why did they draw one symbol rather than another? What meaning does it have to them?

Additional Projects

Any one of these projects can be related to other subjects, as well as tied into community concerns, such as: the fisheries

- political issues affecting the community
- historical or archaeological research into the Micmac culture and other cultures. Again, ancient history and cultural uses could be traced to present day concerns.
- artistic research or creative projects concerning the use of these material: Red ochre, for instance, is used in many cultures throughout time, including by the earliest people known to have come to the Maritimes (near Debert), but also in Siberia and other Native Canadian and Native American peoples.

This lesson could also be tied into Math in a number of ways. Geometric patterns on the clothing is one way the Yupi'k people of Alaska teach Math. Buffy Sainte Marie has a whole science program based on traditional resource use and technologies of Indigenous peoples.

Evaluation:

Evaluation can be done first through discussion, questioning the students about the actual science lesson, but also on the language, cultural use of materials, and history

Another way to do the evaluation would be to have a writing assignment in which the students would be asked to write either a story or a report assimilating the different ideas and topics that were discussed in their own words.

I would also like to have a short questionnaire for them to fill out at the end of the lesson to find out what was or was not of interest to them, and what types of things they would enjoy studying.

VITA

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Saint Mary's University 1991 B.A. in Anthropology and Atlantic Canada Studies
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