

Metaphorical Images of Science: the Perceptions and Experiences of Aboriginal Students
who are Successful in Senior Secondary Science

by

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B.A., University of British Columbia, 1999

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of the Requirements for the Degree of

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Abstract

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The purpose of this research study was to explore why some Aboriginal students participate in senior secondary Biology, Chemistry, or Physics and achieve a high level of academic success (67% or higher) in these courses. The following key questions were addressed: 1. What are the experiences and perceptions of Aboriginal students with regard to senior secondary science? 2. What role, if any, does culture play for Aboriginal students who are successful in the senior secondary sciences? 3. What are the factors that either contribute to or hinder success by Aboriginal students in science-related courses? Ten Aboriginal participants were interviewed from the Greater Victoria School District. Metaphor Interviews, Literal Interviews and a Focus Group were used to collect data. The results indicated that Aboriginal ancestry was important to the identity of many of the participants, but it was not a significant contributing factor in their academic success in senior secondary science.

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DEDICATION

This thesis is dedicated to the ten participants of this research study – thank you for sharing your time, your experiences and your insights. What you have shared will help to improve science education for future Aboriginal students. You are an inspiration to me.

Before I go any further, I would like to share with you a little of my own background as it pertains to this research study and where my interest in the focus of this study came from, but first, I will start by explaining why I am doing this. In his book, *Research is Ceremony: Indigenous Research Methods*, Shawn Wilson explains how he sees himself as more of a storyteller than a researcher/author in presenting information from his research studies:

Indigenous people in Canada recognize that it is important for storytellers to impart their own life and experience into the telling. They also recognize that listeners will filter the story being told through their own experience and thus adapt the information to make it specific and relevant to their own life. When listeners know where the storyteller is coming from and how the story fits into the storyteller's life, it makes the absorption of the knowledge that much easier. (2008, p. 32)

So, I would like to share with you part of my personal story and a few of my lived experiences, not in an effort to remove subjectivity or bias, but in an effort to allow you, the reader, to know the personal context of this research study.

In 1993, I became the first member of my family to graduate from high school, though at the time, I did not recognize how significant this accomplishment was for me or for my family. I continued with post-secondary studies, and as I got older, I started to think about my own sense of identity and connection to my Aboriginal ancestry. I am a member of the Chemainus First Nation, though I have never lived in my Aboriginal community. I was born and raised in Victoria, BC. My mother's background is full First

Nations and my late father's background was mostly English and a small amount of Japanese. My Aboriginal culture played a peripheral role in my life while I was growing up, mostly through my mother, who participated in the traditional Coast Salish winter dance seasons. My mom became a traditional dancer when I was four, but I knew very little about this part of our culture, mostly because my dad did not want my sister or me to become involved with it. To this day, I still know very little about my Coast Salish culture, and out of respect for the secrecy surrounding the Coast Salish winter ceremonies, I will not share with you what little information I do know. Growing up, I saw my mom staying connected to her culture the best that she could, even though we were living in the city. My mom lost a lot of her culture, such as her ability to speak her traditional language, by attending residential school. I also saw the personal and emotional toll that the residential school experience had on my mother.

Though I knew next to nothing about my Aboriginal culture during my school years, I nonetheless always identified as being a First Nations person. I grew up in M'akola Housing, a townhouse complex for Aboriginal families in downtown Victoria. Almost all of my friends were First Nations and I was involved with many activities and groups for First Nations youth both in and out of school. My experience seemed to be quite similar to that of other First Nations youth that I knew who were also growing up in downtown Victoria. But, I really did not know what it meant to *be* a First Nations person. This understanding and cultural connection did not become a major part of my identity until I became an adult.

My experiences at school were positive for the most part. It helped having my twin sister, Kathy, with me almost every step of the way. But it was clear, even from a young age, that my sister did not have the same passion for school as I did. In Grade 10, she stopped going to school altogether, even though she was more than capable, choosing instead to start working and a few years later, starting a family. This is not to say by any means that my sister was not successful. She has a work ethic stronger than many people I know and she is an incredible mother to her two children. But, her experience in the education system was very different from my own.

In university, I started to think about why I was able to graduate from high school when my twin sister and so many of my First Nations friends did not. I recalled enjoying school and doing well, but I was also aware that making it to my graduation was not an easy accomplishment. I experienced many of the same difficult social issues that often affect First Nations youth, including significant stress in my home and family life. In retrospect, I attribute much of my success at school to my own determination, but also to my parents who always took great pride in my accomplishments. Some of my teachers were also very influential, helping me to realize that I was capable of rising above any challenges that I encountered and reaching whatever goals I had set for myself, ultimately inspiring me to become a teacher myself. I have now “come full circle” – teaching at the same high school that I graduated from.

In this Master’s study, I am focusing on the success of Aboriginal students in the senior secondary sciences. One of my favorite subjects in high school was Biology. I enjoyed it so much that I continued to study Biology, as well as my other favorite subject,

English Literature, throughout my undergraduate degree at university. Once I became a secondary teacher, however, I learned that the participation of Aboriginal students in several of the senior secondary sciences is minimal compared to that of non-Aboriginal students. This lack of participation has great implications for the number of Aboriginal students who continue to study science at the post-secondary level and go into science or health-related careers. Though there is research that looks at reasons why Aboriginal students do not participate in the sciences, there is not a lot of research that looks at the small population of Aboriginal students who are participating in science courses in Grades 11 and 12. Is there something that can be learned from these students that will help to improve the participation of Aboriginal students in science-related courses? It is the goal of this research study to see if there are answers to this question.

Terminology

For the sake of clarity, a list of pertinent definitions has been included below. All of these definitions come from the Indian and Northern Affairs Canada (INAC) website (<http://www.ainc-inac.gc.ca/ap/tln-eng.asp>, retrieved February 13, 2010).

- Aboriginal Peoples: The original peoples of North America and their descendants. The Canadian Constitution recognizes three groups of Aboriginal peoples – Indians, Métis, and Inuit. These are three separate peoples with unique heritages, languages, cultural practices and spiritual beliefs.
- Aboriginal rights: Rights that some Aboriginal peoples of Canada hold as a result of their ancestors' long-standing use and occupancy of the land. The rights of certain Aboriginal peoples to hunt, trap and fish on ancestral lands are examples

of Aboriginal rights. Aboriginal rights vary from group to group depending on the customs, practices and traditions that have formed part of their distinctive cultures.

- **Band**: A body of Indians for whose collective use and benefit lands have been set apart or money is held by the Crown, or declared to be a band for the purposes of the Indian Act. Each band has its own governing band council, usually consisting of one chief and several councillors. Community members choose the chief and councillors by election, or sometimes through custom. The members of a band generally share common values, traditions and practices rooted in their ancestral heritage. Today, many bands prefer to be known as First Nations.
- **First Nation**: A term that came into common usage in the 1970s to replace the word “Indian,” which some people found offensive. Although the term First Nation is widely used, no legal definition of it exists. Among its uses, the term “First Nations peoples” refers to the Indian peoples in Canada, both Status and non-Status. Some Indian peoples have also adopted the term “First Nation” to replace the word “band” in the name of their community.
- **Indian**: Indian peoples are one of three groups of people recognized as Aboriginal in the Constitution Act, 1982. It specifies that Aboriginal people in Canada consist of Indians, Inuit and Métis. Indians in Canada are often referred to as: Status Indians, non-Status Indians and Treaty Indians.
 - o **Status Indian**: A person who is registered as an Indian under the Indian Act. The act sets out the requirements for determining who is an Indian for the purposes of the Indian Act.
 - o **Non-Status Indian**: An Indian person who is not registered as an Indian under the Indian Act.
- **Inuit**: An Aboriginal people in Northern Canada, who live in Nunavut, Northwest Territories, Northern Quebec and Northern Labrador. The word means “people” in the Inuit language — Inuktitut. The singular of Inuit is Inuk.
- **Métis**: People of mixed First Nation and European ancestry who identify themselves as Métis, as distinct from First Nations people, Inuit or non-Aboriginal people. The Métis have a unique culture that draws on their diverse ancestral origins, such as Scottish, French, Ojibway and Cree.

- Off-reserve: A term used to describe people, services or objects that are not part of a reserve, but relate to First Nations.
- Reserve: Tract of land, the legal title to which is held by the Crown, set apart for the use and benefit of an Indian band.
- Urban Aboriginal people: refers primarily to Inuit, Métis and First Nations currently residing in urban areas. According to 2006 Census data, off-reserve Aboriginal people constitute the fastest growing segment of Canadian Society. In 2006 a full 56% of Aboriginal people lived in urban areas, up from 50% in 1996.

Rationale

What does “success” mean? In high school, does success equate academic achievement such as high letter grades or earning a Dogwood diploma? As adults, does success mean having a lot of money? Or, does success refer to a sense of personal satisfaction or accomplishment, no matter what the grade or the amount of money acquired? Does success mean the same thing for everyone? There are many varied opinions of what constitutes ‘success.’ According to Mosconi and Emmett (2003), multiple definitions of success exist because of people’s diverse experiences during childhood and because of the various ways people chose to find meaning in their lives. Success can depend on “one’s larger goals, whether that be the acquisition of money and belongings, or the development of relationships and the freedom to choose how to spend one’s time” (Mosconi and Emmett, 2003, p. 69). Our understanding of “success” is an individualistic and personal perception.

Traditional Indigenous values of “success” are different. Cajete (1994) explains that “the Indigenous ideal of living ‘a good life’ in Indian traditions is at times referred to by Indian people as striving ‘to always think the highest thought’ [which meant] thinking of one’s self, one’s community, and one’s environment richly” (p. 46). The traditional Aboriginal perspective about the success of a child was very different. Traditionally, Aboriginal children demonstrated success by developing a deep sense of independence and morality (Friesen & Friesen, 2002). Children were expected to learn “the significance of family, responsibility, respect, and the foundations of relationship and kinship [and] Life was sacred, relationship was sacred, Nature was sacred, and the tribe was sacred” (Cajete, 1994, p. 173, 175).

For the purpose of this study, the word ‘success’ is used more concretely, rather than philosophically, referring specifically to the participation and high academic achievement of 67% or higher by Aboriginal students in senior secondary (Grade 11 or 12) science courses (Biology, Chemistry, or Physics). The 67% achievement score was selected because this is the minimum grade point average required by secondary students to apply for admission to most post-secondary institutions. I realize that this is a very Western definition of success. I do, however, feel that the use of the word ‘success’ as it is defined in this study is appropriate because the participants have accomplished something extraordinary – namely their exceptional achievement in senior-secondary hard sciences. According to the understanding of ‘success’ as it is applied to this study, many Aboriginal students are not successful in secondary science courses. MacIvor states, “at the secondary level, science education is characterized by low enrollment and

achievement levels among [Aboriginal] students” (1995, p. 74). In Table 1, a comparison of the average participation and success rates in BC public schools for Aboriginal and Non-Aboriginal students in the five years between 1999/00 to 2003/04 in Biology 12, Chemistry 12, and Physics 12 (Ministry of Education, 2005) shows some major differences between the two groups, particularly with regard to participation.

Table 1

Average Participation and Success Rates of Aboriginal and Non-Aboriginal Students in BC Public School Grade 12 Science Courses between 1999 and 2004

	<i>ABORIGINAL</i>		<i>NON-ABORIGINAL</i>	
	PARTICIPATION	SUCCESS	PARTICIPATION	SUCCESS
BIOLOGY	12.4%	68.4%	29%	79.8%
CHEMISTRY	5%	76.4%	22%	88.4%
PHYSICS	2.4%	82.8%	13.8%	86.6%

NOTES: The Non-Aboriginal participation percentages refer to the number of students who wrote the provincial exam divided by the Grade 12 enrolment on September 30th of each school year. The Aboriginal percentages include only Aboriginal students who have self-identified as being of Aboriginal ancestry (First Nations: status, non-status, Métis and Inuit) by September 30th of each school year. Success rate for all students refers to achievement of a C- or better (Ministry of Education, 2005).

The above data indicates that participation rate of Aboriginal students in the senior secondary sciences is between two and six times lower than that of the non-Aboriginal population. But, it should be noted that the majority of Aboriginal students who do

participate in these courses generally pass them. Low participation by Aboriginal students in secondary science has serious implications in the number of Aboriginal students who go on to study science-related programs at the post-secondary level, as explained by Mullens (2001):

Science and health educators estimate that fewer than one percent of Aboriginal students are majoring in science-related courses. For example, of the 45,000 engineering students enrolled in the 34 engineering faculties across Canada, approximately 140 are Aboriginal students.... Meanwhile, according to the Canadian Medical Association, only about 100 of Canada's 58,000 physicians are of Native ancestry. (p. 10)

One major consequence of such a small fraction of Aboriginal people studying the sciences is that there is a critical shortage of Aboriginal people in science and health-related careers (Mullens, 2001, p. 9). "We have discovered that Native American students, especially young women, are not our scientists, mathematicians, or technological wizards" (Blankenship, 2003, p. 12). The Canadian Council on Learning (2007) examined information from the 2001 Census of Canada and found that Aboriginal people were significantly underrepresented in both scientific fields of study and science-based occupations. In 2001, Aboriginal students made up only 0.7% of first-year medical students in Canadian universities, even though Aboriginal people accounted for 4.5% of the Canadian population at the time (Canadian Council on Learning, 2008, p. 2). The implications of this under-representation are tremendous. Aboriginal people are striving not only to reassert authority in the areas of economic development and healthcare, but

also to settle treaties and attain recognition of Aboriginal rights, all of which require community expertise in science and technology (MacIvor, 1995; Mullens, 2001).

Addressing the need for more Aboriginal people to be qualified in science-based careers requires us to go to one of the roots of the problem, namely the lack of participation by Aboriginal students in science courses at the senior secondary level. There is a body of research literature that looks at some of the general reasons why secondary science is often at odds with Aboriginal learners.

One common theme in the research is the Western basis of high school science. As Ogawa (1989) explains, “in the discipline of science education, the school subject ‘science’ is tacitly understood as the one in which the knowledges, concepts and processes of Western science alone are taught” (p. 248). Therefore, Aboriginal students do not see their cultural knowledge, or Indigenous science, included or legitimized in their school science courses. Selin (1993) explains, “we have come to regard Western science as the only true scientific enterprise. We think of science as objective, truthful, progressive, and free of superstition and cultural limitations” (p. 39). The Western nature of high school science can result in Aboriginal students feeling culturally disconnected from such courses. Smith (1996) writes:

At this time First Nations knowledge is seldom reflected in approved curriculum and textbooks, causing several problems to emerge for First Nations children as they attempt to learn science. More detrimental to First Nations children is that as they learn the western science perspective they may lose their culture. (p. 1)

It should be noted that science curriculum in British Columbia was changed from kindergarten to Grade 7 in 2005, Grade 8 in 2006, Grade 9 in 2007, and Grade 10 in 2008. One of the most significant changes to the new science curriculum from K – Grade 10 was the inclusion of Aboriginal content learning outcomes. None of the participants of this study, however, experienced these new learning outcomes as they had already completed Grade 10 by the time the new curriculum was implemented. (All of the interviews were conducted in 2007, and the participants were at that time in Grade 11 or 12, or had already graduated from high school.) It should also be noted that Aboriginal content has not been added to any of the learning outcomes in science courses at the senior-secondary level – the courses that were the focus of this research study.

With standardized learning outcomes throughout the province, high school science is also quite generic in nature, placing little value on the local context or on scientific knowledge from other cultures. Most of the course content comes from a small selection of textbooks that can likely be found in the majority of science classrooms across B.C. The way that most science courses are taught is another area of concern for Aboriginal learners. Mullens (2001) explains, “many educators note that Aboriginal students do not do well in a straight lecture environment. They prefer a creative, hands-on learning situation that makes linkages and highlights the relevancy of the material” (p. 15). The lack of cultural context and non-stimulating teaching methods are very likely contributing factors to the lack of success and/or participation by Aboriginal students in senior secondary science courses.

Williams and Snively (2004) express the need for change in science curriculum in the proposal for the “Aboriginal Knowledge and Science Education Project,” stating:

Unless science classrooms and teaching materials provide a meaningful context for Aboriginal students (as defined by their local communities), and unless Aboriginal knowledge coexists with Western science in the science classroom, many Aboriginal students will continue to find the science curriculum inaccessible and culturally irrelevant. (p. 1)

Taking all of the above factors from the research literature into consideration, it is apparent why the Western nature of science education is at odds with many Aboriginal students. There is also a growing body of research literature that examines how science education can be made more culturally based and culturally relevant. One area of research that is lacking, however, is research that explores why there exists a small population of Aboriginal students who are successful in largely western-based high school science courses, despite all of the inherent barriers that are in place before these students even begin their studies.

Purpose

The purpose of this study is to explore why some Aboriginal students participate in senior secondary science courses (Biology, Chemistry, or Physics) and achieve a high level of academic success (67% or higher) in these courses.

Research Questions

My study addresses the following key questions:

1. What are the experiences and perceptions of Aboriginal students with regard to senior secondary science?
2. What role, if any, does culture play for Aboriginal students who are successful in the senior secondary sciences?
3. What are the factors that either contribute to or hinder success by Aboriginal students in science-related courses?

Study Site

The study site for my research was Victoria, British Columbia, located at the southernmost tip of Vancouver Island, on the traditional territories of the Coast Salish people. There are three major traditional nations on Vancouver Island, including the Coast Salish, the Nuu-Chah-Nulth, and the Kwakwaka'wakw. Each nation has a multitude of separate Aboriginal communities, or bands. The two First Nations bands that are local to the Victoria area include Songhees and Esquimalt. As the capital of BC and as the second largest city in the province, Victoria is a large urban setting that brings together Aboriginal people from all across Canada. The diverse Aboriginal population in Victoria includes Status, Non-Status, Inuit, and Métis people who come from a wide range of ancestral lands both near and far. With the exception of the local bands, the

majority of Aboriginal people in Victoria live off-reserve. The diversity of the Aboriginal population in Victoria is reflected in the Aboriginal student populations in the various public schools in Victoria.

The participants of this study were all students from the Greater Victoria School District. In 2004/2005, 1347 of the district's 20 000 students identified as Aboriginal (ANED, 2005, *First Nations Education Program Overview*, p.1). Between 1990/1991 and 2004/2005, the Aboriginal student population in the GVSD increased steadily, going from 688 students in 1990/1991 to 1347 students in 2004/2005 (ANED, 2005, *First Nations Students - Secondary, Middle Schools, Elementary*, p. 3). Aboriginal students make up approximately 7% of the total student population in Victoria. Approximately 11% of the Aboriginal student population lives on the Esquimalt and Songhees reserves while 88.2% of Aboriginal students live off reserve (ANED, 2005, *Did You Know?*, p. 1).

The Dogwood completion rates of Aboriginal and Non-Aboriginal students who entered Grade 8 in 1997 reveals that only 34% of Aboriginal students completed Grade 12 compared to 74% of Non-Aboriginal students (ANED, 2005, *How Are We Doing?*, p.1). Though Aboriginal Dogwood completion rates have been increasing over the years, it is still an area of serious concern as Aboriginal graduation rates remain at less than half that of the Non-Aboriginal population.

Participants

The participants of this study consisted of 10 self-identified Aboriginal students from the Greater Victoria School District who were taking, or had taken, at least one senior-level (Grade 11 or 12) science course (Biology, Chemistry or Physics) and were achieving, or did achieve, success in this science course. ‘Success’ for the purpose of this study refers to academic achievement of 67% or higher in at least one senior-secondary science course (Biology, Chemistry, or Physics). The participant group consisted of 4 males and 6 females. The ten participants were attending, or had attended (for those participants who had already graduated), a total of 5 different high schools within the Greater Victoria School District.

Methodology

My research was conducted using various qualitative research techniques, including a metaphor interview, a literal interview, and a focus group interview. The overriding qualitative method of inquiry was the case study approach. The metaphor interview was the foundational research technique that I used to learn about the participants’ perceptions about and experiences in senior-secondary science. In the metaphor interview method, participants were asked to choose metaphors to explain their thoughts about science. For example, participants were asked the following question: “If science was an animal, what animal would it be and why?” The purpose of literal

interview was to validate the findings from the metaphor interview, as well as to provide additional information from the participants, particularly with regard to their actual experiences in science courses. The focus group interview served to triangulate the findings of the individual interviews by reexamining similar questions from both the metaphor and literal interviews and showing that the participants' perspectives about secondary science education remained the same, even in a group setting. All three of these methods will be explained in much greater detail in Chapter 3 – Methodology.

Limitations

There are certain limitations of this research study that must be acknowledged. One limitation was the fact that the participants came from a variety of unique, personal backgrounds. But, in analyzing the results and to take into account participant individuality, I first focused on what could be learned from the participants as individuals (summarized in Chapter 4), and then reexamined the data as a whole to identify commonalities amongst the participants (summarized in Chapter 5). I had hoped that my participant group would represent the variety that exists amongst the Aboriginal student population in Victoria, which is why participants were selected from as many different high schools within the Greater Victoria School District as possible. However, none of the participants from this study were from either of the local First Nations, nor did any of the participants live on-reserve. This was an unanticipated outcome of the recruitment process. At the same time, the participants who did volunteer for this study were

representative of the 88% of Aboriginal students in the GVSD who live off-reserve. As much as I had wanted at least one on-reserve participant, none came forward in the recruitment process. But, it would have been useful to have had participant representation from the local Aboriginal communities to see if their results would have been similar or different from the results of the other participants.

A second limitation in this research study was my own bias, which came from my own experiences as both an Aboriginal graduate from the Victoria School District and as a current employee of the Greater Victoria School District and ANED (Aboriginal Nations Education Division). I made every effort to limit the role of my personal bias by not including any participants in my study who I was working closely with in my position as an Aboriginal academic counselor. Also, none of the students in this study were students in the courses that I was teaching at the time of the interviews, so there was no “power-over” relationship with any of the participants. To help eliminate bias, I interviewed participants from a variety of different high schools in the Greater Victoria School District so that the results would not be skewed if I had only worked with students from one or two high schools.

A final limitation was gender representation, which was not equal in this study as there were six female participants and four male participants. I was hoping for an equal number of males and females, but recruiting ten participants for this study turned out to be a far more difficult task than I had anticipated, so I ended up interviewing the first ten (and only ten) participants to volunteer. The gender representation was, however, fairly equal and did not skew the results in any major way.

Significance

The results of this research study will be of great importance towards increasing the participation and success rates of Aboriginal students in the senior-secondary hard sciences. There is a breadth of research that investigates what is going wrong for many Aboriginal students in contemporary science education, but there is very little research that examines what is going right for some of these students. By learning from Aboriginal students who have achieved success in contemporary science education, we will not only be able to reinforce strategies that work, but also make suggestions for improving science education for Aboriginal students in general. The implications of these outcomes extend far beyond the high school setting: an increased number of successful Aboriginal science students would likely mean that more Aboriginal students would go on to study science in college and university, and go into health, science, technology, and other science-related careers. As Aboriginal people and communities work towards becoming healthier and increasingly autonomous, the need for more Aboriginal experts in the areas of health and science is unquestionable.

CHAPTER 2: A REVIEW OF THE RELATED LITERATURE

Introduction

The purpose of this study is to explore why some Aboriginal students participate in senior secondary science courses (Biology, Chemistry, or Physics) and achieve a high level of academic success (67% or higher) in these courses. The success experienced by the participants of this study is in contrast to the experiences of many other Aboriginal students, who do not participate in the senior secondary hard sciences. This chapter explores the related literature, beginning with a discussion of the general definitions of science, both Western and Aboriginal. Comparisons between these two bodies of science are then made. Literature that explains why modern-Western-based science education is not working for many Aboriginal students is also discussed. Lastly, literature that offers suggestions for the improvement of science education for Aboriginal students is summarized.

What is 'Science'?

What is 'science'? Though this may sound like an easy question, it is a deeply philosophical and even personal question. There is no single, universally accepted definition of science. The perception of 'science' varies on a cultural and individual basis. Cajete (2000) explains:

Science has been and can be defined many different ways depending on

who is doing the defining. But one thing that is certain is that 'science' is culturally relative. In other words, what is considered science is dependent on the culture/worldview/paradigm of the definer. (p. ix)

In my attempt to answer this question, I will begin by summarizing some of the general definitions of science and then I will then distinguish between Western and Aboriginal science, and lastly explore how these two realms of science overlap.

General Definitions of 'Science'

Science is essentially replicable observation, description, prediction, and experimentation related to the physical world; and technology is finding practical solutions to the contextual problems. The result of science is explanation, the result of technology is a process or purpose. (Baker, 1996, p. 19)

Baker's definition is a general and very familiar description of science. Essentially, this definition describes the components of the scientific method, which is one of the primary foundations of Western-based science. Lederman (2001) describes science as, "the body of knowledge that constitutes the accumulated theories, laws, ideas concepts, principles, etc. that represent the sought after prizes of scientists and that fill the pages of our textbooks" (p. 2) and as "the familiar activities of observing, inferring, concluding, hypothesizing, etc" (p. 2). Lederman says that the role of the scientist is to "observe aspects of nature through their senses in an unbiased manner ... and then derive the facts, theories, laws, and principles of science from these observations" (2001, p. 3). These

descriptions bring to mind images of science textbooks, experiments, and lab reports, of which the scientific method is of utmost importance.

The Western perspective of science is only one of many in the world, yet there is an assumption that ‘real’ science is Western-based. Consequently, other perspectives of science, including Aboriginal science or knowledge, are excluded or devalued. Ogawa (1989) explains:

Another problem concerns the meaning of the term ‘science’ when we refer to it as a school subject. In the discipline of science education, the school subject ‘science’ is tacitly understood as the one in which the knowledges, concepts, and processes of Western science alone are taught. (p. 248)

Cajete (2000) explains how the contemporary understanding of ‘science’ is mostly Western in nature:

Albert Einstein said that the business of science is “reality.” I agree, but the reality brought by modern science is largely based on Western paradigms. Western pragmatic views of science are largely about measurement using Western mathematics. But nature is not mathematical. Mathematics is superimposed on nature like a grid, and then examined from that framework. (p. ix)

The importance and value of Western-based science and the scientific method can not be denied, but it is the exclusion of other perspectives of science that can be problematic for Aboriginal students.

What is “Western” Science?

Western science is also referred to as modern science, standard science, conventional science and official science (Snively & Corsiglia, 2001, p. 9). Western science has its origins in the European scientific revolution of the seventeenth and eighteenth centuries (Selin, 1993; Lederman, 2001; Zarry, 2002). “It is often referred to as ‘Western’ because of its origins in Western Europe” (Hatcher, Bartlett, Marshall, M. and Marshall, A., 2009, p. 3). Cajete (2000) describes the human-centered and theory-driven perspective of Western science:

For Einstein and Western science, creation and existence were made in a certain way by God and will always remain the same; everything and anything in creation and existence just needs to be discovered by humans. Nothing is certain unless it can be referred to as a regular pattern after long-term observation. (p. xi)

Simpson (2002) also explains that Western science is theory-driven, operates in a lecture/lab format, and lacks “real world” relevance with little or no Aboriginal content (p. 21). Western science is often regarded as the only “real” science (Simpson, 2002). But, such a limited perspective of science can exclude scientific knowledge from many other cultures, and potentially alienate students who come from other cultural backgrounds. Snively & Corsiglia (2001) explain, “students bring a broad range of ideas, beliefs, values, and experiences to the classroom which form a spectrum of viewpoints. Unfortunately, science educators have long assumed that only Western modern scientific knowledge was true knowledge” (p. 25). Teaching science from an “expansionist culture

that brought Eurocentric science to various lands and their inhabitants” (Zarry, 2002, p. 3) has implications for all students, of which Aboriginal students are a particularly vulnerable group.

Mullens (2001) articulates why the primarily Western perspective of science that is taught at schools is a concern for Aboriginal learners:

The Western view of science is completely foreign and at odds with Native spirituality or a holistic understanding of the world. The teaching of science from only one cultural perspective and in the manner that dominates science education continues to be a central dilemma of science education today. (p. 11)

Aboriginal knowledge or ‘science’ is fundamentally different from Western science. Some Aboriginal students may experience a type of cultural conflict, whether perceived or not, in their acquisition of classroom science concepts (Aikenhead, 1997). MacIvor (1995) explains, “much of what is learned in contemporary science classrooms is seen as divorced from community concerns. This is particularly true in the case of Aboriginal communities, where the national or provincial curricula present science in unfamiliar contexts” (p.76). Consequently, Aboriginal students may feel at odds with Western-based science education if it has no context for them in the world outside of the classroom.

The Western based perspective of science that is taught at school can also be quite assimilative in nature. As Colorado (1988) explains, “[Aboriginal] people have become dependant on a foreign system of thought for answers to the major causes of our

destruction” (p. 60). The emphasis on Western-based science has in some instances negated the value of Aboriginal science, so that some Aboriginal people may feel that Western-based science has greater validity than traditional knowledge. The dominance of Western science also has the potential to homogenize the global understandings of what constitutes ‘science’.

The need for inclusion of Aboriginal knowledge in science curricula is paramount to *all* students, not just Aboriginal students. We are in an era of environmental destruction – locally, nationally, and internationally. In Canada, this damage has happened in only the last few hundred years. In the many thousands of years prior to European contact, Aboriginal people lived in a way that protected and sustained the environment and resources. As Snively (1995) explains, “long-resident cultures have, in the course of time, developed knowledge and strategies enabling them to sustain environment, resources, and populations” (p. 53). This way of living was based on the Aboriginal worldview that “all life is sacred and that all life forms are connected. Humans are neither above nor below the others in the circle of life. Everything exists in the circle is one unity, one heart” (Alberta Education, 2005, p. 15).

The Western worldview, on the other hand, places “humanity apart from and above the natural world, and in command of apparently inexhaustible resources” (Christie, 1991, p. 28). It took a very small amount of time after European contact for the environmental balance that had existed here since time immemorial to be lost. Europeans viewed these lands as unsettled and uninhabited, even though many large, complex, and diverse populations of Aboriginal people had lived here for many millennia. Early

European traders and settlers viewed the resources in these ‘new’ lands as inexhaustible they saw the resources as a way to produce extraordinary amounts of wealth in a short amount of time. Atleo (2004) describes the colonizers’ first impressions of the “newly discovered” resources:

Colonial descriptions of the “new world” were filled with notions such as: buffalo as far as the eye could see; untold numbers of birds that darkened the sky; salmon so thick on the rivers that one could walk on them. Yes, the earth’s resources were without limit when considered in the context of a smaller world population and a more primitive technology. In this colonial context, it made some sense to develop the economic goal of maximum exploitation for maximum profit. (p. 65)

Thus, over-extraction of the resources began, from trees, to fish, to minerals, to fur-bearing animals, and it was not long before the new-comers realized that the resources were not inexhaustible after all. Many species verged upon extinction, including the sea otter population, many species of whales, and old-growth forests, just to name a few. Now, politicians, environmentalists, and scientists are scrambling to minimize further environmental damage.

Snively & Corsiglia (2001) eloquently express the need to reevaluate how science is commonly taught and the need to incorporate Aboriginal knowledge:

In most science classrooms around the globe, Western modern science [WMS] has been taught at the expense of indigenous knowledge.

However, because WMS has been implicated in many of the world’s

ecological disasters, and because the traditional wisdom component of TEK [traditional ecological knowledge] is particularly rich in time-tested approaches that foster sustainability and environmental integrity, it is possible the universalist 'gatekeeper' can be seen as increasingly problematic and even counterproductive. (p. 6)

Chief Seattle prophetically stated in his famous speech of 1854:

This we know: the earth does not belong to man, man belongs to the earth. All things are connected like the blood that unites us all. Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself. (Cited in Kawagly, 1995, p. 17)

Many people are starting to realize that the answers to environmental sustainability have been here all along, embedded in traditional Aboriginal knowledge. Despite the value of this knowledge, it has remained, until very recently, excluded from the curricula in BC schools, unable to influence the next generation, both Aboriginal and non-Aboriginal, in the area of environmental stewardship.

What is Aboriginal 'Science'?

Aboriginal science is also referred to as Aboriginal knowledge, ethnoscience, or as Indigenous science/knowledge. There is also a branch of science that combines aspects of Western science and Aboriginal science called traditional ecological knowledge, or TEK. In Aboriginal culture, 'science' is not a separate,

compartmentalized subject as it is in Western culture, but an integral part of everyday life. Traditionally, Aboriginal knowledge or science was not even consciously recognized or labeled (Ogawa, 1989). Cajete (2002) explains:

In Native languages, there is no word for “science,” nor for “philosophy,” “psychology,” or any other foundational way of coming to know and understand the nature of life and our relationship therein. Not having, or more accurately, not needing, words for science, art, or psychology did not diminish their importance in Native life. For Native people, *seeking life* was the all-encompassing task Native science is a metaphor for a wide range of tribal processes of perceiving, thinking, acting, and “coming to know” that have evolved through human experience with the natural world. Native science is born of a storied participation with the natural landscape. (p. 2)

Aikenhead (1997) describes Aboriginal knowledge as “thematic, survival-orientated, holistic, empirical, rational, contextualized, specific, communal, ideological, spiritual, inclusive, cooperative, coexistent, personal, and peaceful” (p. 221). Snively and Corsiglia’s (2001) definition includes a few other dimensions of Aboriginal knowledge:

Indigenous science relates to both the science knowledge of long-resident, usually oral culture peoples, as well as the science knowledge of all the peoples who as participants in culture are affected by worldview and relativist interests of their home communities. (p.6)

According to Cajete (2000), “when speaking about Indigenous or Native science, one is really talking about the entire edifice of Indigenous knowledge Thus the terms ‘knowledge’ and ‘science’ are used interchangeably among Indigenous scientists” (p. 3-4).

Aboriginal knowledge is holistic, it is passed down through generations through an oral culture, and it is inclusive of spirituality. The holistic nature of Aboriginal knowledge includes emotional, intellectual, physical, and spiritual realms (Simpson, 2002) and is based on the idea that everything is related and interconnected (MacIvor, 1995). The Nuu-Chah-Nulth express this idea of interconnectedness as “Hishuk ish ts’awalk” which means “everything is one” (Turner, 2005, p. 72).

Dr. Richard Atleo, educator and hereditary chief of Ahousaht, explained this concept further, noting that the Nuu-Chah-Nulth belief system from which their traditional values arise can be articulated as follows:

The Creator made all things one.

All things are related and interconnected.

All things are sacred.

All things are therefore to be respected. (Turner, 2005, p. 72 – 73)

Indigenous science focuses on the “interconnectedness of people and their relationship to each other and their environment” (Fleer, 1999, p. 120). Christie (1991) explains, “in Aboriginal science thousands of seemingly unrelated pieces of information are organized through complex webs and levels of metaphor which are utterly alien to our Western

taxonomies” (p.28). Friesen & Friesen (2002) eloquently describe the holistic and spiritual nature of Aboriginal knowledge:

The Indigenous peoples saw the universe as a whole; everything was connected, and all living things – people, animals, and plants – were perceived as “all my relations.” There were no separate subdivisions of thought such as biological, mental, spiritual, or psychological. The curriculum studied by First Nations children brought everything together, encompassed within a spiritual blanket. Every act, every behavior, was seen as having spiritual implications in that it reflected on the individual’s earthly journey. (p. 33)

Even the understanding of ‘living’ was much more all-encompassing according to the traditional Aboriginal worldview, as Cajete (2000) explains:

In Native science, there is ... an inclusive definition of “being alive.” Everything is viewed as having energy and its own unique intelligence and creative process, not only obviously animate entities, such as plants, animals, and microorganisms, but also rocks, mountains, rivers, and places large and small. (p. 21)

The spiritual basis of Aboriginal knowledge is also one of the key characteristics that separates it from Western science. “Native science has a sacred basis; its teachings are grounded in the natural world” (Colorado & Collins, 1987, p. 57). Simpson (2002) explains that, “the sustenance of our wisdom, worldviews, philosophies, and values comes from the land. The source of our knowledge and our teachers themselves come

from the land and the spirit-world it encompasses” (p. 15). Friesen & Friesen (2002) argue that the modern education system has worked to eliminate all references to spirituality, both Aboriginal and non-Aboriginal, as a means of protecting students of different cultural backgrounds or faiths from being offended, but by doing so, the idea is reinforced to Aboriginal students that spirituality has nothing to do with, and should be separate from, education.

Traditionally, there were no “scientists” in the Aboriginal communities, but rather respected members of the community who possessed a special type of knowledge, whether in medicine, resource use, or nutrition, as Salmón (1996) explains:

Knowledge, in the Indigenous sense, is not a commodity as in the Western sense. It is not an item anyone can chose from a shelf and purchase at their leisure. It is available to those who listen and learn, and in some cases, to those who are chosen for it or who are born to it. (p. 71)

Aboriginal knowledge is also primarily oral in nature and it was traditionally passed down through observation, listening, stories, dances, songs, and totem poles, etc.

MacIvor (1995) explains that “traditional knowledge is that which has accumulated over time and is transmitted across generations from elders to young people” (p. 81). Zarry (2002) describes the transmission of Aboriginal knowledge:

Aboriginal knowledge is often the result of the rational observations of natural events, the classification of these observations, and an application to problem solving, often translated into stories or legends where abstract principles are encapsulated in metaphor. In the past, these legends were

passed down through oral narratives. (p. 4)

One specific branch of Aboriginal 'science' is TEK, or traditional ecological knowledge, which bridges Aboriginal knowledge, environmentalism, and aspects of Western science (Zarry, 2002). The principles of TEK are rooted in the contact that Aboriginal people have had with their ancestral lands for thousands of years (Snively and Corsiglia, 2001; Kimminer, 2002). Cajete (2000) explains, "Indigenous science may also be termed ...TEK, since a large proportion of this knowledge served to sustain Indigenous communities and ensure their survival within the environmental contexts in which they were sustained" (p. 268). TEK has the potential to be very beneficial in improving environmental stewardship, as Zarry (2002) explains:

Through the use of methodologies such as observation and experimentation, and with traditional wisdom such as respect and harmony, TEK generates knowledge that results in a local cultural perspective with a view of long-term sustainable societies with implications for local/global environmental issues. (p. 6)

Zarry goes on to say, "the role of TEK would be to offer solutions to problems and not blame Western modern science for ecological disasters" (2002, p. 6). It has been proposed that TEK can co-exist with Western knowledge in science curricula, as Kimminer (2002) explains:

TEK is highly rational, empirical and pragmatic, while simultaneously integrating cultural values and moral perspectives. With its worldview of respect, responsibility, and reciprocity with nature, TEK does not compete

with science or detract from its power, but extends the scope of science into the human interactions with the natural world. (p. 437)

One example of a school program that is based on the holistic nature of Aboriginal knowledge and the principles of TEK is called “Canoes on Puget Sound: A Curriculum Model for Culture-Based Academic Studies” developed by the University of Washington (Weeks, 2003, p. 10). Students learned how Aboriginal people used body measurements to determine the necessary circumference of prospective cedar logs when making canoes. Traditional stories, language, and history were also part of the program. Aboriginal experts were brought into the classroom and students had the opportunity to paddle canoes, go to the museum, and examine the local environment. Concepts such as symmetry, buoyancy, surface tension, leverages, and counterbalance weights were also included. Students who participated in the program realized that Aboriginal people had ‘science’, including math, geography, and astronomy.

Western and Aboriginal Science: Fundamental Similarities and Differences

Western and Aboriginal science are fundamentally different, but key similarities do exist between these two realms of understanding. For instance, there are commonalities between the two regarding actual knowledge of the world and in the processes for attaining knowledge. As described by Weeks (2003), “[Aboriginal] and Western ideas converge along the rivers of human knowledge. When teachers tap these confluences, learning takes on the rich realities and complexities of life (p. 2). According to Baker (1996):

Like ‘Western’ science, indigenous science consists of a set of explanations which seek to make sense of the natural world and which are consistent with a particular worldview. Through an informed process of theory, experimentation and replication these explanations have become part of the oral tradition of a specific indigenous group, often becoming most visible in their technological applications. (p. 19)

There is sometimes an assumption that Aboriginal knowledge or science is without process, making it less ‘scientific,’ though “laws and standards govern [Aboriginal] science just as they do Western science” (Colorado & Collins, 1987, p. 60). Complex forms of technology and experimentation are integral parts of Aboriginal science (Simpson, 2002). Huntley (1998) summarizes, “science and myth offer different ways of viewing the world, but they teach us the universal truth that there is an empirically obvious relationship between people and Earth” (p. 29).

Wisdom of the Elders: Native and Scientific Ways of Knowing about Nature (1992/2006), by authors Peter Knudtson and David Suzuki “is an exploration of the often striking parallels between traditional Native ecological perspectives and Western scientific ones, ... as well as the undeniable differences, in these two distinct, yet often strikingly complementary ways of knowing about the natural world” (p. 4). The similarity between the two, according to Knudtson and Suzuki, is that “each aims to ... discover some sense of order within the physical universe and conjures up visions of nature that, when seen side by side, can seem strikingly *complementary*” (p. 10). Knudtson and Suzuki (1992/2006) assert that indigenous knowledge:

Reveals a profound understanding, often ingeniously encoded in symbolic systems, of the underlying interconnectedness of the universe – a perspective, increasingly echoed by modern science, that is exceedingly relevant to our times. [Indigenous knowledge tales] remind us, however metaphorically, of the shared origins of all forms of life, the ecological integrity of natural systems, and the ancient bonds of kinship between human beings and other species. (p. 3)

Knudtson and Suzuki (1992/2006) view this sense of interconnectedness within the world as one of the fundamental similarities between Aboriginal knowledge and Western science – and they use the evolutionary tree to represent the Western scientific perspective:

This still-unfolding evolutionary story of life is perhaps the single most eloquent, detailed, and compelling statement that Western societies possess of their fundamental, time-mediated interconnectedness with *all* life forms on this planet Each species represents the single, vibrant tip of one the living braches of the towering evolutionary tree. The tree's trunk corresponds to the ancient ancestral unity of all living things – to their unequivocal biological kinship and their shared record of unbroken success within their respective evolutionary lineages. (p. 23)

Both Aboriginal knowledge and Western science postulate ways of understanding the world, and both are based on a sense of interconnectedness within the world, but this is where the similarities end, according to Knudtson and Suzuki. They explain that the

“critical difference between these two traditional ways of knowing ... arises from opposite ways in which each asks questions about the universe” (p. 10). Two key differences, according to Knudtson and Suzuki, are that Aboriginal knowledge seeks to find meaning by viewing the holistic nature of the world and is infused throughout with spirituality, whereas Western science seeks to find meaning through a reductionist approach that fragments the world and is completely devoid of spirituality. In describing traditional Aboriginal knowledge, Knudtson and Suzuki (1992/2006) state:

Traditional Native knowledge about the natural world tends to view all ... of nature ... as inherently holy The landscape itself ... is inscribed with meaning regarding the origins and unity of all life The Native mind is imbued with a deep sense of reverence for nature. It does not operate from an impulse to exercise human domination over it. Native wisdom sees spirit ... as dispersed throughout the cosmos or embodied in an inclusive, cosmos-sanctifying divine being The native mind ... tends to see the entire natural world as somehow alive and animated by a single life force It does not reduce the universe to progressively smaller conceptual bits and pieces. (p. 13 – 14)

In contrast, Knudtson and Suzuki describe Western science as ‘conveniently human-centered,’ ‘value-free,’ ‘secular’ and ‘spiritually detached’ (p. 121, 161) and they describe the objective nature of Western science:

Rather than becoming active participants in nature, ... [Western scientists] observe nature as object – an inanimate “other” – and

consequently “from afar.” They view nature as a distant abstraction: a composite of the clever, fragmentary insights they have painstakingly gleaned from the measurable aspects of nature The scientist seeks nothing less than eventually to comprehend the workings of the whole universe – to “explain” it rationally by somehow reducing all of its seemingly unfathomable mysteries to a finite set of natural laws that grant order to the cosmos. (p. 11)

Knudtson and Suzuki explain how this fragmentary view of the world results in “mental myopia – this distorted ‘nearsightedness’ that inevitably arises from peering too close at a fractured cosmos” (p. 63 – 64). They also assert that the secular and fragmentary basis of Western science has contributed to modern society’s detachment from nature and the staggering environmental problems in the world today:

Modern science’s dazzling achievements in rationally dissecting the natural world may also be contributing to a sense of psychological, emotional, and spiritual detachment from the rest of the natural world By looking upon other life-forms as evolutionary and spiritual *equals*, or kin, rather than as *its*, or objects, we might glimpse the long-term consequences of human greed and irresponsibility as well as gain concrete empirical knowledge. (p. 65)

Furthermore, Knudtson and Suzuki claim that Western science “has so far been incapable of reliably instilling in people a deeply felt environmental conscience ... and has left [modern] societies psychologically dissociated from their natural surroundings and

spiritually adrift” (p. 161). For these reasons, Knudtson and Suzuki argue that now is the time for modern society to learn from age-old Aboriginal knowledge and wisdom:

We believe that it is time, at long last, for modern, science-driven industrial societies to begin to grant traditional Native nature-wisdom and the long-suffering First Peoples of the world who are its guardians and rightful heirs the respect they have always deserved. (p. 4)

In *Wisdom of the Elders: Native and Scientific Ways of Knowing about Nature* (1992/2006), Knudtson and Suzuki identify some fundamental similarities between Aboriginal and Western ways of knowing, but they also explain how the means by which these two realms seek to understand the world are fundamentally different. Knudtson and Suzuki argue that the reductionist, fragmented and secular nature of Western science cannot continue to dictate how society functions, or it will be at the expense of the entire world as we know it. If environmental repair is at all possible, much of the answers can be found in Aboriginal ways of knowing.

Underrepresentation of Aboriginal Students in the Sciences: Impacts

The overall participation of Aboriginal students in secondary school science is far from adequate, which has some serious consequences. Simpson (2002) argues, “mainstream science education has failed miserably at attracting and retaining Aboriginal students” (p. 20). Aboriginal educator Madeleine MacIvor (1995) summarizes the ripple effect of the underrepresentation of Aboriginal students in secondary science:

At the secondary level, science education is characterized by low enrolment and achievement by our [Aboriginal] students. This limits the number of our young people who can gain entry into post-secondary science, technology, and health-related programs. Not surprisingly, Aboriginal people are very under-represented in science, technology, and health-related programs and professions. Ironically, it is also clear that a very real need exists for our people to gain expertise in the sciences. (p. 73)

According to Mullens (2001), “science and health educators estimate that fewer than one percent of Aboriginal students are majoring in science-related courses” (p. 10). The areas of Canadian post-secondary science programs where Aboriginal students have the lowest participation rates include agriculture, biological sciences, math, physical sciences, engineering, technology, and health and medicine (Simpson, 2002; Mullens, 2001). This underrepresentation has impacts on Aboriginal communities as a whole, as Mullens (2001) states:

In a time of land-claim settlements and moves to self-government all over Canada, aboriginal people with scientific and technical education are needed to manage resources, build and maintain infrastructure, and deliver health care and other scientific services to [our] own people. (p. 10)

The value of science education for Aboriginal students goes far beyond the reaches of the classroom. As such, changes need to be made so that the participation of Aboriginal students in the sciences increases. As Huntley (1998) so adequately states, “the literature in the field, the voices of the elders, and the failure rate of Aboriginal students cry out for

changes to the education system” (p. 40). The Canadian Institute on Learning has stated, “overall, the data suggest that Aboriginal participation in science and technology occupations is unlikely to improve until strategies can be found for producing successful experiences with classroom science among Aboriginal students” (2007, p. 7). An exploration of suggested changes to secondary science education will be summarized next.

Science Curricula and the Impact on Cultural Identity

One of the foremost issues facing Aboriginal learners in science education is the lack of Aboriginal content. Before 2005, Aboriginal content was not a part of the prescribed science curricula at any grade level in BC. Aboriginal content learning outcomes were added to the kindergarten to Grade 7 science curricula in 2005, to Grade 8 in 2006, to Grade 9 in 2007 and to the Grade 10 science curricula in 2008. Aboriginal content has not been added to any of the learning outcomes in science courses at the senior-secondary level. Though Aboriginal content learning outcomes have been added at the K – 10 levels, the actual amount of content is a small fraction of the overall science curricula. All of the BC science curricula, or Integrated Resource Packages, from kindergarten to Grade 12 can be accessed by going to the BC Ministry of Education's website: http://www.bced.gov.bc.ca/irp/irp_sci.htm. The number of Aboriginal content learning outcomes is summarized in the following table.

Table 2

*Current (2010) Aboriginal Content Learning Outcomes in the BC K – 12 Science**Curriculums*

	<i>K</i>	<i>Gr. 1</i>	<i>Gr. 2</i>	<i>Gr. 3</i>	<i>Gr. 4</i>	<i>Gr. 5</i>	<i>Gr. 6</i>	<i>Gr. 7</i>	<i>Gr. 8</i>	<i>Gr. 9</i>	<i>Gr. 10</i>
# of Ab. Learning outcomes.	0	1	1	1	1	1	1	1	1	1	1
Total #of learning outcomes.	10	10	12	11	11	13	12	12	24	23	22
Overall Ab. Content.	0%	10%	8%	9%	9%	7%	8%	8%	4%	4%	5%

The inclusion of one Aboriginal content learning outcome at each grade from the K – 10 levels is definitely a substantial improvement from the complete lack Aboriginal content learning outcomes that existed before 2005. However, the actual amount of Aboriginal content that has been added is negligible. Science curriculum is still predominantly Western-based, particularly beyond grade 7 where Aboriginal learning outcomes drop to only 4 – 5% of overall science course content. Aboriginal content drops off entirely to 0% in Grade 11 and 12 Biology, Chemistry and Physics. Is the inclusion of one learning outcome per grade at the K – 10 levels enough to make difference in the understanding of ‘science’ for students, Aboriginal or non-Aboriginal? A separate study would need to be conducted to answer this question.

Aboriginal content must be a foundational component of science education, as opposed to supplemental. Supplemental inclusion can lead to a “tokenistic approach to indigenous science [that] can oversimplify the complexity of the understandings” (Michie, 2002, p. 39). “Infusion of Aboriginal content is not an add-on or a special event – it is an integral, embedded and ongoing aspect of the classroom experience” (Alberta Education, 2005, p. 53). Friesen & Friesen also believe that, “merely adding Native components to the content of an altogether non-Native curriculum will only increase acculturative stress on [Aboriginal] students” (2002, p. 79). Snively (2009) describes cross-cultural science:

Cross-cultural science education is not merely throwing in an Aboriginal story, putting together a diorama of Aboriginal fishing methods, or even acknowledging the contributions Aboriginal peoples have made to science. Most importantly, cross-cultural science is not anti-Western science. Its purpose is not to silence voices, but to give voice to cultures not usually heard and to recognize and celebrate all ideas and contributions. It is as concerned with how we teach as what we teach. Instead of defining what science is, let students explore what the word “science” means to them. (p. 38)

Presenting both Aboriginal and Western knowledge concurrently allows students to seek knowledge in a more inclusive, multi-faceted way.

The inclusion of Aboriginal content is also minimal in other parts of Canada. According to Sutherland and Dennick (2002), it is estimated that “only 3% of Canadian schools have developed science classroom material with [Aboriginal] content” (p. 27).

Similarly, Smith (1996) states, “at this time First Nations knowledge is seldom reflected in approved curriculum and textbooks” (p. 1). A lack of Aboriginal content in science courses can have a variety of negative impacts on some Aboriginal students. Aboriginal students have varying levels of an Aboriginal perspective in which they base their foundational understanding of the world. Aikenhead (1997) explains how some Aboriginal students move between two very different contexts, based on their level of cultural connection: the community or family context in which the students live and the school and classroom context in which they learn:

Because the subculture of Western science can conflict with the cultures of First Nations students, learning Western science is recognized as culture acquisition that requires Aboriginal students to cross cultural borders from the everyday subcultures of their peers, family, and tribe, to the subcultures of school, school science, and science itself. (p. 218)

If the student is able to comfortably move between these two “worlds,” the resulting cultural impact is minimal. Aikenhead (1997) describes this as ‘enculturation’ - “if the subculture of science generally harmonizes with a student’s everyday culture, [then] science education will tend to support the student’s view of the world” (p. 222). The real concern is if the acquisition of scientific knowledge compromises the student’s cultural identity. Simpson (2002) states, “science can serve either to assimilate Aboriginal students into its framework or further alienate them, undermining their knowledge system” (p. 21). Aikenhead (1997) says that assimilation occurs if:

The subculture of science is generally at odds with student’s everyday

world, as it can be with First Nations students, then science instruction can disrupt the student's view of the world by forcing that student to abandon or marginalize his or her indigenous way of knowing and reconstruct in its place a new (scientific) way of knowing. (p. 222)

The internal conflict that Aboriginal students may face when learning concepts from the perspective of the dominant society can lead to other external concerns, such as achievement levels or participation. As Smith (1994) explains:

Indigenous students are constantly challenged to reconstruct science conceptions, and because of the dissonance between scientific knowledge and cultural knowledge, their cultural identity is challenged. The conflict may hinder the process of conceptualizing science concepts. This may account for the low attainment scores and attitude about science ... and the low participation rate of indigenous students in the sciences. (p. 15)

Aikenhead (1997) also explains, "First Nations educators such as Madeleine MacIvor want students to learn Western science but, at the same time, not be assimilated into Western culture at the expense of their own Aboriginal culture and identity" (p. 218).

Henderson (1996) asserts that, "students must learn to live in two worlds, native and non-native. Students must be helped to make decisions about how they will make their path within both the dominant society and their Aboriginal communities" (p.17). Aboriginal students need to be able to function in both their traditional communities and in the dominant society, which means they must be given the opportunity to learn both Western knowledge and Aboriginal knowledge to prevent further cultural loss.

Improving Science Education for Aboriginal Students

One critical way that science education can be improved for Aboriginal students is to include Aboriginal knowledge and present it with equal value, respect, and importance as Western knowledge. Fler (1999) argues, “Western science needs to be thought of as one world view among many and not the main paradigm with Aboriginal science seen as the other” (p. 132).

Western science is *one* way of studying science, not the only way, and Aboriginal science must be presented as a different form of science, but not as inferior or less reliable or less valid (Simpson, 2002; MacIvor, 1995; Snively & Corsiglia, 2002). Freeman (1992) explains:

No one group of observers has a monopoly on truth, and the history of Western science makes it quite clear that the scientific truths of today will, in ever-decreasing intervals of time, constitute the bulk of tomorrow’s discarded hypotheses and superceded knowledge. (p. 12)

Kawagley (1995) states that underrepresentation of Aboriginal students has less to do with the student’s lack of ability and more to do with a lack of cultural context:

Native students’ aversion to academic mathematics and sciences is often attributable to an alien school culture rather than to any lack of innate intelligence, ingenuity, or problem-solving skills. The curricula, teaching methodologies, and often teacher training are based on a worldview that does not always recognize the Native notion of an interdependent universe. (p. 103-104)

The inclusion of Aboriginal content would also help all students to recognize the contributions of Aboriginal knowledge to science curriculum (MacIvor, 1995).

According to Christie (1991):

We must embed our scientific study as locally as possible, and set up a process of negotiating a balance between as many different perspectives and interpretations as possible including, of course, the enormous body of scientific knowledge made available to us by the scientists of our own culture. (p. 31)

Similarly, Friesen & Friesen (2002) assert that the inclusion of Aboriginal knowledge “provides a means by which Aboriginal students can learn about their historical backgrounds within the school context. The belief is that this will help students gain a more positive self-image and thus improve learning” (p. 34).

Snively (1990) articulates another important reason for teaching from both perspectives, stating, “current research suggests that the scientific traditions – Native oral tradition and Western scientific thought – in combination provide a broader perspective on the natural environment than either can by itself” (p. 56). This method of teaching is sometimes referred to as Integrative Science, which weaves back and forth between Western and Indigenous ways of knowing (Hatcher et al, 2009). Using both of these perspectives will enhance students’ understandings of life and the world by providing a more complete and extensive body of knowledge. The inclusion of Aboriginal knowledge has an overall value that benefits all students in an era of increasing environmental concerns. Christie (1991) explains that we need to “understand, care for,

and respect the part we human beings have to play in the on-going greater ecology of the planet” (p. 31). Aboriginal people lived here for many thousands of years prior to contact and sustained large, dynamic populations of people without doing irreparable damage to the environment. Much can be learned from the Aboriginal worldview in our efforts to curtail environmental destruction: “Indigenous people alone have in hand the knowledge that is sorely needed to help Canadians retract their complete disregard for the welfare of the universe” (Friesen & Friesen, 2002, p. 147).

Another way that science education can be improved for Aboriginal students is changing the way that science is taught. Most secondary science education consists of textbook reading, note-taking, worksheets, test writing, and experiments that are based on the scientific method. Science is taught almost exclusively in the classroom or laboratory settings. This can cause problems for Aboriginal students, as Mullens (2002) explains, “many educators note that Aboriginal students do not do well in a straight lecture environment. They prefer a creative, hands-on learning situation that makes linkages and highlights the relevancy of the material” (p. 11). The Western nature of science, however, “continues to deny the spirit and intelligence of nature. Enclosed in a technologically mediated world, [students] rarely encounter nature in any significant or creative way” (Cajete, 2000, p. 22). Cajete (2000) asserts that the essence of “Native science” is based in creative and participatory interactions within the world (p. 26 – 27). Thus, incorporating Aboriginal knowledge and allowing for authentic, experiential, and creative learning opportunities will enhance how Aboriginal students learn science, as these practices are more in tune with their preferential learning styles. Cajete (2000) also

believes that excluding the creative aspect in school science can have long-term negative implications for students:

Young children are naturally creative until creativity is repressed in formal process of education. When they become adults, they often feel something is missing, but they have no idea how to discover what Among technical professionals and engineers ... creative thinking is rare because of their straightjacketed education; very few are able to think creatively, and they may not even wish to, as such thoughts may frighten or surprise them. (p. 45)

It has also been shown that Aboriginal students prefer greater instructional variety in the classroom, as well as opportunities for peer-orientated learning, such as collaborative and small group learning (Friesen & Friesen, 2002). The modern education system, however, emphasizes conformity in learning, rather than individuality, as explained by MacIvor (1995):

Students are expected to master the same curriculum, at the same rate, at the same age, and demonstrate their mastery by the same means. A more democratic system might give students greater choice in what is learned, and how learning is assessed. (p. 82)

Students who can not 'keep up' with everyone else due to different learning abilities or due to other extenuating circumstances are at risk of being unsuccessful in the education system.

Traditionally, Aboriginal students did not learn in a classroom, but out in the environment under the guidance of an elder, family member, or community member.

Traditional Aboriginal education was individualized, hands-on, and promoted life-long learning and personal reflection (Simpson, 2002). Individuality in learning was an essential aspect of a traditional education, as Friesen and Friesen (2002) explain:

Native communities respect individual differences within the bounds of cultural norms. Young learners are accepted as individuals, and are afforded a great deal of leeway in developing themselves. They are not expected to progress in the same direction or at the same rate of speed as their peers, and when their talents have been developed, they are expected to benefit the community. (p. 32)

Traditional teaching methods include experiential learning, story-telling, observation, inter-generational teaching, apprenticeship, imagination, and ceremony (MacIvor, 1995). In order to make learning more hands-on and experiential, Simpson (2002) suggests that we need to let go of “standardized evaluation techniques” such as quizzes, tests, and multiple choice exams, and instead use “appropriate alternatives (community reports, critiques, field reports, journals, etc.)” (p. 23). It is also essential to take students outside of the classroom and into the environment to facilitate learning as Aboriginal knowledge is deeply rooted in the land (Simpson, 2002). Sutherland & Dennick (2003) explain, “knowledge in the traditional world is not a dead collection of facts, [it] comes about through watching and listening, not in the passive way that schools demand” (p. 3). In addition, Aboriginal knowledge is shared through the oral tradition, so it must be understood that the majority of information will not come from textbooks, as it so frequently does in Western-based classrooms. Snively (1990) says, “textbooks make fine

resources for the teacher, but no textbook can comprise a viable science program for culturally different students. The spiritual stories and heritage of the Native community should become part of the school science experience” (p. 56). Making science education more culturally relevant and more flexible will help to improve the experiences and levels of success achieved by Aboriginal students.

The inclusion of Aboriginal role models is also very important for Aboriginal students. Aboriginal science teachers, scientists, and traditional resource people, such as elders and local experts, can be invited into the classroom to help teach Aboriginal content (Simpson, 2002; MacIvor 1995). Aboriginal role models and mentors can help Aboriginal students to realize that they can be successful in the sciences (Mullens, 2001). Salmón (1996) argues that Aboriginal traditional teachers must be accepted as equals, not consultants, assistants, or guest speakers.

But, it must also be recognized that there is great variety not only amongst types of Aboriginal knowledge, but also amongst Aboriginal students themselves. “Each indigenous people had its own economic, spiritual, political, and historical relationship with its homeland, though similarities did exist. Aboriginal knowledge was not homogeneous (Turner, Ignace, & Ignace, 2000). In addition, not all Aboriginal students identify with their Aboriginal culture and not all Aboriginal students will benefit from Aboriginal styles of teaching. According to MacIvor (1995), “there is no generic ‘Indian’ learning style. While some research may identify patterns of learning among some groups of Aboriginal peoples, there are significant variations between tribes and individuals” (p. 79). Aboriginal students vary considerably in levels of cultural

connection, personal interests, and learning styles. But, research has also indicated that even if Aboriginal students are not strongly connected to their culture, the Aboriginal worldview still resonates deep within them:

Some Aboriginal students enter the classroom looking and acting much like other students Some Aboriginal students may even be blonde, blue-eyed and fair in complexion. Other Aboriginal students may look and/or act differently.

Despite outward appearances, the strongest influences on both groups of students are likely those influences that cannot be seen – the influences of their histories, families, and cultures These influences may run so deep that the students themselves are not fully aware of them and may not be able to explain how they affect them. (Alberta Education, 2005, p. 30)

The need for educators to make Aboriginal knowledge a foundational component of science education is unquestionable, but in doing so, it must be done with an understanding that there is no generic form of Aboriginal knowledge.

Academic Achievement and Resiliency

The goal of study is to examine why some Aboriginal students participate and experience academic success in senior secondary science. As such, another important area that must be addressed is research relating to reasons for student academic

achievement and resiliency. Blum (2005) says that the academic success depends largely on how connected students feel to their school environments:

When one looks at the research literature across different fields of inquiry, three school characteristics stand out as helping young people feel connected to school while simultaneously encouraging student achievement: (1) high academic standards coupled with strong teacher support; (2) an environment in which adult and student relationships are positive and respectful; and (3) a physically and emotionally safe school environment.” (p. 17)

For some Aboriginal students, academic achievement is also linked to feeling culturally respected: “When [Aboriginal] students’ cultural affiliation is valued in the classroom, motivation for learning is highest” (Weeks, 2003, p. 2). Also important to student academic achievement, according to Sutherland (2005), is student motivation and goal setting, particularly “mastery-orientated” goal setting which refers to students “linking the intrinsic value of learning and the belief that effort affects outcome” (p. 598). In addition, Sutherland (2005) explains that previous studies on school achievement by Australian and Navajo Aboriginal students found that extrinsic factors, such as parental/family interest and support were primary student motivators.

Aboriginal students who do well in a largely Western-based education system are often also very resilient. Howard, Dryden, & Johnson (1990) explain, “in the context of schooling, resiliency refers to the ability to thrive academically despite adverse circumstances” (as cited in Sutherland, 2005, p. 600). The adverse circumstances

experienced by Aboriginal students are varied, and could include personal, school, family, social, or home reasons. McMillan and Reed (1994) describe resilient students:

Despite incredible hardships and the presence of at-risk factors, some students have developed characteristics and coping skills that enable them to succeed. They appear to develop stable, healthy personas and are able to recover from or adapt to life's stresses and problems. (§ 2)

In addition, McMillan and Reed (1994) say, “much can be learned from studying students who may be classified as at-risk but are resilient, that is, doing well in school despite the odds against them” (§ 3). Below are McMillan and Reed's (1994) findings on the characteristics of resilient students:

- Educational goals: “successful students have higher educational aspirations than non-resilient students.” (§ 6)
- Self-motivation: “These students were motivated by a desire to succeed, to be self-starting, and to be personally responsible for their achievements.” (§ 6)
- Future goals: “Resilient students have clear, realistic goals and are optimistic about the future. They have hope, despite all the negative circumstances in their lives, and confidence that they can achieve their long-range goals.” (§ 7)
- Do not assign blame: “Resilient students do not believe that the school, neighborhood, or family is critical in either their successes or failures. They acknowledge that a poor home environment can make things difficult, but they do not blame their performance on these factors.” (§ 8)
- Use of time: “Active involvement in extracurricular events at school and in other

areas seems to provide a refuge for resilient students. Hobbies, creative interests, and sports help promote the growth of self-esteem.” (§ 9)

- Being helpful: “Involvement in "required helpfulness" seems to be a factor in resilient students' experiences. Required helpfulness may mean volunteer work in the community, tutoring or buddying at school, or taking care of siblings or otherwise helping at home. These activities seem to lend purpose to the difficult life of an at-risk student and serve to increase their caring about others.” (§ 10)
- One positive adult relationship: “Most resilient at-risk students have had the opportunity to establish a close bond with at least one caregiver who gives them needed attention and support. This support may be from people other than parents, such as siblings, aunts, uncles, or grandparents who become positive role models. Resilient children seem to be adept at finding these substitute caregivers, much as they are adept at eliciting positive responses from many people around them.” (§ 11)
- Family support: “Family support seems to be an attribute of successful at-risk students. Parents of resilient students have higher expectations for their children's education. Such expectations exert pressure on the children to remain engaged in school and work toward high achievement.” (§ 12)
- Teachers: “resilient at-risk students mentioned school staff who had taken a personal interest in them as being important to their success.” (§ 16); “Students feel that they can talk to "good" teachers and counselors about almost anything and that the teacher or counselor will listen without judging the student. These

counselors and teachers "push" the students and at the same time are very supportive.” (§ 16)

- Outside support: “resilient students have a psychological support system that provides a safety net and encouragement. This system is evident in the way students are meaningfully connected to others, in or out of school.” (§ 18)

It should be noted that the majority of participants in this study demonstrated all of the qualities of resilient students listed above.

A research study conducted by Dawn Sutherland (2005) entitled, “Resiliency and collateral learning in science in some students of Cree ancestry,” found that both intrinsic and extrinsic motivation were important contributing factors in the development of Aboriginal student resiliency. Intrinsic motivation included student attendance, being concerned about course work, and being open to challenges while learning. Extrinsic Motivation was primarily in the form of family/friend support: “there are some students in this sample who would not be attending school at all save for the influence of family and friends” (p. 609). Resiliency factors included career awareness, positive peer relationships, and intrinsic and extrinsic motivation, which were all found to be important in enhancing the learning of science for the participants of Sutherland’s study. Though both the design of my research study and participant group were very different from those in Sutherland’s study, there were nonetheless some striking similarities. The participants of my research study had similar intrinsic, extrinsic and resiliency factors in common with the participants of Sutherland’s study. The common characteristics amongst the participants of my study are discussed further in Chapter 5.

Concluding Thoughts

There is a definite need for the current participation rate of Aboriginal students in secondary science to improve. Aboriginal communities require the expertise and knowledge of Aboriginal scientists and healthcare providers. Blankenship (2003) concludes:

If we are going to continue as a culture, we need to get our young people educated in the contemporary world of science and math so they will come back one day and run our forestry, water conservation, and forestry programs. (p. 14)

If participation rates of Aboriginal students in senior secondary science do not improve, the pattern of low enrolment in science-related programs at the post-secondary level will continue, as will the shortage of professionals in these areas. Research in the literature emphasizes the importance of including Aboriginal knowledge in the science curriculum and also changing some of the ways that science is taught to help improve the experiences of Aboriginal students in science courses. Will the addition of the new Aboriginal content learning outcomes in the BC K – 10 science curriculum improve the participation rates of Aboriginal students in the senior secondary sciences? Only time and further research will be able to answer this question.

In the meantime, what can be learned from the small population of Aboriginal students who are successful in the senior secondary hard sciences? These Aboriginal students defy the odds and rise above the challenges that are inherent to contemporary science education. What are the reasons behind their success? What can be learned by

examining what *is* working for Aboriginal in science education in order to facilitate the participation of even more Aboriginal students in the senior secondary sciences? This research study has attempted to answer these questions, the results of which are presented in the chapters that follow.

CHAPTER 3: METHODOLOGY

Design of the Study

Introduction

The purpose of this study was to learn about the perceptions and experiences of Aboriginal students who were successful in the senior-secondary hard sciences. This research project is qualitative in design due to the personal nature and interview-based methods of data collection. Insights gained from this study came from listening to and examining the information and experiences shared by the ten participants. As Creswell explains, “qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them” (1998, p. 15). Other key characteristics that make qualitative inquiry appropriate for this research project is that it is a holistic research method and it is focused on understanding a given social setting, as opposed to making predictions about the setting (Janesick, 1994). In other words, the social phenomenon is already recognized, and in this case, the phenomenon is the academic success of Aboriginal students in senior-level secondary science.

The intention of the study was not to arrive at a conclusion that could be applied to all Aboriginal students who have had this experience. Instead, my intention from the outset of this research study was to work with a small group of participants, listen to their stories, and from the insights gained from these stories, arrive at some common themes

that could be applied to the overall participant group. Creswell describes the result of a qualitative study as being like a narrative, or a story: “we let the voices of our informants speak and carry the story through dialogue” (1998, p. 20).

Case Study

The overall research design that I used in this study was most similar to the case study design. Creswell (1998) states that case study “is an exploration of a ‘bounded system’ or a case (or multiple cases) over time through detailed, in-depth data collection involving multiple sources of information rich in context” (p. 61). There was essentially one case in this study which was represented by ten individuals. The ‘case’ was the successful Aboriginal science student and the case was bounded by the three participant criteria: 1. Each participant self-identified as Aboriginal. 2. Each participant had taken or was taking at least one senior-secondary Physics, Biology or Chemistry course. 3. Each participant was achieving or did achieve at least 67% in this course. The multiple sources of data collection in this study consisted of metaphor interview, literal interview, and focus group.

The context of the study was the school setting – specifically the public secondary school setting in Victoria, BC. Participants came from five different high schools within the Greater Victoria School District. All but one of the interviews was conducted within the high schools that the participants were attending or had graduated from. The interview dates, times, and locations were arranged by Aboriginal staff members at each

school. The Aboriginal staff members also made introductions between the participants and me before the interview began. The interviews were conducted in counseling offices or meeting rooms at each school. The only interview not conducted within the school setting was held instead at a meeting room at the Victoria Native Friendship Centre. This participant had already graduated and she said that it was more convenient for her to meet with me at the VNFC rather than at her previous high school. All of the interviews were scheduled during school hours and took between one and one and-a-half hours to complete. The focus group meeting was held in the Aboriginal classroom at Victoria High School. It was important that the context of the interviews be the school setting as the main focus of the interviews was related to the participants' school-science educational experiences. I also wanted the participants to feel comfortable during the individual interviews by using a familiar setting.

Strategies of Inquiry

In reference to his own research, Wilson (2008) explained:

As qualitative research by its definition has no single focus, it may be appropriate to change the traditional positivistic language of 'research methods' to look more at 'strategies of inquiry' By using the term 'strategies of inquiry,' I am implying that one specific research method would not fit the subject being studied. Instead of writing down one (or several) chosen methods and planning to stick to them, I developed

a general strategy of where I wanted to go. This strategy needed to allow for change and adaptation along the way. (p. 40)

My own research unfolded in a way very similar to what Wilson has described in the above quote. I too had an end goal in mind when I started my research: to learn about the experiences and perceptions of Aboriginal students who were successful in the senior-secondary hard sciences. I based my inquiry into this topic by focusing on three research questions:

1. What are the experiences and perceptions of Aboriginal students with regard to senior secondary science?
2. What role, if any, does culture play for Aboriginal students who are successful in the senior secondary sciences?
3. What are the factors that either contribute to or hinder success by Aboriginal students in science-related courses?

In order to explore these questions, I needed to use suitable strategies of inquiry, or qualitative research methods. As such, I decided to use the following three research methods: metaphor interview, literal interview, and focus group. An overview of each of these strategies as they apply to this study and my reasons for using them is presented below.

Metaphor Interview

According to the Random House College Dictionary, “metaphor is defined as ‘the application of a word or phrase (or symbol) to an object or concept that it does not

literally denote, in order to suggest comparison with another object or concept” (as cited in Cajete, 1999, p. 162). Similarly, Ogden and Richards define metaphor as “a primitive abstraction. It involves referring to a set of concrete relationships in one situation for the purpose of facilitating the recognition of an analogous set of relations in another situation” (as cited in Beck, 1978, p. 83). Metaphoric thought processes are believed to be a common mechanism in how people think, as explained by Aubusson, Harrison and Ritchie (2006): “metaphor is not merely a linguistic phenomenon. It is also a fundamental principle of thought and action” (p. 1). According to Cajete (2000), “it may be said that we all use the metaphoric mind to describe, imagine, and create from the animate world with which we constantly participate” (p. 27). Similarly, Lakoff and Johnson (2003) state:

Our conceptual system ... plays a central role in defining our everyday realities. If we are right in suggesting that our conceptual system is largely metaphorical, then the way we think, what we experience and what we do every day is very much a matter of metaphor. (p. 3)

I used metaphor interview as a strategy of inquiry in this study because I wanted to learn about the perceptions that the participants had about ‘science,’ which meant that I needed to use a research method that would allow me to get closer to the intuitive core of their understanding. Beck (1978) explains:

Metaphors mediate between our abstract and our more concrete thoughts. A metaphor points to the existence of a given set of abstract relationships hidden within some immediately graspable image. By doing so, it helps

to ground our conceptual structures in the reality of concrete experience. (p. 84)

Metaphors also allowed participants to describe complex perceptions in a more accessible way. “Metaphors carry our understanding across the boundaries of verbal thought” (Beck, 1978, p. 88). Cajete (1999) states, “not all thoughts lend themselves easily to verbalization Visual thinking usually precedes verbal thinking and verbalization in the creative process. In a sense, verbal thinking serves to explain visual thinking” (p. 67). Furthermore, Cajete (1999) argues that, “the strategic use of metaphor is essential in that it provides a ‘connective bridge’ between the imagination and fantasy faculty of the right brain on the one hand, and concept and reason faculty of the left brain on the other” (p. 163).

The way that the metaphor questions were designed in this study always started with the visualization component followed by the verbalization component, or explanation. More specifically, participants were first asked to generate or choose from metaphors provided to answer a question, and each response was then followed by the question “why?” to extend upon the participant’s reasoning behind their metaphor choices. Cajete (1999) explains:

Visualization in science may consist of a kind of weaving of intuition, observations and concepts in the mind’s eye. To use an artistic analogy, this process may begin with a visual rough sketch of the area of concern, followed by a play with composition. Applying tools of thought, which have been learned in order to fill in details, further define forms, colors

and texture. Visualization allows you to place the problem in context before you so you can look at it, study its nature. (p. 67)

As Aubusson et al. (2006) explain, “in metaphor and analogy, a familiar entity is used to provide information about, interpret or communicate ideas about a less well known entity” (p. 4). In the case of this research study, the familiar entity was the participants’ metaphor selections, and these were explained in relation to the lesser-known entity, namely their thoughts and perceptions about science.

Thomas (2006) explains why metaphor is good technique to use in research with students: “language is metaphorically structured, then by examining students’ metaphors for learning and their roles as learners we might be given a window into their culture in relation to teaching and learning” (p. 108). Similarly, Snively (1987) found:

In addition to probing for beliefs, the metaphor interviews probed what the students think is desirable and how they felt. The metaphor interview did more than probe for single beliefs and or single values or single emotions. By asking the students to project responses onto metaphors in an imaginative way, the students were less likely to be consciously aware of the beliefs and values that they were communicating. The metaphor interviews allowed the study of how, in most situations, a complex cluster of beliefs, values and feelings influenced the students’ response. (p. 443)

Each individual interview in this study began with the metaphor interview component as a means of exploring the essence of what each participant thought about science.

Metaphors allowed the participants to express complex thoughts in an accessible way. The metaphors provided a visual representation to the participants' perceptions about science, and after they provided or chose a metaphor, they were able to provide verbal explanations for their metaphor choices. The metaphor interview was also a suitable technique to use with youth, the majority of whom were meeting me for the first time. I observed that the metaphor interview was not intimidating for any of the participants – in fact, this method was creative, interactive, and thought-provoking for them. This kind of research was respectful of the participants because it did not “put them on the spot” and it was also consistent with Aboriginal ways of knowing and learning because it was hands-on, creative, individualistic, and visual.

In addition, the metaphor research method allowed me to address my three research questions in a more inherently indirect and non-leading way. Through the selection and discussion of metaphors, the participants were able to describe in their own words, their thoughts about science, what they liked and disliked about science, and how they would like to see science education changed. They could also describe their role in learning science and share experiences from studying science over the years. The design of the metaphor interview also allowed me to see if or to what extent the participants related to science using Aboriginal frameworks and also to articulate any conflicts they identified between Western and Aboriginal science.

Literal Interview

The metaphor interview was followed by the literal interview, which served to validate the findings in the metaphor interview and also to provide additional background information about the participants with regard to their actual experiences in science courses. The information from the literal interviews was used to help write a profile summary for each participant. Participants were asked questions regarding their interests, goals and their Aboriginal ancestry. They were also asked to share some of their experiences as students, as Aboriginal students, and as Aboriginal science students. Seidman (1998) explains, “telling stories is essentially a meaning-making process. When people tell stories, they select details of their experience from their stream of consciousness” (p. 1). Seidman (1998) also articulates why participant’s stories are valuable in qualitative research: “individual’s consciousness gives access to the most complicated social and educational issues, because social and educational issues are abstractions based on the concrete experience of people” (p. 1). Furthermore, Seidman (1998) states, “the primary way a researcher can investigate an educational organization, institution, or process is through the experience of the individual people” (p. 4). According to Wilson (2008), “interviews are focused discussions that allow the researcher to gather information directly from the point of view expressed by the research subject” (p. 41). Some of the experiences, or stories, that the participants were asked to share in this study included recounting their earliest memories of studying science, times when they felt successful in science and times when they didn’t feel successful in science.

The use of the literal interview allowed for a more concrete exploration of abstract ideas discussed in the metaphor interview. It also allowed me to address important topics that were not a part of the metaphor interview, such as the participants' thoughts about Aboriginal science. I also placed the literal interview after the metaphor interview because I did not want to influence any of the participant's metaphor responses by any ideas raised in the literal interview questions. The literal interview questions were more direct and personal than the metaphor interview questions, so having the metaphor interview first also served as an 'icebreaker' of sorts and allowed for greater rapport and comfort to be established between the participants and me.

Focus Group

At the end of the study, the participants were invited to come together to participate in a focus group discussion. The purpose of using this research method was not necessarily to gain any new information, but more to reaffirm the participant's perspectives shared during the individual interviews by re-asking many of the same overall questions in the focus group as were asked in the individual interviews. This served to validate the findings from the individual interviews. Snively (1990) explains:

[Small group discussions give students] opportunities to identify and articulate their own orientations with others in small-group situations. In this way pupils are encouraged to defend their own ideas, have personal interest in the discussion, and focus on relevant issues. Students need to

know that what they have to say is important, no matter how far the content deviates from the science concepts perceived by the teacher.

This allows opportunities to meet individual student needs and interests, as well as promote feelings of self-worth. (p. 55)

The focus group served not only to validate findings from the individual interviews, but also to help the participants to explore their views in greater depth through group interactions. According to Krueger (1988):

A focus group can be defined as a carefully planned discussion to obtain perceptions on a defined area of interest in a permissive, nonthreatening environment The discussion is relaxed, comfortable, and often enjoyable as participants share their ideas and perceptions. (p. 18)

There are several additional advantages of using focus groups, as described by Krueger (1988):

- “One-to-one interviews do not capture the dynamic nature of group interaction; inhibitions are often relaxed in group situation” (p. 44).
- “The format allows the moderator to probe and the flexibility to explore issues not possible within the more structured questioning sequences typical of questionnaires or surveys” (p. 45).
- “Focus groups can provide speedy results” (p. 45).

Due to the busy schedules of the participants in this study, only half were able to attend the focus group, but the findings of the focus group (discussed in Chapter 5) validated the findings from the individual interviews. There was tremendous consistency between

what the participants said in the focus group compared to what each of them said in their individual interviews. This demonstrated that the participants held strong to their perceptions, and that they did not alter their perceptions even in the group setting.

The focus group also allowed me to share preliminary findings with the participants to ensure that I was on the right track with my analysis and that I could go forward with writing my results. I wanted to confirm that I was representing the participants in an accurate way, and the focus group provided the opportunity for this dialogue to happen. Bringing results back to the participants is also an essential component of Indigenous research, as Linda Smith (1999) explains:

Indigenous methodologies tend to approach cultural protocols, values and behaviours as an integral part of methodology. They are ‘factors’ to be built in to research explicitly, to be thought about reflexively, to be declared openly as part of the research design, to be discussed as part of the final results of a study and to be disseminated back to the people in culturally appropriate ways and in a language that can be understood There are diverse ways of disseminating knowledge and of ensuring that research reaches the people who have helped make it. Two important ways not always addressed by scientific research are to do with ‘reporting back’ to the people and ‘sharing knowledge’. Both ways assume a principle of reciprocity and feedback. (p. 15)

The focus group helped to validate my analysis and gave a voice to the participants in their approval of my research results. It also brought closure the research stage of my

study. Most importantly, the focus group felt like a celebration of this inspiring group of participants and served to acknowledge the critical role that each of them played in exploring this important research topic.

Procedures

All of the research in this study was conducted in Victoria, BC. I received my “Human Research Ethics Board Certificate of Approval” on March 13, 2007. My research was conducted in five stages.

Stage 1 – Permission

Before I could begin recruiting participants, I first needed to acquire permission from many different people before I could proceed with my research. I sent consent letters to the chiefs of the two First Nations communities in Victoria – Chief Andy Thomas from the Esquimalt First Nation and Chief Robert Sam from the Songhees First Nation (see Appendix A). It was proper protocol to seek consent from the chiefs as I was conducting research with Aboriginal students on their traditional territories.

Next, I sent a consent letter to Nella Nelson, Coordinator of Aboriginal Education for the Greater Victoria School District (see Appendix B). I then sent two consent forms to each secondary principal in the Greater Victoria School District: the GVSD’s

“Principal Form for Consent” (see Appendix C) and my own principal consent letter (see Appendix D).

Stage 2 – Recruitment

Due to district regulations and ethics considerations, I could not recruit students directly in each of the high schools, so I employed the assistance of the Aboriginal counselors or Aboriginal academic support teachers at each high school. I started by sending each Aboriginal contact an introductory letter to give them an overview of my research study and their role in the recruitment of participants (see Appendix E). Once they confirmed interest in helping to recruit participants, I gave each Aboriginal school contact a consent form (see Appendix F).

The Aboriginal school contacts then identified participants for the study and gave potential participants the information packages for this research study, including a recruitment poster (see Appendix G), a participant consent form (see Appendix H), and a parental consent form (see Appendix I). Interested participants gave the signed consent forms to the Aboriginal school contacts, who in turn gave the consent forms to me. The Aboriginal school contacts were responsible for setting up the time and location for each of the individual interviews. The involvement of the Aboriginal staff members also brought a sense of community to my research study.

Stage 3 – The Individual Interviews

Interviews were conducted with the first ten eligible participants to volunteer for this research study. Four of the participants were male and six of the participants were female. Eight of the participants were secondary students at the time of their interviews and two were recent secondary graduates. All but one of the interviews was conducted at the high schools where the participants were attending (or had attended). These high schools included Oak Bay, Spectrum, Mount Douglas, Reynolds and Victoria High. One participant, who had already graduated, had her interview conducted in a meeting room at the Victoria Native Friendship Centre. All ten interviews were conducted between March 30th, 2007 and May 31st, 2007.

The interviews were approximately one hour to one-and-a-half hours in length. The metaphor interview was conducted first followed by the literal interview. At the very beginning of the interview, each participant was asked to write down his/her personal definition of ‘science.’

In the metaphor interview, participants were first asked to provide a metaphor of their own to describe science as an animal and then as an object. After every metaphor question, the participants were asked ‘why?’ as to provide insight into their reasoning behind the selection of each metaphor. For the remainder of the metaphor interview, participants were provided with sets of metaphor options and asked to select metaphors that they felt represented ‘science,’ their experiences in science classes, the way that they thought science was taught, and lastly, the way they would change the way that science is taught if possible. (See Appendix J for the entire list of Metaphor Interview questions).

Each metaphor option was typed on a single, white index card. For example, in one question, participants were presented with three sets of metaphors, with each set having five options, and they were asked to select one metaphor from each set to represent 'science.' The metaphor options presented in set number 1 included *a car, a totem pole, a circle, a tree, and a drum*. Each set contained at least one strongly-themed Aboriginal option to see if the participants related to science using any of these metaphors. Overall, the participants said that they enjoyed the metaphor interview process as it was a creative, non-intimidating way to begin the individual interviews.

The second half of the individual interview consisted of the literal interview in which participants were asked to answer a set of straight-forward questions (see Appendix K). Questions were asked in order of the following overall themes: 1. Background. 2. Interests, work, goals. 3. Aboriginal ancestry. 4. Experiences in school. 5. Thoughts about science. 6. Experiences in science. 7. Achievement. 8. Experiences as an Aboriginal science student.

Stage 4 - The Focus Group

The focus group was held at the end of June, 2007, when the students had finished regular classes and exams for the year. This meeting was held in the Aboriginal classroom at Victoria High School at lunch time. The meeting started with a pizza lunch and informal conversation. The desks were arranged in a circle and then the focus group session began, consisting of questions very similar to those asked in the individual

interviews (see Appendix L). The entire meeting, including lunch and the focus group, took approximately two hours.

Stage 5 – The Analysis

When multiple individuals are used, as in this study, Creswell (1998) explains that the analysis of the data using the case study method generally follows the following format:

A typical format is to first provide a detailed description of each case and themes within the case, called a ‘within case analysis,’ followed by a thematic analysis across the cases, called a ‘cross-case analysis,’ as well as assertions or an interpretation of the meaning of the case. In the final interpretative phase, the researcher reports ... the “lessons learned” from the case. (p. 63)

This is the same overall process of analysis that I used in this study. Before the analysis began, the amount of data first had to be reduced. I did this by removing content that was repetitive or that I did not fully understand. Next, I read the reduced transcripts and highlighted quotes that stood out to me. Seidman (1998) explains:

The first step in reducing the text is to read it and mark with brackets the passages that are interesting What is of essential interest is embedded in each research topic will arise from each transcript. The interviewer must affirm his or her ability to recognize it. (p. 100 – 101)

The reduced version of each participant’s interview is included in Chapter 4. The next step, according to Seidman (1998), is to:

Select all the passages that you marked as important and put them together into a single transcript The next step is to read the new version, with a more demanding eye Ask yourself which passages are most compelling, those which you are just not willing to put aside. Underline them. Now you are ready to build a narrative based on them. (p. 103)

At the end of each interview is a summary, or profile, of each participant. The summary gives a synopsis of the participant and highlights any themes or remarkable content from the individual interviews. This is what Cresswell (1998) refers to as a “within case analysis” (p. 63).

Once the ten individual interviews had been reduced and a profile summary written for each participant, the next step was to look for themes across all ten interviews as a whole, referred to as a “cross case analysis” (Cresswell, 1998, p. 63). To do this, Seidman (1998) says that the researcher should, “mark individual passages, group them in categories, and then study the categories for thematic connections within and among them” (p. 102). The cross-case analysis is presented in Chapter 5.

I made every effort to look at the emerging themes as holistically as possible. As Wilson (2008) explains:

Logic needs to become more intuitive as the researcher must look at the entire system of relationships as a whole. To break any piece of the topic away from the rest will destroy the relationships that the piece holds with the rest of the topic. (p. 120)

To group the themes holistically, I used a mind-map process, which showed how all of the themes were essentially connected to the central premise of this study, namely the experiences and perceptions of successful Aboriginal science students regarding science. Three overriding themes emerged from the data as a whole: 1. The Participants. 2. Secondary Science. 3. Participant Recommendations.

Each of these three areas then became the basis of the next set of mind-maps. Associated sub-themes were placed around each of the central themes. For example, the ‘participant’ mind-map consisted of the following sub-themes: 1. Cultural connection. 2. “Success.” 3. School experience. 4. Goals. I then read through the transcripts and added pertinent references next to each sub-theme in the form of codes. My coding method consisted of the first letter of the participant’s name¹, followed by the abbreviation “lit” or “met,” depending on whether or not the quote came from the literal or metaphor interview, and the code ended with the associated page number from the condensed transcript. A few of the participants had names that started with the same letter as another participant, including Abby and Alan and Tara and Tim. To distinguish between them, I would put a male (♂) symbol or a female (♀) symbol beside the initial. For example, the code T♀lit24 meant that the quote came from Tara’s literal interview, page 24.

The “Secondary Science” mind-map consisted of the following sub-themes: 1. Individual views of science. 2. Experience studying science. 3. “Likes” regarding science. 4. “Dislikes” regarding science. 5. Future connections to science.

¹ Pseudonyms are used for each of the participants.

The “Participant Recommendations” mind-map consisted of the following sub-themes: 1. School science. 2. Aboriginal science.

Some of the sub-themes on the three mind-maps were further divided if there was a lot of information in the sub-theme. For example, the sub-theme “Experience studying science” was further divided to include: 1. reasons for taking science. 2. “Success” in science. 3. Not feeling successful in science. 4. Experience as an Aboriginal student. 5. Active/passive role in science.

The process of analysis in this study was not about breaking apart the data, but grouping data into themes that emerged from across the interviews. To use a metaphorical example, the data from this study was like a great, big, complex puzzle – with a multitude of different pieces all jumbled up in a box at the beginning of the analysis process. In order to make sense of the pieces and to see the big picture, I needed to start by grouping the pieces together that were similar. What emerged in the end was an intricately detailed picture of ten incredible Aboriginal science students, rich in insights and perspectives about secondary science.

Validity

I structured the individual interviews by starting with the most open questions and qualitative methods, as to not lead the participant responses in any way. For instance, each individual interview started with each participant writing down his/her personal definition of science. I did this right at the beginning, before any of the questions had

been asked, as not to influence their definitions in any way. I then proceeded with the metaphor interview, which is inherently a much more open method than the literal interview, which came later. In addition, I audio-recorded and transcribed all of the interviews as analyzing the participants' word-for-word responses helped to increase validity and decrease bias. To help eliminate bias and to increase validity in the metaphor interview, I first asked the participants to come up with their own metaphors for science as an animal and as an object. I did this so that I could gauge their perceptions about science without influencing them by any of the metaphor options provided by me in the rest of the metaphor interview.

I also triangulated the data by asking the same overall questions using a variety of different approaches. The approaches that I used included a metaphor interview, a literal interview, and a focus group. In doing so, I hoped to see patterns of repetition in the answers of each participant, thereby increasing the reliability of the participant's answers.

CHAPTER 4: FINDINGS

Introduction

The findings from each of the ten participant interviews have been summarized into separate “cases”. The order of the findings is presented in the same order that they occurred in the interview: 1. The metaphor interview 2. The literal interview. In order to reduce the amount of data, I have removed from each interview redundant statements and also statements from the participants that I didn’t understand or found difficult to interpret. In addition, I looked for consistency between the metaphor and literal interviews while summarizing the findings for each of the cases below. I observed in this set of interviews that both the metaphor and literal interviews were coherent—there was a strong tendency towards the same descriptions, viewpoints, and conclusions. The analysis of the findings is in Chapter 5.

Case # 1 – Fiona

Metaphor Interview: Fiona

When asked to generate her own metaphors for science (an animal and an object), Fiona generated the metaphors “squid” and “mountain,” and gave the following explanations:

Science is like a squid or a jellyfish because they have spawn off, they have lots of arms and science is at the centre, they are multi-limbed.

Science is like a mountain because it is born of the earth. It gets bigger and bigger – part of a cycle trying to move towards a peak of knowledge. It would crumble back or it is continuously being reviewed – a circle kind

of.

When thinking about the word “science”, and asked to respond to metaphors provided,

Fiona chose the following metaphors and gave the following explanations:

A court case. Science is used in court cases – used in court cases against Aboriginal rights and title, such as land claim issues and fishing rights.

A feast or potlatch. Science is being contributed to by many people.

Fiona’s relationship with science was often passive and she sometimes questioned how science is applied:

I would be the passenger and science would be the car. I’m not really involved with science. I don’t really offer much to it. I don’t really like it anymore.

An elder is to a community. An elder arguing not its value, but its accuracy, how it is used.

When asked to respond to the question “How is science taught in schools?” Fiona gave the following metaphor response:

A calculator: I want to choose the more stereotypically mathematical or scientific option just because it’s reinforced so much that ‘this is science, because it’s math.’ A calculator has connotations of plugging in numbers, like trying out different theories and coming up with results and finding which one is the most suitable – and then playing with it to see how it can be applied.

When asked to choose her least favourite metaphor for how science is taught, Fiona responded:

A longhouse – science is definitely not taught as a longhouse, well there is procedure, but not in the sense that it’s part of a tradition or that there are teachings that are viable in life – daily life. And it’s

closed off; it's not open to be really criticized and changed or continuously reviewed to be different.

When asked to select metaphors for how science education could be changed, Fiona responded:

A garden. It would teach that science isn't the only option; we made it what it is, by putting different things in it and sometimes it doesn't work out or looks really bad or something happens to it that ruins it. It's a garden – sure it's beautiful and it offers us something, but sometimes its functions are not as obvious or exaggerated.

A medicine wheel. It would take in components more of a circle – it has different components but they are all kind of equal so you don't really give more weight to one of them.

The Literal Interview: Fiona

At the time of the interview, Fiona was in her first year of university and she had graduated from high school in the previous year. She had always attended school in Victoria. Her educational goals include studying Indigenous Governance and possibly pursuing a degree in Anthropology. She also plans to go to graduate school and possibly study law. During high school, Fiona had planned to become a doctor.

Fiona is half Aboriginal with Coast Salish ancestry from her mother's side and she said it annoys her when people automatically assume that she is Métis. She described her connection to her Aboriginal ancestry as weak, though she felt connected to her Aboriginal ancestry through her university studies, but said that it felt strange to have to go to a school to learn about Aboriginal issues, culture, and history. Fiona described one of her university professors who inspired her, saying he focused on issues “that hit right

at home”, particularly in bringing to her attention how “inaccurately people perceive the Indigenous people of Canada” and the court cases that are happening in BC.

Consequently, Fiona would like to also be able to give something back to the Aboriginal community, which has greatly influenced her post-secondary and career choices.

Fiona believes she has gone far in her education because she has taken on a leadership role in her family:

I feel responsible. I feel a certain level of responsibility for what I do. I feel like I’m a role model. I feel like whatever I do, I have to give back, so there’s a reciprocity there and I try to build relationships with people because I’m one of the first in our family who has actually gone to university.

Fiona described success as “achieving the goal that you set out for yourself and having others realize that you actually did what you set out to do.”

In high school, Fiona felt that she was told to “just to graduate” due to her Aboriginal ancestry, so she said that one of the reasons why she made it so far in school was self-motivation – to show people at her school that she could succeed academically. One of the hardships that Fiona faced in high school as an Aboriginal student was the way that she felt Aboriginal people were represented in school curricula:

Misconceptions are continuously hammered into people - I don’t really mean to bash the curriculum, but it’s not very good and so it’s hard to avoid it when it’s right there in front of you every day in a text book.

There actually have been situations where I've had to just leave the school and go home and have some tears from situations like that.

Fiona continued to say, "everything taught at the high school level seems to be taught from a very European, Western kind of perspective and there's not much [of a different perspective] incorporated in it, at least in B.C., as far as I know."

The significance of science has changed for Fiona:

In high school, I thought science was "it" – science was the absolute bottom line But now I'm changing my perspective. I feel like I'm critiquing it now It's not part of my life anymore. Before I was going to go into science and I was going to do something along those lines, but now I just want to avoid it.

Fiona had planned to study science at the post-secondary level and she hoped to eventually go into medicine, but this changed once she started university. In one of her elective courses at university, Fiona learned about Aboriginal issues for the first time and she aspired to bring change or at least greater attention about these issues to other people.

One of the shortcomings of studying science for Fiona was doing everything in a lab: "you don't really get to go outside and do anything like that. It would be pretty cool to go to a beach and get some kelp or collect something." Fiona says that it would be beneficial to include other perspectives, including local content and also the Aboriginal perspective:

It would be interesting to see different perspectives – like not all science can be the same around the world – even the local perspective: like if

you're teaching in B.C., maybe incorporate ... the trees and plants around you, and any sort of Aboriginal perspective, like in terms of medicines ... you actually feel like you know your environment and you feel like you're part of it. I think it's pretty important for students.

Fiona achieved high B's and A's in her senior-secondary Chemistry and Biology courses, and she attributed her high grades to her original goal of continuing to study science. Fiona felt successful studying science when she was signaled out by her teacher as an acknowledgement of her good grades. She also felt good when grades were posted and other students would wonder who got the top mark, and it was her.

Fiona didn't feel different from other students in terms of being an Aboriginal science student, but she often felt like she was the only Aboriginal student in most of her science classes. She believes that there is an under-representation of Aboriginal students in senior secondary science because, "there's not a lot of encouragement to go into a lot of sciences ... it's kind of contradictory to what you're taught at home, so it's just reinforcing that 'living in two worlds' kind of thing." Fiona believes that Aboriginal people have science, but she says Aboriginal science/knowledge was never included in her science courses at school. Fiona explained that Aboriginal science/knowledge should be included in the school science program because it provides a different perspective and could be beneficial to the environment.

Summary: Fiona

Fiona is a goal-orientated student who takes on a leadership role in her family. Fiona was a successful student in senior high school science and she had planned to study

science at the post-secondary level and go into medicine, but the content of science did not hold her attention over the long term. Words and phrases that Fiona used to describe science included “the scientific method”, “lab work indoors”, “mathematical”, and “a lot of rules”. Fiona selected the ‘calculator’ metaphor to describe how science was taught at school. She often spoke about the rigidity of science curriculum, including how it was taught and what was (or more importantly, what was not) included.

Fiona’s Aboriginal ancestry did not play a significant role in her success in secondary-school science. Once Fiona was introduced to the Aboriginal perspective in her first year of studying university, however, her interests shifted away from science. Fiona identified a rift between Aboriginal knowledge and the Western nature of school science. Of all of the participants, Fiona was the most critical of science. If Fiona could change the way that science is taught, she would include a local, authentic Aboriginal perspective. Fiona expressed that contemporary Western science is often used against Aboriginal people in their fight for rights. Fiona believes that Aboriginal science knowledge should be included in the science classroom because it “provides a different way of seeing things”, and “encourages people to form a relationship with their environment”.

Case # 2 – Abby

Metaphor Interview: Abby

When asked to generate her own metaphor for science, Abby responded,

Science is a monkey. Monkeys are always interested in everything that’s

around them and so they always have to examine things. I just find that science does that too – examines organisms or anything like that.

When thinking about the word “science”, and asked to respond to metaphors provided, Abby chose the following metaphors and gave the following explanations:

Science is a car. There are so many parts in a car just like there are so many parts to science and how you do research and studying – there’s processes just like there is to keep a car running.

Science is a story or a legend: in science, when you find anything new in research it always has a story behind it – how it became what it is today.

Abby’s favourite metaphor for science was ‘a car’: “you need all the parts in the car to keep the car running, just like how you need all the parts of science to complete your research properly.”

The following metaphors look at Abby’s relationship with science. She was asked to complete the statement “I am to science as...” by selecting from different options provided for each question.

I am to science as a passenger is to a car. Whenever I was part of science, I always had a partner and because I’m not familiar with stuff, I usually like to let somebody else take the lead. I’ll just help them out along the way.

A child is to a community. When I’m involved with science, even though I may be part of conducting research, I’m still taking in information and learning at the same time, just like a child is learning.

When asked to select a metaphor for how science is taught in school, Abby responded:

Science is taught like a garden. If the teacher is teaching us about science, then we would have to come up with solutions of how to either fix the problem or for the science to progress, and that’s just like with a garden where you need to water it in order for it to grow.

Abby's own metaphor for how science is taught was 'a court house' and she explained, "there is a judge just like there is a teacher and they're usually in charge of everything."

When asked to select a metaphor for how science education could be changed, Abby selected 'a painting' and offered the following explanation:

Anything a teacher teaches us, it's your own interpretation, just like how a painting is anybody's interpretation instead of it being one thing or the other.

The Literal Interview: Abby

Abby was a first-year college student at the time of the interview and she was taking an Aboriginal program. She had graduated from high school in the previous year. She had lived and attended school in Victoria her whole life. In high school, Abby was involved with basketball and dance. Abby is half Aboriginal with Cree ancestry from her mother's side. She said that she did not know very much about her ancestry or culture and that her only connection to her Aboriginal ancestry was through her mother who told her "a little bit here and there about it."

Abby said that her experience in high school was not easy and there were times when she wanted to quit. Abby's motivation for staying in school was the fact that she would be the first person in her family to graduate:

I know there were times when I just wanted to quit because I absolutely hate homework - I despise homework, but I just kept thinking there's nobody in my family who's graduated and I thought I wanted to be the first one in

my family to do that.

Abby said that what she liked the most about science was, “learning things that you never knew about before.” What she disliked about science were the negative ways that she believes science is used on Aboriginal territories:

I guess [First Nations] bands don't really like anthropologists going into their territory and digging up things. It's kind of invasive and I don't like that, but I'm kind of in the middle because I want to know, but it's invading peoples sacred grounds.

Abby said that she would like to see an Aboriginal perspective included in science education.

Abby's main inspiration to study science at the senior secondary level was to be in the same classes as her friends. As a result, she said, “I went in the class too and actually learned a lot.” Abby completed Biology 11 with a B and Biology 12 with a C. She attributes her high mark in Biology 11 to her teacher:

I think it was the teacher, just the way he was teaching things. I understood it – how he was teaching us and he always gave us these exercise booklets that we could go over and I found it really helpful to study for tests and I think I connected better with that teacher than my grade twelve teacher.

Abby felt like a successful science student because she attended class. She says that being a successful science student means, “attending, listening, being able to not only take in information from teachers but being able to express it in your own way.”

A challenge that Abby experienced while studying science was the Chemistry unit in Biology 12. She said, “I noticed I struggled a lot in that because that’s a part of math and I don’t do well with math.... I just couldn’t follow the formulas. I couldn’t understand it and that’s why I didn’t feel successful.”

Abby said she did not feel any different as an Aboriginal science student and she explained that people often did not know she was Aboriginal due to her mixed ancestry. When asked if Aboriginal people have science, she said “I think in our cultural base” and then she explained what she thinks makes Aboriginal science different:

When it comes to experiments and doing full research, I don’t think Aboriginal people do that, because my understanding is they leave things the way they are – just how they are You don’t need to dissect every little thing in life.

Abby said Aboriginal knowledge was not included in her science courses, but she said it should be because, “I think it gives people more of an awareness of Aboriginal people’s land and all the things that happened before our time. It’s just good knowledge to have.”

Summary: Abby

High school was not easy for Abby and there were times that she wanted to quit, but knowing that she would be the first person in her family to graduate was the main motivation that helped her to reach graduation. Abby was successful in senior secondary science, particularly in Biology 11. Abby perceived science as being complex, as evidenced in her explanation for why she saw science as ‘a story/legend’. She recognizes that there is much more to science than what is immediately seen on the surface,

including the stories behind science. Abby's involvement in science was passive and she saw herself as being involved in science most often as an observer and recorder, but not as a leader. In the metaphor interview, she described her role as being the passenger and in the literal interview, she said she signed up for senior secondary science to follow her friends. She identified the role of the teacher as being very important in learning about science, as she explained after stating that she thought science was taught like a 'court case'.

Abby described her connection to her Aboriginal ancestry as weak. She also explained, "I'm mixed races, so half the time people don't even know I am First Nations." If the way that science is taught could be changed, Abby would like to see more individual interpretation included, as well as an Aboriginal perspective. Abby believes that Aboriginal people have science, but she said Aboriginal science is different because it does not change things or break things down to their smallest components. Abby stated that "most Aboriginal people don't agree with [Western] science." She observed that Aboriginal peoples' lands are sometimes subject to invasion or desecration in the name of science.

Case # 3 – Elaine

Metaphor Interview: Elaine

When asked to generate her own metaphor for science, Elaine generated the metaphor "whale" and gave the following explanation:

Science is a whale. A whale is one of the biggest animals and science, it's a pretty broad topic. It can go into lots of different things and it's versatile. Also it's big but there's lots of little intricate things about a whale as well – same with science, different branches you can go into.

When thinking about the word “science,” and asked to respond to metaphors provided,

Elaine chose the following metaphors and gave the following explanations:

Science is a totem pole. Science has different layers to it – there's different subjects that you can go into and they all have different meanings and people can interpret things in different ways, just like a totem pole.

A pyramid – relating to the chain of life and who's at the top and who's at the bottom and just going up that way – kinda the cycle of life and everything.

In answering the metaphor questions that explored her relationship with science, Elaine described what she considered to be the prescribed and limited curriculum in science:

I would be a passenger and science would be the car. I've encountered science in school and you can't really decide where you want to go with it. It's all taught and you're on a schedule of what you learn so I haven't really had the chance explore my own things that I like to do.

A reader is to a book. I don't really do my own experiments as an author would, so I'm more just following along what other people have done.

When asked to respond to the question, “How is science taught in school?” Elaine gave the following metaphor responses:

Science is taught like a church. You don't have the freedom of learning what you want. They, like the school board, decide the curriculum you have to follow it and it's kind of religious in that way.... It's whatever everyone is being taught. It's all the same.

A longhouse. Even though you don't have the choice of what you're being taught, you can choose to do the course, and choose if you want to stay in or out

of the course and how you work your way within the course, making it more interesting for yourself.

When asked to select metaphors for how science education could be changed, Elaine responded:

A forest. A forest is like a big area and there's lots of little corners and things that you don't normally see or you can go exploring in. There's more room for exploration and finding your own way around.

A sport. There is room to make science more interesting and fun in the way it is being taught so maybe doing more hands-on experiences and things like that.

The Literal Interview: Elaine

Elaine was in the final months of Grade 12 when her interview was conducted. She had always lived and attended school in Victoria. Programs that Elaine was involved with during school included leadership and dance. Elaine is half Aboriginal with Mikmaq ancestry on her father's side. She described her cultural connection as "pretty vague" and she said, "I've never really talked about it with my dad. I've done a little bit of research trying to find out my heritage, but it doesn't really lead me anywhere."

Elaine is considering studying science at the post-secondary level with a focus on sports medicine. Her inspiration to pursue this career came from her passion for dancing. Elaine attributed her own determination and drive as the main reasons why she made it so far in school:

I try hard, I guess I succeed that way, like I want to do well and I want to succeed

in life so I think that there is a drive to just want to do it and it just happens.... not necessarily to prove people wrong, but to prove that I can do it.

Elaine defined success at school as follows:

Everyone is successful in their own way. Some people say like, 'oh I succeeded. I got an A'. Others say, 'I succeeded and I got a B'. Some even say, 'I succeeded and got a C'. It's really for yourself. I don't think you can put it on a scale compared to a generalization; success for yourself, like setting a goal and accomplishing that goal or even making realistic goals.

When asked what she liked about science, Elaine stated, "I'm a curious person and I always like knowing how things work or what's underneath things or how things have been made so that's a big interest for me and I like finding out things like that." One thing that Elaine would like to see changed in how science is taught would be allowing for more freedom: "maybe not having a set curriculum and letting the students choose what they want to go into or even having more projects where they can explore something that they're more interested in."

The most enjoyable experiences in science for Elaine were the hands-on activities, such as the dissections and the field trips. She recollected one field trip where she got to go outside to collect water samples from the ocean. Elaine's inspiration to study science at the senior secondary level came from her active lifestyle: "I wanted to learn more about health and how things work and get put together." Elaine completed Chemistry 11, Biology 11 and Biology 12, and when asked why she thought she did so well in her science courses, Elaine said,

It's not something that I have to do, so when we're getting taught, I'm actually more interested in it and I'm asking questions to learn more, so it's beneficial to me in the sense that I like it and I chose to take the courses.

Elaine considered herself to be a successful science student because she put in the extra time studying, she enjoyed it, and she wanted to learn more.

Elaine said her experience as an Aboriginal science student was the same as everyone else's. She explained, "I've grown up not really with that heritage, so for me, I don't really think about it that way. I don't notice it, so for me, I do feel like any other student and there really isn't a difference." Elaine said that Aboriginal people do have science, and an example she gave was "tales from elders", which she said "have Biology and they relate to nature." She said Aboriginal science/knowledge was not included in her high school science courses, but she said it should be because, "it is an important part of being exposed to new things. I don't think anything should be left out and it's definitely evident in the world, so it should be put into the education system or science in general." She added that science is "a really important part of education and everyone should be exposed to it and maybe for certain people, there might be easier ways for them to relate to science if it was taught differently."

Summary: Elaine

Elaine was successful in senior secondary science and what she learned in Biology was particularly relevant to her goal of pursuing sports medicine. Elaine was

able to connect what she had learned about human anatomy to her passion for dance, which helped to inspire her career choice. A criticism that Elaine expressed about science was what she considered to be the prescribed and restrictive nature of science curriculum, which she felt was in preparation for the provincial exams. She described science as being taught like ‘a church’. If science education could be improved, Elaine said she would like to see more hands-on experiences, flexibility, and individual choice in what students study in science and said that she would like to see science taught more like ‘a forest’ or ‘a sport’. Despite her criticisms, Elaine said that taking science at the senior secondary level is a choice and it is up to students to make their own learning experience more interesting.

Elaine described her connection to her Aboriginal identity as “pretty vague”. Elaine said that Aboriginal people do have science and she gave an example of oral teachings from the elders. Interestingly, Elaine said that Aboriginal students might relate to science better if it was taught differently.

Case #4 – Alan

Metaphor Interview: Alan

When asked to generate his own metaphors for science (an animal and an object), Alan generated the metaphors “primate” and “Rubik’s cube” and gave the following explanations:

Science is primate because the primate is constantly learning new things, becoming smarter and smarter as time goes on.

Science is a Rubik's cube. There are a lot of different ways to do science, but there is always at least one outcome and science is hard.

When thinking about the word "science" and asked to respond to metaphors provided,

Alan chose the following metaphors and gave the following explanations:

Science is a car. Science is always moving forward. Science is also a totem pole because you can always add something new to it.

Science is a puzzle. You're constantly fitting things together, grouping – this piece goes with that piece, like standing stuff together to make one big picture.

Alan described his participation in science as being quite passive, as indicated by his responses to the following metaphor questions:

I would be the passenger and science would be the car. I'm just following it as it goes along.

A child is to a community. A child doesn't exactly help with too much, and in science, I just go with the flow.

When asked to respond to the question "How is science taught in school?" Alan gave the following metaphor response:

A computer. When you first get a computer, most people don't know much about it, like the more you go with it, the more you stay with it, the more you learn about it.

Alan's least favourite metaphor for how science is taught was 'a church' and he explained, "a church is something you believe in and science you have to prove." When asked if the way that science is taught could be changed, Alan selected the metaphor 'calculator' because, "a calculator makes it easier to do math and science could be taught in a more straight-forward way."

The Literal Interview: Alan

Alan was in Grade 11 at the time of the interview and he had attended school in Victoria his whole life. He moved to Victoria from his Aboriginal community when he was just a few months old. Alan was spending a great part of his life playing soccer. He was in the soccer academy at school, and he played for youth and men's teams outside of school. When asked why he thought he made it so far in his education, Alan cited his older sister as the main reason. She was in her third year of a university, studying genetics and math, at the time.

Alan's post-secondary goal is to study science. He plans to become a biochemist or a physicist. The inspiration for this career area came from enjoying science in school. From studying science, Alan said he was "able to take what I learned in any of my classes and use it elsewhere." Alan said he did not face any challenges at school or any difficulties as an Aboriginal student. He considered himself to be a successful student because he was passing and understood everything he was learning.

Alan said his inspiration to study science started in Grade 9 when he found he was enjoying science more than he did in his younger grades. At the senior-secondary level, Alan completed Biology 11, Chemistry 11 and Physics 11 and he had planned to continue studying science in Grade 12. He attributed his high marks in his science classes to studying every night, doing homework, and reading about what he was studying. At times, Alan felt unsuccessful in science when he was "physically and mentally exhausted" by it.

Alan's Aboriginal ancestry is from the Kwakwaka'wakw territory. He felt connected to his Aboriginal ancestry, attending potlatches whenever he could. Alan believes that Aboriginal people have science and he stated "herbs used for health and food" as an example. Aboriginal science/knowledge was not included in Alan's science courses, but he said it should be included in Biology. According to Alan, the value of science for Aboriginal people in general is "some diseases attack different races more and I think by studying ourselves, we can figure out how we can help ourselves" and he cited cancer as an example, saying that cancer is a part of both sides of his family.

Summary: Alan

Alan studied Biology, Chemistry and Physics at the senior-secondary level, though Physics was his favourite area. He particularly liked the math that is associated with Physics and he did well in science because he enjoyed what he was learning. One metaphor that Alan used to describe science was a "Rubik's Cube" because he perceived science as being both fun and challenging. Alan plans to study Biochemistry or Physics in university and a major role model for him was his older sister, who was studying math and science at university. Alan's only criticism of science is the quantity of the course content. Though Alan had lived away from his Aboriginal community since he was an infant, his connection to his culture has remained quite strong as he returns to his community for cultural gatherings whenever possible. But, his cultural connection did not play a significant role in his success in secondary science. Alan believes that Aboriginal knowledge could be incorporated into Biology. Alan stated that the value of

learning about science for Aboriginal people would be in addressing health issues that impact Aboriginal people.

Case #5 – Russell

Metaphor Interview: Russell

The metaphors that Russell generated on his own for ‘science’ included “owl” and “mountain” and he gave the following explanations:

Science is an owl. Owls just seem to be very smart, intelligent.

Science is a mountain. You can find all kinds of science on a mountain. Like earth science, biology, physics. You can find any kind of science on a mountain that you want to find.

When thinking about the word ‘science’ and asked to respond to metaphors provided, Russell chose the following metaphors and offered the following explanations:

Science is a puzzle. You have to look for the things first and then connect them to get the bigger picture.

A pyramid. You have to take into account all of the angles to make sure that it will not crumble or fall. You have to figure out how to make all of the stones go up with quite a bit of ease.

In answering the metaphor questions that looked at Russell’s relationship with science, he selected the most passive of the choices offered:

I would be a passenger and science would be the car. I am just learning right now and when I get more experience, then I will become more like a driver and if I become very experienced, then more like a mechanic.

A reader is to a book. It seems to be the least involved right now and then it

goes to character and then to author.

Russell's least favourite metaphor for how science is taught was 'a church' and he explained, "the church and science don't seem to go together because they would contradict each other too much."

When asked the question, "If the way that science is taught could be changed, which metaphor best describes the way that you would like to see it changed?" Russell responded:

Science could be taught more like a carving. There's more hands on work with it so that people who need to actually do the stuff can learn a lot better with hands-on than just from reading out of a textbook.

The Literal Interview: Russell

Russell moved to Victoria from Alberta when he was in grade 3 or 4 and he had lived and attended school in Victoria since that time. He was in Grade 12 at the time of the interview. Russell's Aboriginal ancestry comes from his father's side and he does not know very much about his ancestry; he said he has no connection to his Aboriginal culture or people. His hobbies and interests are "word-working and martial arts – basically anything where I can use my hands, instead of just reading." Russell's post-secondary goal is to go into an apprenticeship-trades program to become a carpenter so he is "not stuck behind a desk." When asked why he thinks he made it so far in his education, Russell said, "basically, it was my own choice." Russell considered himself to

be a successful student, stating “I’m passing all my classes and I do what I like to do for some classes.”

The most interesting topic in science for Russell was Biology – “The way that the human body works or how animals’ bodies work.” Russell completed Biology 11 and 12 and he said he took these courses instead of other science courses because they required less math and they were more hands-on than other science courses.

Russell did not feel any different from other students as an Aboriginal science student. Russell agreed that Aboriginal people have science, but he could not give any examples. He said Aboriginal knowledge was never included in his science courses, and when asked if it should be, he answered “maybe.”

Summary: Russell

Russell is a hands-on, visual learner, which is the main reason why he is pursuing carpentry as a career. Russell’s relationship with science was passive and if science could be improved, Russell would like to see it become more experiential and visual, as evidenced when he said that he would like to see science taught more like ‘a carving’. A theme that is apparent in the metaphor interview is that Russell likes seeing the “big picture” when learning about science. He described science as being like ‘a mountain’ and like ‘a puzzle’. Russell did well in science because he was inquisitive. Russell’s connection to his Aboriginal culture is very weak and his ancestry did not play any role in his success in science. Though he agreed that Aboriginal people have science, Russell was not able to give any examples of Aboriginal science and he was the only participant

who responded “maybe” when asked if Aboriginal knowledge should be included in science education.

Case # 6 – Tim

Metaphor Interview: Tim

When asked to generate his own metaphors for science (an animal and an object), Tim generated the metaphors “lion” and “home” and gave the following explanations:

Science is a lion. It kind of came with everything; science is really powerful to humanity and lions are the king of the jungle.

Science is a home. I feel comfortable in science; I just never felt puzzled by science.

When thinking about the word “science” and asked to respond to the metaphors provided,

Tim chose the following metaphors and gave the following explanations:

Science is a circle. It seems like the stuff you learn is always kind of relevant to stuff you’ve learned before. It keeps like going back and forth. [For example] what you learn in Grade 8 science, you still have to keep going back to in Grade 12 chemistry and if you don’t pay attention in those [earlier] courses, Grade 12 chemistry becomes a lot harder.

Science is a medicine wheel. Medicine wheels helps people and science helps people a lot.

When asked to select his least favourite metaphor to describe science, Tim selected “story or legend,” explaining, “legends seem kind of like fantasies and science is all facts, unlike legends.”

When responding to the metaphor questions that explored his relationship with science, Tim selected the most passive of the options provided:

I would be a passenger and science would be the car. I've kind of been like an audience of science right now. I haven't done much in science. I've learned it. I haven't really taken control of science or made science.

An inmate is to a prison. A guard and warden seem like to have lots of control over the prison and I don't feel like I have much control over science.

When asked to select metaphors that represent how science is taught in school, Tim chose the following metaphors and offered the following explanations:

Science is taught like a garden. It takes a lot of care and just paying a lot of attention to the garden to keep it running, looking good and you have to really focus in science.

A longhouse. There is lots of giving and sharing in the longhouse. That's how science is taught- a teacher sharing knowledge to all the students.... one wise person sharing with everyone else.

When asked to select a metaphor to describe how he would change the way that science is taught, Tim selected the metaphor "a painting" and explained, "it's creative and it seems like a lot of science classes are just reading and remembering. Painting takes a lot of creativity and it would be more fun to learn."

The Literal Interview: Tim

Tim was in Grade 12 at the time of the interview. He lived in Victoria and attended school in Victoria his whole life. Lacrosse and hockey were a big part of his life when he was younger. Tim didn't have any specific post-secondary plans, though he was

considering becoming a science teacher. When asked why he thought he made it so far in his education, Tim said it was because he had “a natural aptitude for science and math”. In Grade 12, Tim started to feel like a successful student because he tried to study more and get good grades. He described himself as “an under-achiever” until Grade 11.

The aspect of science that Tim liked the most was doing experiments and he also liked his teacher because he “made things more relevant to kids, so science seemed to come easier.” A positive science experience for Tim was getting a good report card, which he described as being very rewarding: “you feel like you have done your work and earned it.” Tim’s inspiration to take Chemistry and Physics at the senior secondary level was to keep his options open after he graduates. Tim completed Chemistry 11 and Physics 11 and Chemistry 12. Tim said he felt successful in Chemistry because he had learned a lot.

Tim’s Aboriginal ancestry is Coast Salish, but he only felt “a little bit connected” to his culture or people. Tim said that Aboriginal people have science “traditionally, but not a lot in the present.” He said Aboriginal knowledge was not included in his science courses, but he thought “there could be room to include it in science”. Tim said that most students would respond to Aboriginal science, except for “narrow-minded students.” Tim said science is “undervalued in most [Aboriginal] communities.” Tim believes it’s important for Aboriginal people to learn about science “if they can because knowledge of science could help the communities.”

Summary: Tim

At the senior secondary level, Tim completed courses in Physics and Chemistry and he said that he did very well in these courses due to his natural ability and because he worked hard in science. Tim was the only participant who was considering becoming a science teacher as one of his possible career options. Tim had a very positive opinion of science, saying that he felt “comfortable in science,” “science helps people,” and “you have to give for science to give back to you.” Some of the metaphors that Tim used to describe science included ‘a home’, ‘a medicine wheel’, and ‘a garden’. Tim enjoyed the experiments in science and he recognized that what he is currently learning in science is built upon what he had learned in previous courses. If science education could be changed, Tim would like to see it become more creative and fun to learn, rather the “reading and remembering” that he associates with science.

Tim described his connection to his Aboriginal culture as being quite minimal. Tim believes that traditional Aboriginal knowledge could and should be incorporated into science education, but there would be some “narrow-minded students” who would not be interested in it.

*Case #7 – Tara**Metaphor Interview: Tara*

When asked to generate her own metaphors for science (an animal and an object), Tara generated the metaphors “bear” and “bike” and gave the following explanations:

Science is a bear. Science is very tough and a bear is very tough. It’s kind of

hard to get past science but once you get started, you can do it and finish it. You can get past the bear after awhile, too, once you stop being afraid of it, you can just walk by it.

Science is a bike. Once you start to get rolling on it, you can finish it. Like once you start learning how to ride a bike, you don't know how at the beginning and you're scared, then you start riding it and it gets easier. If you try your hardest at science, you could just roll through it and finish.

When thinking about the word "science" and asked to respond to metaphors provided,

Tara chose the following metaphors and gave the following explanations:

Science is a tree. They both have layers, like science has layers of different things, like Biology and it goes up and a tree has many different layers too. They both branch out. Also because of how many different things there are to do in science.

A pyramid. There's building blocks with science, like you have to get one whole thing done, then it all builds up to one little tiny thing at the end. Science is also like a forest because there is so much of it.

Tara's least favourite metaphor for science was 'a court case' and she explained:

It makes it seem like it's something bad. Science is really, really, really tough to get through, but really, it's a good thing to do and once you get started and you keep doing your work, you'll get through it.

Tara was then asked questions that explored her relationship or experience with science.

She selected the following metaphors to complete the statement, "I am to science as a...":

A reader is to a book. Science needs someone to be there, to keep it going, and if somebody doesn't read a book, it's not going to do very well, so I think, I was in science so it could stay there and it is fun and when you get a book, you want to read it for fun.

A guard is to a prison. I'm like a guard because I didn't get into everything. I sometimes just stand on the outside and watch what they were doing. I wouldn't

get into the conversations and stuff like that.

Tara was asked to select from metaphors provided that described how she thought science is taught in school. She chose the following metaphors and offered the following explanations:

Science is taught like a car and a forest. The teacher speeds right through it and they teach you a whole bunch of stuff, so that would be the car, like a whole whack of things and they try to get it done in six months or whatever and it seems like a lot of information in that time period. A forest because it's so big and there's so much information that you have to learn about and you just cram it all in and sometimes it's hard to remember it.

A prison. There are hard guidelines you have to follow and you can't step out of them, or else you will get behind or you'll be doing the wrong thing and you just need to follow in line what everyone else is doing

A painting. It can get creative, but at the same time, you have to follow what you're doing and in painting, you have to get creative but follow your outline.

Tara's favourite metaphor for how science is taught was 'a car' because, "you have to get through it all so fast. They are both on a set goal, like if you're driving a car, you're trying to get somewhere. When you're in science, you're trying to get to the end and do your exams." When asked to generate her own metaphor for how science is taught, Tara said science is taught like "a race" and she explained, "to see who finishes and see who does the best and your teacher tries to teach you everything, but then only a certain few remember how to do it and they will try to race to the end and finish." Tara was asked to select a metaphor to represent a change that she would like to see in how science is taught, and she selected "a garden" and she gave the following explanation:

There are many flowers and many fruits in a garden and there could be more

of each thing in each science course. Science could be like in Grade 8 where you can learn little bits of everything instead of just one set subject.

The Literal Interview: Tara

Tara was in Grade 12 at the time of the interview. She had only attended school in Victoria for one semester prior to graduating. Previously, Tara went to school in Nanaimo, where she had also grown up. Tara said that she also spent some time in her Aboriginal community on the west coast of Vancouver Island. In her younger grades, Tara was a part of the jazz band and she was on the basketball team. Tara plans to take the First Nations Family Support program at Camosun College. She said she would like to become a counselor, or something in a related field, because she feels “like I’ve been through a lot to know how to help people and I’ve been through it, so maybe I can help them through it.” Tara said that she does not feel very connected to her Aboriginal culture, stating, “I feel out of the loop most of the time.” But, she said that she felt knowledgeable about Aboriginal people from taking BC First Nations Studies 12 in high school.

Tara cited her older sister, who was the first person in her family to graduate, as being the main reason why she made it so far in her education: “I wanted to push myself to be the second, to make my parents proud. To see my sister get through it made me feel like I could do it too.” Tara also felt motivated by her mother while going to school: “she always tells me when I’m having a hard time with school, ‘you can get through it. You

can do anything you need to do.” Tara felt like a successful student, and when asked what being successful means to her, she said:

To be able to get through it, even if you’re behind in grades, you’re still successful because you’re still doing it and you’re pushing yourself to strive for the best. Just as long as you’re here and trying to do it, you’re being successful.

When asked what she liked the most about science, Tara replied, “I like how there’s so many experiments and it’s challenging. In the end, you feel like you gave your best. You feel happy that you found the answer to what you were doing. It gives you a sense of pride.” Tara described what she disliked the most about science: “how many words you have to memorize for one certain chapter – there’s a lot of vocabulary.” Tara had a few suggestions when asked how she would like to see science education changed:

More hands-on things instead of just reading from a book and writing notes all the time and looking at pictures. Bring in things. There are experiments, but not as many as there could be. There are a lot of experiments and labs in the book, but they usually just skip over most of them.

When asked if there were any topics that she would like to see included in science education, Tara referred to a guest speaker who came into her BC First Nations Studies 12 class: “she was talking about the First Nations medicines and the way First Nations sciences could be incorporated – that would be kind of cool.”

Tara said she did not acquire any overall skills from science that she could use elsewhere in her life. She does not plan to study the sciences after graduating, saying, “it’s just not something I think I will use in my future. It’s just something you have to do to get through school.”

The most interesting topics in science for Tara were from Biology and Chemistry: “I liked learning about plants and animals and how the body works. I liked chemistry too because I liked the math part of it and making the equations all balance.” One difficulty that Tara faced while learning science was memorizing the photosynthesis cycle, which she said was “hard to remember.” When asked what her inspiration was to take Biology in grade 11 and 12, she said, “I really wanted to just so I could say I did and be proud rather than, ‘I dropped my sciences because I didn’t want to do them anymore.’” Tara achieved B’s in Biology and she considered herself to be a successful science student, explaining, “I put myself in it and pushed myself through and finished it up.” Tara said she did not ever feel unsuccessful in science because, “I was always there. I did not, not attend class. I went there and did it all – did my homework – I think doing that is pretty successful.” Tara described feeling successful studying science when she got her report card: “in the end, you feel like, ‘yeah! I finished it! I did it and got really good marks,’ I felt pretty proud of myself.”

Tara did not feel any different as an Aboriginal science student and she said that her experience in science was the same as everyone else’s. Tara said that Aboriginal people do have science and when asked for examples, she said, “they came up with ways to perform experiments to get what they wanted. They have their own medicines and

they test them and figure out which works and not.” Tara said Aboriginal knowledge was not included in any of her sciences courses, but she said that it should be: “it would be a good way to learn things, especially for Aboriginal students, they’d get more into it, instead of thinking, ‘oh, this is boring’ and they’d maybe want to explore more sciences if they were learning about their own people.” When asked what she thought the value of science is for Aboriginal people in general, Tara replied, “I don’t think most of them care about it because they have their own ways of doing things. We’re trying to push stuff on them and they just like their way of trying to do things.”

Summary: Tara

Tara was the only participant who had not lived in Victoria for most of her life. Tara had only lived and attended school in Victoria for one semester before graduating. Previous to that, Tara had primarily lived in Nanaimo, though she had also spent some time in her Aboriginal community on Vancouver Island’s west coast. Despite this, Tara said that she did not feel very connected to her Aboriginal ancestry.

Tara described how intimidating she initially perceived science to be, and the incredible sense of pride that she felt when she completed her science courses. Tara had strong internal motivation to do well in science and she was motivated to graduate by her older sister, who was the first person in her family to graduate. She described science as being like ‘a bear’. A major criticism that Tara expressed about science was the vast amount of content that was covered over a limited amount of time and she said that science is taught like ‘a car’. If science education could be improved, Tara would like to

see additional hands-on activities and greater variety in content at the senior secondary level, instead of having to take courses that focus solely on one branch of science.

Tara said that Aboriginal people have science and that they performed their own experiments. Tara believes that including Aboriginal knowledge in science courses would make science more relevant and interesting for Aboriginal students. Tara explained that Aboriginal people have their own science and that the contemporary education system pushes Western science on Aboriginal students.

Case # 8 – Maya

Metaphor Interview: Maya

When asked to generate her own metaphor for science, Maya said science is “an owl” because, “owls seem knowledgeable and they always seem to be paying attention to what’s going on - curious. We have to observe in science.”

When thinking about the word “science” and asked to respond to metaphors provided, Maya chose the following metaphors and gave the following explanations:

Science is a circle. There are different aspects of science, but they’re all basically related to each other. I think there’s a lot of things that can fit in a circle too, other than science.

Science is a puzzle. There are different parts that make science whole and they both take awhile to figure out.

A forest. You have to figure out where you’re going, what you’re looking at. There’re both really into nature and the natural environment.

Maya's least favourite metaphor for science was 'a song or dance' and she explained, "it just doesn't seem right to me. Science doesn't go with intuition; it's like proving things rather than just enjoyment. They just seem really different."

Maya was asked to generate her own metaphor for science, and she said science is "an ecosystem" because "everything is related to each other: Biology ... Chemistry and Physics."

Maya's responses to the metaphor questions that explored her relationship with science indicate that she does not feel like she is control of what she is learning in science:

I would be a passenger and science would be the car. I feel like I don't really figure things out for myself. I'm kind of told them and then tested on them rather than figuring it out myself or directing my studies.

A guard is to a prison. I don't feel like I'm in the prison of science, but I don't feel like I'm in complete control of it, so the in-between one seems more natural.

Maya was then asked to select metaphors that represent how she thinks science is taught. She often described the way that science is taught as being repetitive, mechanical and uncreative:

Science is taught like a car. It's mechanical and the same all the time. In the younger grades, I felt like there was more variety, but now [in high school] it just seems to be repetitive.

A calculator. Similar to the car – science is mechanical, not much creativity involved.

When asked to select her least favourite metaphor for how science is taught, Maya selected “a painting” because a painting is “so much more creative, and it’s not as structured. There’s no right or wrong.”

If the way that science education could be changed, Maya selected “a painting” and “a boat” and gave the following explanations:

Science could be taught more like a painting. You would have more creativity involved and you could specifically focus on things you are interested in.

A boat. I think it’s similar to a car because you’re going somewhere, but at the same time you’re kind of drifting around and you can go in different avenues and tangents.

The Literal Interview: Maya

Maya was in Grade 12 at the time of the interview and she had lived and attended school in Victoria her whole life, except for three times when she was a child and lived with her family at different international locations for brief periods of time. During school, Maya had been on the swim team, basketball team and she was also a peer counsellor. When asked why she felt she had made it so far in school, Maya said that her main motivation was internal: “I don’t think it seems right to work hard for something for someone else.... I feel like I needed to do it for me. So, I think it’s internal more than external.” Maya is undecided about what she would like to do for a career, but she is considering nutrition, social work or photography. Maya’s grandmother was Cree and her mother did not discover her Aboriginal ancestry until she was in her 30’s. Maya said she has learned a lot about her culture though her mother.

Maya had some suggestions regarding how she would like to see how science is taught in school changed:

I think a lot of the teachers, especially in grade 12, really seem to go by the curriculum and it all seems like a big lead up to the provincial exams. I think we could do different things and learn in different ways because everyone learns differently.

Maya would like to see more individuality while learning and more group-work included in secondary science, and less note-taking and tests:

I really like it when we do individual things where you learn by yourself or in groups and then present it to the class because it switches it up and it also builds presentation skills that I think are lacking for me personally. We did a little bit of that in grade 11 where we would present current things in science, but in grade 12, it's completely 'take these notes' then next week it's a test.

A difficulty that Maya experienced while studying science in school was when she took Physics 12. She ended up dropping this course because she was getting a lower percentage than she wanted on her transcript, which she said may have adversely affected her university applications. She explained the circumstances of her decision to withdraw from Physics 12:

I had a really good teacher in Grade 11 but in Grade 12, the teacher had this technique where he would just do one big question in class and go over like a hundred different steps and then, after a couple weeks, he'd hand you a test

and it wasn't the right learning style for me at all.

Before dropping Physics 12 Maya said, "I kept thinking 'I'll just work harder, I'll do better' and it never really happened....So, I just wasn't successful."

At the senior secondary level, Maya completed Biology 11, Physics 11, and Biology 12, earning A's in all of them. She says she took these courses because, "I kind of enjoy using the formulas [in Physics] and Biology, I like to know just the basics of how the body works." Maya gave the example of the kidney: "it would be kind of weird to have a kidney and not know how it works." When asked why she thought she did so well in these courses, Maya said, "I'm good at taking notes and keeping them together, which is really important for science. It doesn't take me a lot of effort to learn courses like that." Maya felt like she was a successful science student, and she explained, "I've learned a lot in science and I'm glad that I'm taking them and the science that I have learned will be helpful in the future." A time when Maya felt particularly successful in science was in Grade 11 when she was able to help her friends: "It was a good feeling to be able to help other people when they didn't understand."

Maya said that her experience as an Aboriginal science student was "pretty much the same I think a lot of people don't see me as Aboriginal, but that's part of my identity." Maya believes that Aboriginal people do have science and she said, "it's a different kind of knowledge. I think it would be pretty cool if that was involved in science courses." Maya said Aboriginal knowledge was not included in her science courses, but she would like to see it included. When asked what the value of science is for Aboriginal people in general, Maya responded, "I think knowledge is power and

science is a good thing to have – [for Aboriginal people] to be able to make changes in their world that need to happen.”

Summary: Maya

Maya earned A's her senior-secondary science courses and she said that keeping her marks high was important because she wanted to have a strong university application. Though she did very well in science, Maya expressed criticisms of high school science education. Maya did not feel like she had a choice about what she learned in science and she described the way that science was taught as being provincial-exam-driven and rote, with lots of note-taking, tests, and limited opportunity for hands-on learning experiences or group work. She said that science was taught like 'a car' and like 'a calculator'. Maya said that science could be improved by incorporating more creativity and allowing for individual choice in what students learn. Maya said that students learn in different ways, but science is taught exactly the same to all students.

Maya's Aboriginal ancestry is from her grandmother. Maya's mother did not discover that they had Aboriginal ancestry until she was an adult. Maya's Aboriginal ancestry is important to her, though she said many people do not necessarily recognize her as being Aboriginal. Maya agreed that Aboriginal people have science and that Aboriginal knowledge should be included in science, but she did not give any examples. Maya stated that "knowledge is power" and the value of science for Aboriginal people is "to be able to make changes in their world that need to happen.”

Case # 9 – Howard

Metaphor Interview: Howard

When asked to generate his own metaphors for science (an animal and an object), Howard generated the metaphors “elephant” and “ocean” and gave the following explanations:

Science is an elephant. Science is big and complex, but it’s interesting and it’s hard to grasp sometimes, but once you do, you feel like you’re on top of the world, like riding on the back of an elephant.

An ocean. It’s huge and it’s deep and it keeps expanding and it can always be added to and taken away from.

When thinking about the word “science” and asked to respond to metaphors provided, Howard chose the following metaphors and gave the following explanations:

Science is a totem pole. Like a totem pole, there are different steps to science and different faces to science like Biology and Chemistry. They’re both really complex in how you learn them and they take a long time to learn.

A story or legend. Science is told to everyone the same.

A forest. Science is growing and the further you go in, the more you learn and the more you look, the more you want to explore.... There’s all kind of mysteries to it like you don’t know what you’re going to find and it’s always changing too.

Howard’s least favourite metaphor for science was ‘a circle’ because “a circle feels limiting, enclosed. It doesn’t have any depth to it.”

The next questions explored Howard’s relationship with science, and his answers indicate that he sees himself as an active part of science:

I would be the driver and science would be the car. When I get older, I want to

travel and explore and find new things. I want to be able to lead my own path through what I learn in science.

A character is to a book. We're all a part of science and we all affect it and it's like we're all playing this little game inside a book that could be science.

A child is to a community. I haven't learned much about science and I still want to learn more. In order to be an elder, I'd have to know quite a bit, and to be a chief I'd have to know a lot more than I do.

Howard was then asked to select metaphors that represent the way that science is taught in school. He often explained that science is taught the same to all students, but students' experiences differ based on what they choose to do with what they learn in science and also to what depth they choose to explore science:

Science is taught like a factory and a boat. Everyone learns the same thing and we're all taught the same, so we all end up with the same base coming out of it. But it's also like a boat because it's like you're on the ocean and you're trying to explore the ocean and you might all see the same thing, but you may come out with different ideas in your head when it's over.

A computer. It's methodic and it's the same to everyone. It's what you get out of what you're taught and how much you care to explore it deeper where you learn more than everyone else, just like how you can look at the surface of a computer and see the same thing as everyone else, but if you look deeper you can find things hidden from others.

Howard's own metaphor for how science is taught was 'a story:' "A story with a lesson at the end – you can read all you want, but what you think about after is what you learn."

Howard was asked to select a metaphor to represent how to change the way that science is taught and he selected "a forest" and offered the following explanation:

Science could be taught more like a forest. This would let us explore what we choose to explore and go as deep as we choose, but that wouldn't work for most

people because they don't want to be there anyway, but then you have the odd few who would go deep into the center.

The Literal Interview: Howard

Howard was in Grade 11 at the time of the interview and he had lived and attended school in Victoria his whole life. Howard's Aboriginal ancestry is Métis "from Ontario. Cree or Iroquois, we're not sure." When asked to describe his connection to his Aboriginal ancestry, Howard replied, "I'd say that I'm fairly connected to it deep within myself. I don't really need to talk about it with anybody else, but I think about it a lot." Howard completed digital imaging photography and entrepreneurship courses at school and as a result, he said "I will know how to support myself with my hobbies." Howard said he would like to become a photographer after he graduates, which was inspired by his experience in school:

I took digital imaging last year and I got attached to it and really liked it because I had a good teacher and he's pretty much taught me everything. It's something I can do and like to do because it gives me time to think about things.

Howard described why he thought he made it so far in his education:

Up until this year, just because I wanted to, but now because I'm so close and I don't really have any reason to drop out when I only have one year left. I know right now I could easily go and support myself, but I want to finish, just in case....I don't like to fail. I don't like to quit.

When asked if he considered himself to be a successful student, Howard was on the fence:

I'm alright. If I tried really hard and I actually put some effort into it, I'm sure I could do pretty good....I know I don't do the best that I can do, but I've lost my motivation to do the best I can do at school, because I've never really had to try very hard at it, so I don't really care about it too much. I haven't done homework for years. I haven't really kept up with it for a long time.

Howard said he liked science because "it gives me the chance to explore things that I otherwise wouldn't get to explore and learn things and sometimes add my opinion to things." What Howard said he disliked about science was "only that it's so set in stone."

Howard said that the skills and knowledge he gained from science education will be useful to him elsewhere:

In the future, when I go traveling, I will be able to recognize what's around me and know how it's going to react. I also learned about the Great Bear Rain Forest and I want to go there. My teacher used to work up there, so that's the most important thing I learned in science is that I might have a chance to go up there.

Howard said he did not consider studying science at the post-secondary level because "it's too expensive" and also that he did not need to: "I'm considering a career that uses Biology – wildlife photography. You don't need university level education for that; you can still learn it from hands-on."

Howard completed Biology 11 and he planned to take Biology 12 the following year. He also tried Physics 11, but dropped it for Biology 11 because Biology “has to do with animals.” Howard earned a B in Biology 11 and when asked why he thought he did so well, he responded, “it interested me, so I tried a bit harder.” A time when Howard felt successful in science was, “when I was one of four people in my Biology class that was actually passing; that was nice and I was at the top.” A time that he didn’t feel successful in science was, “last year, when I did really bad on a test.”

Howard said that his experience as an Aboriginal science student was not any different than other students’. Howard believes that Aboriginal people have science, and he explained:

Well, we knew more about the environment around us. When the Europeans came [Aboriginals] knew about the environment and how to move with it, so there’s obviously science involved with that. You can’t just wonder around in the bush for 3000 years and not have some sort of science.

Howard said that Aboriginal knowledge was not included in his science courses, but he said he would like to see it included: “I think in Biology, including information about the beliefs [of Aboriginals] might be kind of interesting. Most people wouldn’t care, but I’d find that interesting.” When asked what he thinks the value of science is for Aboriginal people in general, Howard replied, “I guess it’s just to be able to understand what’s around you more and understand what’s going on in the world so you can better judge what actions you should make.”

Summary: Howard

Howard has a lot of respect for science, as evidenced in both parts of his interview. Howard saw himself as having an active role in his science classes, but it is interesting that he explained that he would “lead his own path through what I learn in science” *after* he graduates. Howard described science instruction as being the same for all students (like ‘a factory’), but said it is up to the students to individualize what they learn while taking science (like ‘a boat’). Howard did well in science because he had a natural ability, though he admitted that he often lacked motivation to do the homework. However, Howard was goal-orientated and an independent thinker. Howard would like to see the way that science is taught changed to allow students to determine the depth to which they explore their study of science, but he admitted that not all students would have the same level of interest as he did. His response as to whether or not Aboriginal knowledge should be included in science was similar. He said he would find the inclusion of Aboriginal science interesting, but said many other students would be ambivalent.

Howard is Métis and even though he was not sure which area his Aboriginal ancestry came from, he still felt a very deep, internal connection to it. Howard’s response to the question, “Do Aboriginal people have science?” was an adamant ‘yes’ and he said that the value of science for Aboriginal people is being able to make more informed decisions by having greater knowledge.

Case # 10 – Wendy

Metaphor Interview: Wendy

When asked to generate her own metaphors for science (an animal and an object), Wendy generated the metaphors “owl” and “beaker” and gave the following explanations:

Science is an owl. Owls are usually a symbol of wisdom and so science is a way of gathering knowledge and increasing your wisdom about the world and how it works. Often in cartoons, you see owls with the grad hat – it’s just associated with learning and it’s just generally a symbol people use in learning.

Science is a beaker. You fill it up with knowledge, ideas, experiments and different tests and hypotheses and it contains so many different aspects and branches.

When asked to respond to the metaphors provided, Wendy chose the following metaphors to represent ‘science’ and gave the following explanations:

Science is a circle. Everything in our world is connected in a circle so people and our environment and all the chemicals that make us up and how the world interacts with each other – so it’s like a circle. Everything has common elements and it all comes back to each other.

Science is a story or a legend. Science tells a story of the world and how it works and how things function: why plants grow, why things are the way they are.

A feast or a potlatch. There are so many different branches and so many different areas that like some people find interesting. It just covers everything and there’s so many different areas that you can go into, like psychology or medicine – it all involves science.

Wendy’s least favourite metaphor for science was ‘a song or a dance’ and she explained, “it’s like two different aspects of people. One’s more scientific and the other’s the more creative.”

Wendy's relationship with science was passive and she was not very involved with it, as indicated in her responses to the following metaphor questions:

I would be the passenger and science would be the car. I'm just along for the ride and experiencing it and taking from it what I need to and how I think it can apply for the rest of my life.

A reader is to a book. At the high school level, you're just learning all the basics so it can be interesting, but it's not that engaging. I'm not that active in it as far as trying to use it or taking it to the next level and actually seeking outside knowledge out of science.

A child is to a community. It's not something that I am leading in and it's not something that I am extensively knowledgeable in and I wouldn't feel comfortable leading a group or expressing any sort of wisdom. At the moment, I'm still at the very shallow stages of learning about science.

When asked to choose metaphors that represent the way science is taught in school,

Wendy selected the following metaphors and gave the following explanations:

Science is taught like a car. A car because you have a choice of which course you choose and a vehicle has potential to take you somewhere else. It can actually apply somewhere in the rest of your life. It does prepare you for going elsewhere if you want to pursue sciences.

A computer. It's very methodical and straightforward and a lot of science is not really abstract. It's taught, especially at this level, not very in-depth manner, so it's more like computing. It's not creative – it's just sitting there, like when you're sitting in front of a computer, you're just staring at a screen and plugging things in.

A calculator. It's all concrete; it's nothing that really pushes the boundaries of what we know.

Wendy's least favourite metaphors for how science is taught were 'a carving' and 'a painting' and she explained, "I don't really see science as creative so much as just

physical knowledge. With carving and painting, it's about expressing yourself and I don't really see science as a mode to express myself." Wendy's own metaphor for how science is taught was 'a sea' because "there are so many different aspects and elements and there are places that we haven't yet explored and there's just a lot to it."

If the way that science is taught could be changed, Wendy selected the metaphors "sport" and "garden" and gave the following explanations:

Science could be taught more like a sport. This would make it more engaging and more actively involved and not just sitting there in class, like copying the page we are reading out of the textbook. That doesn't really involve students and get them interested. Mostly the way that science is taught doesn't involve people and engage them enough in a way that keeps them interested.

A garden. It's something that works together and is more involved. You have to take care of it, as opposed to a teacher's just reading out of a textbook and not really thinking of creative ways or caring about how the kids are going to absorb this knowledge. It's not getting rid of the curriculum, but actually getting the students engaged and absorbing, like nutrients from the ground, absorbing the nutrients from the science.

The Literal Interview: Wendy

Wendy was in Grade 11 at the time of the interview and she moved to Victoria from Vancouver when she was three. She attended private school until Grade 8 and then she went to public schools for high school. Wendy was taking photography at school and she was part of the debate team. After she graduates, Wendy is considering going to university to study psychology or political sciences. Wendy's interest in psychology came from a psychology course that she took at school. Wendy does not have a definite career goal, but she is considering starting her own business, perhaps a coffee shop that would "contribute to the local economy." Wendy's Aboriginal ancestry is Cherokee but

she says, “I’m not that close with my heritage. I know stuff about it, but I’m not that involved with it.”

When asked why she thinks she has made it this far in her education, Wendy says, “the fact that if I get an education, I will do better and will be able to support myself better and make more money and just generally have a better life if I continue with education.” Wendy considered herself to be a successful student because she was a part of the “Challenge Program” at her school, which she described as, “an enriched learning environment and taking the material that we learn to the next level and not just doing worksheets.” Wendy described success as, “being happy and just being content with what’s going on in my life. Not necessarily material money success, but just at a place where everything is working out.”

When asked what she liked about science, Wendy responded, “the fact that like everyone has some sort of curiosity about the world and how it works and it just sort of explains certain things and certain aspects of what our reality is.” Regarding what she didn’t like about science, Wendy said,

It’s not creative and it’s just so concrete and methodical and I just like things that are more abstract and take a different level of thinking and not just plugging in numbers or memorizing names of different plants and animals.

Just something that takes more of a creative involvement.

If the way that science is taught could be changed, Wendy said, “I don’t know how they could make it better. I guess it more depends on the teacher than the actual system itself.”

Wendy completed Chemistry 11 and she planned to take Biology the following year. Wendy decided to take Chemistry 11 because, “I thought it would be useful, especially if I wanted to pursue anything in psychology. You need either Biology 12 or Chemistry 11 as a prerequisite to any introductory psychology courses in university.” Wendy completed Chemistry 11 with a B, and she says she did better in the second half of the course because there was a different teacher:

We had two different teachers for the semester. The first term teacher was really bad then we got a new teacher who was just a better teacher and a lot more interesting and made the work not as tedious to do.

So the first term I didn't do as well because the teacher ... was using out-dated texts and she didn't have any base in science or chemistry. She was basically a Grade 9 science teacher but the next teacher was actually studying chemistry at UVic and actually knew what she was talking about and could explain things better. In general it was just a better learning environment.

When asked if the teacher can make a difference in how well students do in science, Wendy replied, “definitely.” Wendy considered herself to be a successful science student and said she felt successful in science when she was “getting a decent mark in the class.” Wendy said she did not ever feel unsuccessful in science because “success is relative to what I define it as. I didn't feel unsuccessful in class. I just wasn't very engaged.”

In terms of being an Aboriginal science student, Wendy said her experience studying science was the same as for other students. When asked if Aboriginal people have science, Wendy said, “definitely” and she explained,

Especially with the medicine and just using the natural environment to actually help them[selves]...Nowadays, people definitely abuse the resources we have. They [Aboriginal people] have more the ability to be ‘one with nature’ as opposed to just stripping nature of everything and so they ... respected and utilized their environment in a more productive way. When the white explorers came to North America, the Aboriginal people were the ones with the medical help for them.

Aboriginal knowledge was not included in any of Wendy’s science courses, but she said she would like to see it included, “especially where there’s a lot of Aboriginal students. I don’t know how that would be incorporated, but, I think it’s important somehow. Even if it was extracurricular or something like that, Aboriginal science I guess.” Regarding the value of science to Aboriginal people in general, Wendy responded, “I think everyone has the right to equal opportunity and you know, it just can be useful to anyone non-exclusively.”

Summary: Wendy

Wendy was a strong academic student and member of her school’s Challenge Program. She did well in her courses because she felt that doing well in school would help her to build a stronger future for herself. Wendy had a very holistic view of science,

describing how she saw everything in science connected by common elements - like 'a circle'. However, Wendy did not see herself as being very involved or engaged in science and she had several criticisms about secondary science education. She described science as "methodical," "nothing abstract," "nothing creative" and "concrete" – like 'a calculator' or 'a computer'. She said that changing the way that science is taught is not about changing the curriculum, but about teachers deciding to make what they are teaching more engaging and interesting for the students. Wendy said that science is often taught in a passive way that involves taking a lot of notes from the textbook. Despite her criticisms, Wendy said that taking science has the potential to take students further if they choose to study this area after high school.

Though she described her own connection to her Aboriginal ancestry as weak, Wendy's views about Aboriginal knowledge were very insightful. Wendy agreed that Aboriginal people have science and she described the difference between how Aboriginal people traditionally used the land and how modern society uses the land and resources. Wendy said incorporating Aboriginal knowledge into science education would be beneficial for schools that have lots of Aboriginal students. She also said that science is valuable for everyone.

CHAPTER 5: ANALYSIS OF THE METAPHOR AND LITERAL INTERVIEWS

Introduction

In this chapter, important themes that emerged from across all ten participant interviews are identified. The first section looks at the definition that each participant gave for the word “science,” followed by a section that summarizes the overall themes and exceptional responses from the metaphor and literal interviews as a whole. Lastly, key themes from the group interview are identified.

Personal Definitions of ‘Science’

At the beginning of each interview, the participants were asked to write down a personal definition of ‘science.’ This question was asked at the very beginning of the interview so that the participants’ definitions would not be influenced by any of the questions that followed. Their definitions of ‘science’ were as follows:

Fiona: “Science is a method of understanding and postulating the world. It is a social construction and its theories are not proven.”

Abby: “Science is the study of living and non-living organisms of life.”

Elaine: “The study of humans and animals into great depth exploring all aspects of life and life’s effectors.”

Alan: “Science – the study of all things that make up our world and making the unknown, known.”

Russell: “The discovery of new forces, organs, etc.”

Tim: “The thing that explains everything.”

Tara: “Science: a group process to find a conclusion to a hypothesis.”

Maya: “Science → the study of the world around us and how things interact.”

Howard: “A way to understand the world we live in and easily share this knowledge with others, thus contributing to a greater global knowledge.”

Wendy: “Science: means by which to gather knowledge systematically.”

Discussion: Participant’s Definitions of ‘Science’

The participant’s definitions of ‘science’ were divided into two categories:

1. Definitions that primarily had to do with knowledge or understanding: Fiona, Abby, Tara, Wendy and Richard
2. Definitions that primarily had to do with the world as a whole or interconnections within the world: Elaine, Alan, Tim, Maya and Howard

All of the participants were able to come up with a personal definition of ‘science’ without any difficulty, and as a group, their definitions were thoughtful and perceptive.

Knowledge and holistic interconnections were identified as being key attributes of science. Fiona’s definition was the only one that seemed critical of science in saying that she believes that science is a “social construction.” The definitions did not have any overtly negative connotations, perhaps because all of these participants did well in senior secondary science. A few of the definitions seemed to reflect attributes of Western science with words like “method,” “effectors,” “forces,” “hypothesis,” and

“systematically.” This is not surprising as these students had only ever studied Western science, and yet their perspective of science was overall very open-minded with emphasis on the bigger picture of the world. It would be interesting to compare the definitions of science from this group to those of Aboriginal students in younger grades or to those of Aboriginal students who have an aversion to senior secondary Biology, Chemistry, or Physics courses.

Overall Themes from the Metaphor and Literal Interviews

In reviewing and analyzing the participant’s interviews, some very rich and interesting themes emerged across all ten cases, providing an insightful look into the experiences in senior secondary science of this group of Aboriginal students. The themes have been grouped into three overall sections: the participants, secondary science, and participant recommendations, and each section has been further divided into smaller sub-sections.

The Participants

Before the interview process began, the only attributes that I knew the participants would have in common were those specified in the participant selection criteria: they would all self-identify as Aboriginal, be in grade 11 or 12 or a recent high school

graduate, and have completed a senior secondary Physics, Biology, or Chemistry course with a final mark of 67% or better. Once the study was completed, I found that the participants had many more attributes, experiences, and perceptions in common. I have divided these participant commonalities into four sub-groups: cultural connections, “successes,” school experiences, and goals.

Cultural Connections

One striking similarity is that all ten of the participants were living in Victoria, off-reserve and away from their ancestral Aboriginal communities. Only four of the participants, Alan, Tim, Tara and Fiona, had Aboriginal ancestry from Vancouver Island, though none of the participants had ancestry from the local First Nations communities of Esquimalt or Songhees. Seven of the participants identified as having mixed Aboriginal and non-Aboriginal ancestry: Fiona, Alan, Elaine, Maya, Howard, Wendy and Richard, and of these, five had Aboriginal ancestry from areas outside of BC (Cree, Mikmaq, Cherokee and Cree-Métis) and one did not know where his Aboriginal ancestry came from (Russell). Living off-reserve and away from Aboriginal ancestral communities is common to many Aboriginal students in the Greater Victoria School District and this participant group is representative of the Aboriginal cultural diversity that exists in the large, urban setting of Victoria.

Seven of the participants described their level of cultural connection as being weak. Fiona explained, “my connection is very weak ... I feel rather disconnected, if anything, and feel like I need to figure out how to change that.” Similarly, Elaine

described her cultural connection as “pretty vague” but also expressed an interest in learning more about it:

My dad is First Nations ... I've never really talked about it with my dad.

I've done a little bit of research trying to find out about my heritage, but it doesn't really lead me anywhere, but I have a lot of interest for it.

Abby described having a limited knowledge about her culture, saying, “the only connection that I have is my mom ... I don't know all of my ancestry but my mom tells me a little bit here and there about it.” Russell said that he had no connection with his Aboriginal ancestry, Tim said he felt “a little bit connected,” and Tara said she felt “not very connected” and “out of the loop most of the time.” Wendy said, “I'm not that close with my heritage ... I know stuff about it, but I'm not that involved with it.”

Three participants described having stronger connections to their Aboriginal ancestry. Alan moved to Victoria at the age of three months from his Aboriginal community in Alert Bay, but said he felt connected to his Aboriginal culture because, “I go to a lot of the potlatches. I try to go to as many as I can.” Alan did explain, however, that his involvement in the soccer academy at school and in soccer leagues outside of school prevented him from attending some of the potlatches that he wanted to go to. Maya, whose Cree ancestry comes from her grandmother, said she felt connected to her culture because, “my mom didn't find out that she was Native until she was 30, so she really involved herself [in the culture] a lot ... so I feel like I have learned a lot about it through her.” Howard described his connection to his Métis culture as a feeling within

himself: “I’d say that I’m fairly connected to it deep within myself. I don’t really need to talk about it with anyone else, but I think about it a lot.”

The majority of the participants described weak connections to their Aboriginal culture, and even those who identified as having stronger cultural connections were still quite limited in actual cultural involvement. All of the participants have spent the majority, if not all, of their lives living away from their Aboriginal communities. All of these participants lived primarily in the urban, predominantly non-Aboriginal environment. This could explain, at least in part, why this participant group was able to navigate quite comfortably through a Western-based education system and science education program. It would be interesting to conduct the same study with Aboriginal science students who lived in their Aboriginal communities to see what difference a more entrenched cultural connection would make in their secondary science experience.

The School Experience

In looking at the overall experiences in school for the participants of this study, a few commonalities stood out. It is notable that 9 out of 10 participants described being involved with clubs, sports teams, or extracurricular activities at school. The range of activities that they participated in as a group was expansive, including dance, band, basketball, leadership class, soccer, lacrosse, hockey, swimming, peer counseling, photography, and the debate team. The only participant who said he was not involved in extra-school activities was Russell, although in another part of the interview, he had said he was involved with carpentry and martial arts. Being connected to school through

sports or extracurricular activities seems to be an indicator of overall success at school for this particular group.

Only one participant, Abby, described her overall experience in school as being quite challenging, stating:

It wasn't easy. I know there were times I just wanted to quit cause I absolutely hate homework, ... but I just kept thinking there's nobody in my family who's graduated and I thought I wanted to be the first in my family to do that.

Like Abby, all of the participants could identify factors that helped them to make it to the final stages of their secondary education, which I will discuss later in this chapter.

The majority of the participants said that their overall experience at school as an Aboriginal student was no different than that of other students. But, Tara and Elaine said that difficulties do exist for some Aboriginal students at school. Tara explained, "a lot of people say it can be harder on some [Aboriginal] people; it just depends on who you are and what you do." When I asked Elaine if she had faced any difficulties as an Aboriginal student, she said, "personally, no. But I know other people who have and I try to be supportive, of course, but not personally, no."

Two of the participants said that even though they did not face any significant challenges as Aboriginal students, they did identify specific negative experiences. Fiona described having a very emotional response to the negative way Aboriginal people were sometimes represented in her classes, saying, "there actually have been situations where I've had to just leave the school and go home and have some tears from situations like

that.” Fiona also said that she was told by the Aboriginal counselor at her school “just to graduate,” and Fiona’s internal response to this advice was, “just because I have a certain background doesn’t mean I can’t go further like my [non-Aboriginal] friends are doing ...I’m getting good grades, I’m going to university. ... It was kinda self-motivat[ing], like show them that I can do it.” In addition, Fiona said that she felt like one of the only Aboriginal students in her school. Another participant, Maya, said that she did not experience any major difficulties as an Aboriginal student, but “sometimes people have rude jokes and it’s uncomfortable, but it’s not that often.” Later in the interview, Maya said, “I don’t think a lot of people see me as Aboriginal, but that’s part of my identity.”

Observations about Teaching: Effective and Ineffective Teaching Strategies

Though I did not specifically ask the participants what makes an effective or ineffective teacher, several of the participants shared their observations about their teachers during the literal interview. Both Fiona and Howard said that their most memorable teachers or professors made course content relevant to their lives. Fiona, who was in first year university at the time of her interview, said that one of her professors “really influenced me in the subject matter that he taught which focused on issues that hit right at home.” Specifically, Fiona said, “he really brought to my attention just how much or how inaccurate people perceive the Indigenous people of Canada.” This professor has had a major influence on how Fiona saw her future, which was made very clear when she said, “he brought a lot to my attention and I feel like I do want to give something back to my community.” Similarly, when I asked Howard why he

wanted to become a photographer as his career choice, he explained, “I took digital imaging last year and I kind of really got attached to it and really liked it because I had a really good teacher and I have him again this year and he’s pretty much so taught me everything.”

When I asked Alan what helped motivate him at school, he said that the attentiveness of his teachers was an important part: “it’s just the way that they help. They’ll actually sit down with me if I’m having trouble and tell me what I’m doing wrong, then I will get what I’m doing wrong.”

Fiona and Abby said that feeling a connection with a teacher is also important. When I asked Fiona what she liked the most about taking science in high school, she said:

I had a really awesome teacher! That makes a really big difference. Actually it was with the one prof I had in grade 11 and 12 – I actually built a relationship with him and I talked to him about whatever situation was going on with me and my daily life.

Abby said that she did better in Biology 11, earning a B, than she did in Biology 12, where she finished with a C, because of her grade 11 teacher:

I think it was the teacher – just the way he was teaching things. I understood it – how he was teaching us and he always gave us these exercise booklets that we could go over and I found it really helpful to study for tests ... and I think I connected better with that teacher than my grade 12 teacher.

Similar to Abby's experience, Wendy said described how the teaching styles of two different teachers in her Chemistry 11 class impacted how well she was doing in the course:

We had two different teachers for the semester. The first term teacher was really bad then we got a new teacher who was just a better teacher and a lot more interesting and made the work, it was just not as tedious to do. So the first term I didn't do as well just cause the teacher like, her teaching style, she was using out-dated texts and she didn't have any base in science or chemistry. She was basically a Grade 9 science teacher but the next teacher was actually studying Chemistry at UVic and actually knew what she was talking about and could explain things better. In general it was just a better learning environment.

Effective teaching practices not only impact how well a student does in a particular course, but can also play a major role in inspiring a career choice. Adversely, having an ineffective teacher can cause a student to drop a course entirely. This was Maya's experience when she took Physics 12. She said that she did well in Physics 11, but ended up dropping Physics 12, and explained:

It's funny because I had a really good teacher in grade 11 and I just sort of assumed it would be the same in grade 12, and it [was] completely different. Also with the teacher, he had this technique where he would just do one big question in class and go over like a hundred different steps and then, after a couple weeks, he'd hand you a test and ... it just [wasn't] the right learning

style for me at all.

Having negative experiences in courses due to ineffective teaching strategies can not only impact a student's achievement in the course, but also their perception about the subject matter as a whole, which may have a potentially long-term impact if the student loses interest in the subject entirely and decides not to study it at the post-secondary level or consider it as a career choice.

Success: Factors that Contributed to Success at School and Individual Perceptions of Success

For the purpose of this study, success was defined as achievement of 67% or higher in one or more senior secondary Biology, Chemistry, or Physics courses. All ten of the Aboriginal participants in this study had demonstrated academic success in science. In a broader sense, these participants were also successful in the education system because they had reached grades 11, 12, or graduation – an accomplishment not experienced by the majority of Aboriginal students.

When I asked the participants what it meant to be a successful student, their responses varied. Alan felt like a successful student because he was passing and understanding what he was learning. Russell also said that passing was a measure of success, as well as enjoying what he was doing in some classes. For Tim, success meant he was making an effort to study and get good grades. Maya explained that she felt like a successful student because, "I'm happy with what I do in school, I feel like I get what I need to do done. I feel like I'm prepared to go to university." For these four participants,

success at school meant more than just passing, and also included a personal component, such as understanding, effort, or enjoyment.

Fiona said that two measures of success for her included being acknowledged for the work that she did and also receiving two scholarships when she graduated. She defined success as, “achieving the goal that you set out for yourself and having others realize that you actually did what you set out to do.” Abby described success as reaching personal goals, but said that goals are not necessarily the same for all students:

Having the drive, and I mean everyone is successful in their own way.

Some people say like, ‘oh I succeeded. I got an A.’ Others say, ‘I succeeded and I got a B.’ Some even say, ‘I succeeded and got a C.’ It’s really for yourself. I don’t think you can put it on a scale compared to a generalization; success for yourself, like setting a goal and accomplishing that goal or even making realistic goals.

Similarly, Tara described success in school as putting effort into the course and not giving up, though not necessarily getting high grades:

[Being a successful student means] to be able to get through it, ... even if you’re behind or whatever in grades, you’re still successful because you’re still doing it and you’re pushing yourself to strive for the best. Just as long as you’re here and trying to do it, you’re being successful.

Wendy felt like she was a successful student because she was in the Challenge Program in her school, and when I asked her to tell me about this program, she explained, “well there’s a regular program, then Honours, and then Challenge, which is ... an enriched

learning environment and taking the material to the next level.” When I asked Wendy what “success” meant to her, she said it was based on personal satisfaction - “it just means being happy and content with what’s going on in my life – not necessarily like material-money success, but just at a place where everything is working out.” It is interesting that none of the participants described success in school as getting high grades, but mainly as achieving personal goals, gaining knowledge, making an effort, and earning special recognition, such as winning scholarships for Fiona, or getting into the Challenge Program for Wendy.

Only one participant, Howard, seemed hesitant to classify himself as a successful student: “I’m alright. I’m not good, I’m not that bad, like if I really tried hard and put some effort into it, I’m sure I could do pretty good.” Still, this response is related to the other responses in that Howard was getting decent marks, but did not necessarily see himself as a successful student because he was not making a real effort, which several of the other participants described as being an important aspect of school success.

I also asked the participants why they believed they had made it so far in their education, and their responses fell into two categories: having internal motivation or a natural ability, and having family support or role models. The first category had the highest representation, with eight out of ten participants identifying internal motivation or natural ability as being important contributing factors to their overall educational success. Maya explained:

I feel like a lot of my motivation’s internal because, I don’t think it seems right to, to work hard for something for someone else. Um, of course it’s

nice if my family is happy about it, but at the same time, I feel like I need to do it for me. So, I think it's internal more than external.

Howard's reasons for making it so far in his education were similar: "because I wanted to. ... I know right now I could easily go and support myself, but I want to finish ... I don't like to fail. I don't like to quit." Russell's response was almost exactly the same: "basically, it was my own choice." Similarly, Elaine expressed:

I try hard, ... I want to do well and I want to succeed in life, so I think there is a drive to just want to do it and it just happens. ... It's more just the idea of graduation and the idea of success that motivates me to want to do well – not necessarily to prove people wrong, but to prove that I can do it.

Fiona and Abby were internally motivated to continue with school because they would be one of the first in their families to graduate or go to university. Fiona said:

I feel a certain level of responsibility for what I do. I feel like I'm a role model. I feel like whatever I do, I have to give back, so there's a reciprocity there and I try to build relationships with people because I'm one of the first in our family who has actually gone to university.

For Abby, knowing that she was going to be the first person in her family to graduate is what kept her in school, even though there were times when she thought about quitting.

Tim and Maya also felt that they made it far in their education due to a natural ability. Tim admitted, "I would like to say [I had] lots of focus, but I didn't really do that. [I] just had a natural aptitude for science in life I guess, and math." Maya's response was

similar: “I’ve always found school not to be that hard. Like in elementary school, I kinda coasted, but then in high school, I tried a little bit harder and got a bit more motivated.”

Wendy was motivated to finish her education because she felt it would give her a better future: “I know that if I do get an education, ... I will do better and will be able to support myself better and make more money and just generally have a better life.”

The support of family or having family role models were also important contributing factors that several of the participants cited when asked why they had made it so far in their education. Fiona said her aunt was a role model for her; Tim said his older sister, who went on to study genetics and math in university, was a role model for him; and Tara said that her older sister, who was the first person in their family to graduate, was an important role model for her: “my sister was the first person to graduate in our family and I wanted to push myself to be the second, to make my parents proud To see her get through it made me feel like I could do it too.” One of my favourite responses was also from Tara, when she explained the importance of her mother’s support: “my mom always tells me when I’m having a hard time with school, she’s like, ‘you can get through it. You can do anything you need to do.’ So I know I can do it just cause she tells me.” Though Howard said his main reason for staying in school was internal, he also said it was also “kind of for my parents cause they’d get pissed if I drop out.”

Another striking similarity amongst these participants was that they all had post-secondary and/or career goals in mind. Even the participants who were not entirely sure what they wanted to study in university or pursue as a career still had some ideas. An

additional noteworthy similarity was that post-secondary or career goals for eight of the ten participants were inspired by experiences or courses in school. Fiona plans to do work for her Aboriginal community, inspired by an Aboriginal studies course that she took in the first year of her university education. Elaine's goal to become a sports therapist was inspired by taking dance at school and Alan attributed his goal of becoming a biochemist or physicist to his enjoyment of studying science in school. Russell enjoyed participating in carpentry in school, and decided that he wanted to become a carpenter so that he could have a job that wouldn't leave him "stuck behind a desk." Tim was not positive what he wanted to pursue as a career, but one idea he had was to become a science teacher because, "it's just one of those things I could picture myself doing." He also said that science teachers get to do more experiments than math or English teachers. Howard enjoyed his photography classes so much in school that his goal is to become a wildlife photographer, but he explained, "you don't need a university education for that. You can learn it from hands-on You can learn it from whomever or yourself even." Lastly, Wendy was considering studying psychology in university and her interest in the subject came from a psychology course that she took in school.

Tara's goal of becoming a counsellor came from her own life experiences: "I feel like I've been through a lot to know how to help people and I've been through it, so maybe I can help them."

Maya was the only participant who was not sure where her inspiration came from for the various career choices that she was considering (nutrition, social work, or photography). Her plan was to go to university and see what area inspired her. She said,

“I’m not sure specifically what it was [that interested me in these areas], but I was just naturally interested, drawn to them I think.”

These ten participants represent an exceptional group of Aboriginal students. They were successful, not only because they earned good marks in science, but because they had defined ‘success’ for themselves and were striving to reach their own goals. These students had internal motivation to do well in school and to stay committed to their education, and many of them had supportive families or family role models who demonstrated what success in school could look like. They also found what kind of activities were of interest to them, whether these were clubs or sports teams, and they became actively involved and skilled in their interests at school. All of the participants also had plans of what they were going to study at post-secondary or do as a career after high school.

Secondary Science: Perceptions and Experiences

A second overall theme from the interviews was the participants’ perceptions about science and their experiences in senior secondary science courses. The participants’ perceptions about science have been divided into three subtopics: individual views about science, what the participants liked about science and what they disliked about science. Themes relating to their senior secondary science experiences have been broken down into the following five subtopics: experiences as Aboriginal students in

science, their roles in science, reasons for taking science, “success” in science, and future connections to science.

Individual Views of Science

The first half of the interview with all of the participants was the metaphor interview, and for the first two questions, participants were asked to come up with a metaphor of their own to describe science, firstly as an animal and secondly as an object. Asking these open-ended metaphor questions right at the beginning elicited responses from the participants which were not influenced by any of the metaphors provided by me during the rest of the metaphor interview, or from the literal interview questions. Their answers to these two questions provided insight into what the participants thought about science overall.

Russell, Maya and Wendy all said that science was like an owl because owls seem to represent wisdom, intelligence or being smart. As Wendy explained:

Owls are usually a symbol of wisdom and so science is like a way of gathering knowledge and increasing your wisdom about how the world works Often in cartoons, you see owls with the [graduation] hat – it’s just associated with learning.

Similarly, Alan said that science was like a primate because, “it’s constantly learning new things and becoming smarter and smarter as time goes on.” Abby said that science was like a monkey because it represents curiosity, and Tim said that science was like a lion because, “science is really powerful to humanity and lions are the king of the jungle.”

Both Fiona and Elaine's animal metaphors for science had to do with the many branches of science. Fiona said that science was like a starfish/jellyfish/squid and Elaine said that science was like a whale because, "it's one of the biggest animals and science is a pretty broad topic It's big, but there's lots of little intricate things about a whale, as well as with science – different branches you can go into."

Abby's and Howard's responses were similar to each other in that they both described science as being challenging, but also rewarding. Abby said that science was like a bear because:

Science is very tough and a bear is very tough. It's kind of hard to get past [science] but once you get started, you can do it and finish it and you can get past the bear after awhile, too, once you stop being afraid of it, you can just walk by it.

Abby gave a very similar response to the second question, when she was asked to describe science as an object, explaining that science is like a bike - "once you start learning how to ride a bike, ... you're scared and then you start riding and it gets easier. If you try your hardest, you could just roll through and finish." Interestingly, Abby echoed these sentiments during the literal interview, saying that success in school meant "trying your best and not giving up." Similarly, Howard explained that science is like an elephant because it is "big and complex, but it's interesting and hard to grasp sometimes, but once you do, you feel like you are on top of the world, like riding on the back of an elephant."

The choices that the participants made in describing science as an animal demonstrated that they associated science with knowledge, challenge, and accomplishment, but none of their metaphors described science in a negative way.

When asked to describe science as an object, four of the participants described the vast size of science and the evolving nature of science: Fiona (mountain), Russell (mountain), Howard (an ocean), and Wendy (a beaker). Wendy explained, “as you fill the beaker up with ideas, knowledge, experiments, ... it just contains so many aspects and branches out in different ways.” Alan said that science is like a “Rubik’s Cube” because “science is hard” and also because “there are many ways to do science, but only one outcome.” Tim’s metaphor revealed a very positive opinion of science when he described science as “a home” because he felt comfortable in science and never puzzled by it.

Next, participants were asked to choose metaphors for science that were provided by me. The metaphors were presented in three sets, each set with five metaphor choices. In the first set, the metaphor choices were *car*, *totem pole*, *circle*, *tree*, and *drum*. The most popular choice was the *circle* metaphor, which was selected by half of the participants, with each participant explaining that the circle represented interconnectedness within scientific knowledge. Tim explained that everything he learned in science was connected to something else that he had learned earlier and Maya explained that even though there are many branches in science, they are connected to each other. Four participants selected different metaphor options, yet their explanations for their choices were similar to those given for the circle metaphor in that they identified

the many branches and subjects that make up science: Abby (car), Elaine (totem pole), Tara (tree), and Howard (totem pole). One unique metaphor choice for this set was Alan's, who said that science is like a car because it represents "moving forward." Based on these responses, the participant group recognized the many subjects of which science is comprised of as a whole.

In the second set, the participants were asked to select one the following metaphors to describe science: *puzzle*, *medicine wheel*, *garden*, *story/legend*, or *court case*. Half of the participants selected *puzzle* and again, gave very similar explanations compared to the previous set by explaining that science is made up of many small parts that can be put together to show one big picture. Abby, Howard and Wendy all said that science was like a *story/legend*, but each had different explanations. Abby said that science was like a *story/legend* because science is always evolving and science tells the stories behind discoveries that are being made. Wendy's explanation was similar in saying that she believed that science tells the story of the world and how the world works. Howard's explanation was very different in that he said that science is taught to all students exactly the same. (He expanded upon this idea later in the literal interview). Tim's explanation for his choice of *medicine wheel* again reflected his positive opinion of science, stating that science helps people, just like a medicine wheel does. Fiona's explanation for choosing the *court case* was consistent with the antagonistic relationship that she sees between science and Aboriginal people: "I always think of the way that science is used in court cases ... against a lot of land claim issues, fishing rights, a lot of Aboriginal rights and title." Fiona's responses were unique, greatly due to a

contemporary Aboriginal issues course that she was taking at the time in her first year of university. Fiona explained later in the literal interview that this course entirely changed the perspective that she had of science while in high school. (This is discussed later in the chapter in the section about future connections to science).

For the final set of metaphors presented in this question, participants were asked to choose from *pyramid*, *forest*, *feast/potlatch*, *song/dance*, or *experiment* to describe science. The most common selection was *pyramid*, with five of the participants choosing this option. Fiona, Alan and Tara each said that science is like a *pyramid* because it is evolving and it builds up towards a peak of knowledge, often very specific in nature. Elaine and Russell both selected *pyramid* because they felt it represented scientific processes: Elaine equated it with the hierarchy that is inherent in the food chain, and Russell said that building a pyramid is like following a proper process in science, “you have to take into account all of the angles to make sure it will not crumble or fall.” Howard’s explanation for his choice of *forest* related to the exploratory nature of science: “the further you go in, the more you learn and the more you look, the more you want to explore.”

Four of the participants selected *feast/potlatch* and three of the four explanations had to do with the idea of giving and sharing at a feast or a potlatch. Fiona said that science is like a *feast/potlatch* “in the sense that science is being contributed to by many people and they bring what they have to offer together and they share; and we kind of take what we need from it.” Tim explained, “you have to give for science to give back to you, so if you want to do good in science [and] you want to learn, you have to really try.”

Howard's first choice was *forest* and he included *feast/potlatch* as a second choice, stating, "it's like a feast because everyone can share their knowledge." Wendy selected the same metaphor, but her explanation did not make any clear connection with a feast or potlatch:

- Wendy: "There's so many different branches and so many different areas that like some people find interesting, like I really don't like Physics but I'm more interested in like Biology and that kind of stuff and so it just covers everything and there's so many different areas that you can go into like even like Psychology or like medicine – it all involves science and so it's really a lot to choose from.
- Me: "Can you think of any other similarities between science and a feast or a potlatch?"
- Wendy: "Um, not really."

It is interesting that four of the participants selected *feast/potlatch* to represent science, particularly as they all lived away from their Aboriginal communities and for the most part, described having a weak cultural connection, and yet three of the participants demonstrated a clear understanding of what a feast or potlatch is, and associated science with this cultural metaphor.

Secondary Science: Dislikes

The metaphor and literal interviews provided some valuable insights into the criticisms that the participants had about science education. Even though all of the participants were academically successful in senior-level secondary science, they did not

necessarily like aspects of the science curriculum or some of the ways that science was taught to them.

Fiona, Tara, Howard and Wendy each described science being taught in a closed or uncreative way. In the metaphor interview, Fiona said that science is taught like a *computer* and a *calculator*, and she explained her choices by saying, “I want to choose the more stereotypically mathematical or scientific option just because it’s reinforced so much that ‘this is science’. Cause it’s math.” Later in the literal interview, Fiona explained, “science is taught in an absolute way like there are no other approaches we only learn Western science, of a European sense, like what old European guys thought.” Not only was Fiona aware that science is sometimes used against Aboriginal people, but also that the Aboriginal perspective is not included in “science.” Tara was the only participant that selected *prison* as one of her choices to describe how science is taught, explaining:

There are hard guidelines you have to follow and you can’t step out of them, or else you will get behind or you’ll be doing the wrong thing and you just need to follow in line what everyone else is doing.

Howard said that he did not like that science is “so set in stone” while Wendy’s biggest criticism about science education is that it lacks creativity. She selected the metaphors *computer* and *calculator* to describe how she believes science is taught, saying that they represent the “methodical”, “concrete,” “not anything abstract” nature of science, adding, “it’s not creative ... like when you are sitting in front of a computer, you’re just sitting

there, staring at a screen plugging in things.” Wendy used these exact same descriptors in the literal interview when asked what she disliked about science.

Half of the participants identified what they viewed as the boring or repetitive nature of science education. When describing the experiments from her Chemistry class, Fiona said, “they all kind of seemed the same all the time – there was very little variety.” During the metaphor interview, Elaine said that science was taught like a *church*, explaining:

You don’t have the freedom of learning what you want. ‘They,’ like the school board, decided the curriculum and you have to follow it and it’s kind of religious that way ... it’s whatever everyone is being taught.

It’s all the same.

Maya described the static nature of secondary science compared to elementary school science when she was explaining why she thought science is taught like a *car*: “it’s mechanical, the same way all the time. It doesn’t really change much. In the younger grades, I felt like there was more variety, but now it just seems to be repetitive.” Wendy described feeling disengaged in science, which often meant “sitting there in class, copying the page we are reading out of the textbook and copying down notes. That doesn’t really involve the students and get them interested.” Howard’s response to how science is taught was similar, but also unique from the responses described above. He said that science is taught like a *factory* because “everyone learns the same thing and we’re all taught the same, so we end up with the same [knowledge] base coming out of it.” But, Howard also said that science is taught like a *boat* because it’s up to the students

to take their learning further: “it’s like you are on the ocean and you’re trying to explore the ocean and you may all see the same thing, but you may come out with different ideas when it’s over.” In explaining why he also thought that science was taught like a *computer*, Howard said, “it’s methodic and the same to everyone,” but it is up to students to decide “how much you care to explore it deeper where you learn more than everyone else.” Through their responses, the participants have made it clear that just because a student is doing well in science, it does not necessarily mean that they always find the classes enjoyable or stimulating.

Another aspect of science that four of the participants disliked was memorization, whether of vocabulary, or of content. Elaine, Maya, and Wendy all said that they felt some of the content in science was pointless or irrelevant to them. Elaine, Tara and Maya also expressed that the content of science courses seemed driven by the prescribed curriculum and/or provincial exams. Maya stated, “a lot of the teachers, especially in Grade 12. ... really seem to go by the curriculum and the provincial exams. It all seems like one big lead up to the provincial exams.” Tara’s explanation of why she thinks that science is taught like a *car* and a *forest* was similar:

A car cause they [science teachers] speed right through and they teach you a whole bunch of stuff, ... and they try to get it done in six months or whatever, and it seems like a lot of information in that time period. A forest because it’s so big and there’s so much information that you have to learn about and you just cram it all in and sometimes it’s hard to remember it.

Tara expanded upon the car metaphor, which she said was her favourite metaphor to describe how science is taught: “they are both on a set goal, like if you’re driving a car, you’re trying to get somewhere. When you’re in science, you’re trying to get to the end and do your exams.” When asked to generate her own metaphor for how science is taught, Tara said that it is taught like “a race”, and she explained, “to see who finishes and who does the best, but then only a few remember how to do it and they will try to race to the end and finish.” Tara made an insightful observation in saying that the pace of science classes can be too fast for some students, resulting in some students not making it to the end of the course. In the literal interview, Tara also observed that there are many lab activities included in the textbooks, but she said that these are often skipped over in class due to a lack of time. The criticisms that the participants described about how science is taught, such as being repetitive, boring, unimaginative, too fast, and heavy on notes and memorization all seem to be rooted in the larger issue of the vast curriculum that teachers must get through in a limited amount of time.

Conflicts with Science

Some of the responses in the metaphor and literal interviews revealed some topics or representations which the participants identified as being in conflict with secondary science. One metaphor-interview question which generated some very interesting responses was when I asked each participant to look over the 15 metaphors that I had provided and pick one which they felt represented how science is not taught. Fiona said, “science is definitely not taught as a *longhouse*. Well, there is procedure [in science], but

not in the sense that it's part of a tradition or that there are teachings that are viable in life – daily life.” Earlier in the metaphor interview, Fiona said that her least favourite metaphor for science was a *totem pole*, because totem poles represent “more of a traditional Aboriginal teaching than they do scientific knowledge.” Later in the literal interview, Fiona explained that science is “kind of contradictory to what you're taught at home, so it's just reinforcing that ‘living in two worlds’ kind of thing.” Of all the participants, Fiona most strongly identified a conflict between school science and traditional Aboriginal knowledge. Of particular interest was Fiona's speculation that this might be one reason why Aboriginal students are underrepresented in senior secondary science courses.

Alan and Russell both said that science is not taught like a *church*, with Alan stating, “a church is something you have to believe in and science, you have to prove” and Russell explaining, “the church and science don't go together because they would contradict each other too much.” Similarly, Tim said that science is not taught like a *story/legend* because, “legends ... seem kind of like fantasies and science is all facts, unlike legends.” This response was somewhat unexpected for Tim, who earlier in the interview had said that science is like a *medicine wheel* because it helps people and like a *potlatch* because science is about give and take in order to be successful in it. The conflict for Tim with the *story/legend* metaphor is that it does not represent factual content to him, which he sees as being essential to science. Alan's, Russell's, and Tim's responses represent a very Western perspective of science that does not include aspects of spirituality or beliefs and that “science” is based on factual knowledge alone.

Maya and Wendy both selected metaphors that represented enjoyment or creativity as being in conflict with how science is taught. Maya said that her least favourite metaphor for science was *a song or dance* because science “is like proving things rather than just enjoyment,” and she said that science is not taught like a *painting* because it is “much more creative and not as structured.” Similarly, Wendy said that her least favourite metaphor for science was a *song/dance* because, “it’s like two different aspects of people. One’s more scientific and the other’s the more creative aspect.” Wendy also said that she did not think that science was taught like *a carving* or *a painting* because these metaphors are “not about knowledge, [they are] about expressing yourself and I don’t really see science as a mode to express myself.” These answers echo the participants’ earlier criticisms of secondary science education.

Despite disliking aspects of science education and identifying various conflicts with science, a few of the participants spoke against some of the metaphor options because they did not like associating science with metaphors which, to them, had negative connotations. These participants were able to criticize science education and still have respect for it, or at least be protective of it. For instance, Abby’s least favourite metaphor for science was a *prison* because, “there is no right or wrong answer – if anybody is answering anything [incorrectly], they are not going to get punished for it.” Elaine’s least favourite metaphor for science was also the *prison* metaphor, and she explained, “you’re not forced to be there and prison seems like an unhappy environment and maybe a depressing environment or a scary environment and science doesn’t really relate in those ways to me.” The *court case* was Tara’s least favourite metaphor for

science because “it makes it seem like it’s something bad ... [science is] really, really, really tough to get through, but it’s a good thing to do and once you get started and you keep doing your work, you’ll get through it.” All of the participants in this study experienced academic success in science and some of them disliked associating science with some of the more negative metaphor options. It would be interesting to interview participants who did not do well academically in science and see if they react differently to the metaphor options, including the most inherently negative *prison* metaphor option.

Secondary Science: Likes

Though all of the participants identified aspects of secondary science that they did not like, all of the participants also identified aspects of science that they liked and enjoyed. Opportunity for hands-on, experiential learning was by far the aspect of science that the participants liked the most.

When asked to describe their earliest memories of science, all but one of the participants recounted a vivid memory of a specific, hands-on learning experience during elementary or middle school:

- Fiona: “Dinosaurs – that’s the earliest thing I remember. That was when I was pretty young in elementary school. We were drawing them and trying to learn the names and then have a picture of [the dinosaurs] and draw a line to the name.”
- Abby: “I guess it would have to be in elementary school when we learned how dropping a bowling ball and a feather and they dropped at the same rate. That’s the first time I learned about science.”

- Elaine: “I remember doing labs in elementary school ... like with caterpillars and things and just kind of studying them and observing them in their habitat.”
- Alan: “I remember in Grade 7 doing a project – the old volcano – filling it up with everything we could just to get it to overflow and putting little things on the side to see what happens.”
- Tim: “Probably Grade 5 – [my teacher] was really fun and did lots of fun experiments and stuff. There was one where we had to make a grapefruit launcher and shot it across the field. He was just a fun teacher.”
- Tara: “Probably growing plants. We grew bean plants in elementary school – that was pretty fun. We also had science fairs in elementary school. ... I had an invisible fire extinguisher once and it was like a baking soda thing and you just hold it over the fire and it just goes out. Then I had one about a plant to see which one would grow better if one was in the dark and one was in light.”
- Maya: “I remember in Grade 8 making models of the cells and also this one thing where we made models of the lungs using balloons. I don’t remember that much from elementary school. I don’t think I was really focused on school that much in elementary school.”
- Howard: “It would probably be that time in Grade 3 when we had a big thing of water and we were putting dye in it to see how it reacted in water. And then the next thing is when we had to cut open the sheep’s eye in Grade 8.”
- Wendy: “Probably studying the solar system and bugs and spiders and stuff. I always liked that when I was a kid. I was always interested – it’s just cause when

you see it, but you don't know about it, so actually learning about it and what it was – is kind of interesting and just what was out there.”

- (Only Russell said that he did not have any early memories of studying science).

When asked what they liked about secondary science education, nine of the ten participants also identified hands-on, learning activities. Abby, Elaine, Tim, Tara, Russell and Maya all said that they liked doing experiments or dissections. Elaine stated, “I always like the hands-on experiences, so actually dissecting something or looking at something or observing anything.” Elaine also said that she liked going on field trips and she recounted one field trip where she got to go to the beach and collect water samples. Alan, Tara and Tim said that they liked doing science-related equations: Alan enjoyed doing calculations in Physics whereas Tara and Tim both liked balancing equations in Chemistry. Alan explained, “being able to calculate how fast things fall and kinetic energy, ... that's kind of mind-boggling!” Maya said that she really enjoyed collaborative learning while doing group work, though she observed that these activities happened less frequently at the senior secondary level than in her younger grades. Howard enjoyed being able to explore in science and being able to add his own opinions while Fiona said that she liked being able to help other students.

In addition to hands-on learning opportunities in science, all ten participants also said that they appreciated the knowledge or information that they gained from taking secondary science. Abby, Elaine, and Wendy all said that they were naturally curious people and that science helped to satiate their curiosity by explaining how things worked or came to be. In describing what she liked about science, Abby said:

Learning things that you never knew about before ... I'm that type of person that always has to know how it was made and how it became what it is today, so having science, it just gives you a lot of knowledge. I just enjoy that part.

Very similarly, Elaine articulated, "I'm a curious person and I always like knowing how things work and what's underneath things or how things have been made, so that's a big interest for me and I like finding out things like that."

Alan appreciated gaining knowledge from all three major branches of science: "being able to understand almost everything in the world – to know Chemistry [and] what stuff is made of, what you can add together to make stuff, and Physics – how fast something falls, and Biology, just trees and all that." Biology was a popular subject amongst the participants, with half of them saying that they liked learning about plants, animals or how the human body works. Maya explained that what she learned in Biology was relevant to her, and to illustrate this point, she said that it would not feel right to her to have kidneys and not know how they worked. Howard said that he enjoyed the topic of evolution and learning about how things came to be. Fiona liked learning about scientific theories, particularly how these change over time, echoing her earlier explanations of why she thought science was like a mountain (growing and crumbling back on itself) or a circle (never-ending revisions, changes, and different conclusions).

A few of the participants also identified more personal reasons for liking secondary science. Abby said that she liked being with her friends in her science classes and Alan said that he found science to be a lot of fun. Fiona and Tim both said that they

liked science because they had exceptional teachers. Tara expressed feeling a sense of personal accomplishment by taking science:

I like how there's so many experiments you can do and it's challenging, but in the end, you feel like you gave your best and you feel happy that you found the answer to what you were doing. It gives you a sense of pride or something.

This sense of pride from taking and completing secondary science was a common theme in Tara's metaphor and literal interviews.

All of the participants described a complex perspective about secondary science as they could criticize aspects of science curriculum or the way that science is taught, and yet they also identified aspects of science education that they enjoyed or could give examples of scientific knowledge that they found interesting or relevant.

Secondary Science Experiences

In Grades 11 and 12, the type of science courses that students take is a personal choice. Students are only required to take one science course at the Grade 11 level to satisfy BC graduation requirements, yet many of the participants in this study decided to continue taking science at the Grade 12 level. Another unique attribute common to members of this participant group was the choice that each of them made to take Biology, Chemistry, or Physics courses at the senior secondary level – courses considered to be a part of the “hard sciences” and courses that Aboriginal students in general tend to avoid. When asked why they decided to take these courses, the participants gave a wide range of

reasons. Self-choice was the most common explanation, as expressed by five of the participants (Elaine, Alan, Tara, Howard and Wendy). For example, Elaine said in her metaphor interview that science is taught like a *longhouse* because:

You can enter as you please – it's your choice to go and explore ... you're not forced to do anything – you're in control ... even though you don't have the choice of what you're being taught, you can choose to do the course [and] you get to choose if you want to stay in it or out of it and work your way through the course, making it more interesting for yourself.

In the literal interview, Elaine said that she took Chemistry 11 and Biology 11 and 12 because she was interested in these subjects and because it was her choice to take these courses, which she said increased her motivation to do well in them.

Fiona and Abby said that they signed up for their science courses because their friends were taking the courses. Russell and Tim made their senior secondary science course selections to give them a “back-up plan”, with Russell saying he thought science would be useful if his career choice as a carpenter didn't work out and Tim saying he thought he might need science in case he decided to go through with his idea of becoming a high school science teacher. Wendy's reason for taking Chemistry 11 was similar: “as far as post-secondary education goes, I thought it would be useful, especially if I want to pursue anything in Psychology.”

One striking similarity amongst the participants is that nine out of ten described having a predominantly passive role in their science education experiences. This trend was revealed in the metaphor interview questions which explored each participant's

relationship with science. Here is a summary of pertinent responses that the participants made when asked to select metaphors to complete the statement, “I am to science as a ...”

- Fiona: *a passenger is to a car* – “I’m not really involved with science. I don’t really offer much to it.”
- Abby: *a passenger is to a car* – “I always had a partner and, cause I’m not familiar with stuff, I usually like to let somebody else take the lead.”
- Elaine: *a reader is to a book* – “I haven’t really experimented in science as a character would and I didn’t really do my own experiments as an author would, so I’m more just following along what other people have done.”
- Alan: *a passenger is to a car* – “I’m just following it as it goes along.”
- Russell: *a passenger is to a car* – “I’m just learning right now and when and if I get more experience, then I will be more like a driver and if I become very experienced, then I will be like a mechanic.”
- Tim: *a passenger is to a car* – “I’ve kind of been like an audience of science right now. I haven’t done much in science. I haven’t really taken control of science or made science.”
- Tara: *a guard is to a prison* – “I didn’t get into everything [in science]. I sometimes just stand on the outside and watch what they are doing. I wouldn’t get into the conversations and stuff like that.”
- Wendy: *a passenger is to a car* – “I feel like I don’t really get to figure things out for myself. I’m kind of told them and then tested on them rather than figuring it out myself or directing my studies.”

The passive role that these participants identified in describing their relationship with science seem to fall into two categories: 1. Lack of involvement within science classes or 2. Lack of self-direction in science education.

The only participant who described a more active role in his science education was Howard who said that he is to science as *a driver is to a car*, explaining, “when I get older, I want to travel and explore and find new things. I want to be able to lead my own path through what I learn in science.” It should be noted that Howard sees himself as a driver in science only *after* her graduates. In terms of his current experience in secondary science, Howard said that he is to science as *a child is to a community* because, “I haven’t learned much about it and I want to learn more. In order to be *an elder*, I’d have to know quite a bit, and to be *a chief*, I’d have to know a lot more than I do.” Howard’s second example does not necessarily indicate a passive experience in secondary science, but more of an acknowledgement that he still has a lot of knowledge that he has to learn in order to assume a more dominant role in science.

Another exceptional response to this question was Fiona’s, who said that she is to science as *an elder is to a community*, and she explained, “I’m interpreting the elder as arguing it [science]. Arguing not its value, but its accuracy or how it is used.” This response supported a common theme throughout Fiona’s metaphor and literal interviews in which she critiques science and the negative impacts of science on Aboriginal communities and the conflict that she sees between Western science and traditional Aboriginal knowledge.

Another response that the majority of participants had in common was saying that their experience in senior secondary science as Aboriginal students was virtually the same as for non-Aboriginal students. Two exceptional responses were from Tim and Fiona. Tim said that his experience as an Aboriginal science student was “probably different because I was an underachiever in Grade 8, 9, 10, and 11 and peaked in Grade 12 – so I guess it was just laziness or procrastination.” For Fiona, she said that her experience was different because she usually felt like the only Aboriginal student in her science classes:

I think [my experience] was mostly the same, well ... from a third person point of view, like I was just like everyone else, so nobody really saw me as the Aboriginal student in the room, but I’m pretty sure I was the only one in all of the classes, which is kind of disappointing... I was [thinking] one time, ‘man, I’m the only Indian in here.’ I felt like one of the very few and it changed the way I approached it [science] and the reason why I wanted to do so well.

From an outsider’s perspective, Fiona said that she would not have stood out as being any different from the other students in her science classes, but from an internal perspective, Fiona was well-aware that she was often the only Aboriginal student in her science classes, something that made her feel somewhat lonely or alienated, but also something that gave her extra motivation to do even better in her science classes.

Participant responses to the notion of “success” in senior secondary science included a wide range of opinions. Most participants measured their success in science in

more than one way. Fiona, Tim, Maya and Howard said that they had a natural ability in science, and thus did very well in science. Eight of the participants said that they felt successful because they had good study or work habits in science. Study and work habits that the participants identified included attendance, listening in class, studying, doing homework, reading, getting extra help, staying organized or making a choice to do as well as possible in their classes. Half of the participants also said that they felt successful in science because of the knowledge that they gained. Seven participants identified good grades, test scores, or report cards as indicators of success in science. Elaine described feeling successful by “writing the test and doing well – it makes you feel good, like ‘wow, I actually accomplished this! I have this under my belt and I can do it.’” Tim said that when he got a good report card, “you feel like you have done your work and earned it.” Tara’s explanation was similar, “when I get my report card, like when I see how good I did ... you feel like, ‘yeah! I finished it! I did it and got really good marks.’ I felt pretty proud of myself.” Fiona and Maya said that they also felt successful when they were able to help other students and Elaine said she felt successful because she was enjoying what she was learning. Many of the participants equate “success” with a personal investment in their learning, resulting in some of the more obvious measures of success, such as grades or test scores.

Eight of the participants were also able to identify various factors that caused them to feel unsuccessful in science. For Elaine, Tim, Maya and Howard, it was receiving a poor mark on a test or an assignment. Several participants also said they felt unsuccessful if they were trying their hardest in science, but were still not getting very

good academic results. This was Maya's experience in Physics 12. Maya recalled thinking to herself during Physics 12, "'I'll just work harder, I'll do better' and it never really happened." Maya said that she would study before the tests and do practice exercises from her Physics workbook, but she still did not get the high test marks that she was hoping for, ultimately causing her to drop the course. Half of the participants identified feeling unsuccessful in science when they struggled with the math, chemistry, or physics equations in science. Feeling exhausted, unsupported, or having difficulties staying focused were a few other examples that participants gave.

Interestingly, Tara and Wendy said that they never felt unsuccessful in science. When I asked Tara if there were any times that she did not feel successful in science, she replied, "no, because I was always there. I did not, not attend class. I went there and did it all – did my homework. I think doing that is pretty successful." Maya's response to the same question was, "um, not really. Success is relative to what I define it as. I didn't feel unsuccessful in class. I just wasn't very engaged." These responses were very consistent with a question that I asked earlier in the literal interview, when I asked participants what it meant to be "successful." Tara said students are successful as long as they keep going to class and trying their best, even if they are falling behind or if their grades are slipping. Wendy said that being successful is feeling content and happy with her life, and is not connected to materialism or money. These two participants measure success in a very personal and individualistic way and do not allow external markers, such as grades or wealth, to influence their own perceptions of being successful.

Future Connections to Science

I was very interested to find out if these Aboriginal science students visualized having a connection to science after they completed high school. Half of the participants responded “no” and said that science would not be a part of their futures. Of these, three participants said that they had previously considered a career in science when they were younger, but had since changed their minds. Abby considered being a crime scene investigator, Tara considered being a scientist, and Fiona considered being a doctor, but all three of these participants decided to pursue different areas that did not include science. In fact, these three participants decided to focus on Aboriginal programs at the post-secondary level. Abby and Fiona were already taking first-year post-secondary Aboriginal courses at the time of their interviews and Tara had planned to apply to an Aboriginal program once she graduated from high school. When Fiona graduated, her plan was to pursue medicine, but in her first year of university, she took an Aboriginal course as an elective, and her entire career goal and also her perspective about science changed. Fiona described this shift in her perspective:

In high school, I thought science was ‘it’, like science was the absolute bottom line ..., but now I’m changing my perspective ... I feel like I’m critiquing it [science] now... It’s not part of my life anymore. Before, I was going to go into science..., but now I just want to avoid it.

When Fiona started university, she had planned to study biochemistry and microbiology, and eventually go into medicine. When I asked her why she changed her mind, she spoke about the impact that taking an Aboriginal-issues course at university had on her:

I decided in my first year that I just wanted to take other things cause I hadn't experienced all of these classes – you don't get them in high school. I found out about these other things that really bothered me and I felt I needed to know about [them] and maybe somehow change, or bring it to other people's attention and I kind of just forgot about the whole science thing. This is more important – like, what can I do if I get a degree in microbiology for my community or for people, other than the people in my waiting room?

Fiona's experience, as well as Abby's and Tara's, indicate a need at the high school level for Aboriginal students to see that a career in science can still be connected to their goals of working for the betterment of Aboriginal people and communities. An interest in science-related careers can be fostered when students are young, but sustaining this interest through the secondary years can be challenging for students, especially if science is viewed as oppositional to Aboriginal concerns and issues.

Tim, Maya, and Wendy said that a connection to science beyond high school for them was a possibility. Tim said it would depend on whether or not he decides to become a science teacher. Maya and Wendy questioned if some of the areas that they planned to study at the post-secondary level could be classified as "science" courses. Maya said she was considering studying "forms of science that are related to environmental sciences and geography, if that's a science?" Wendy was considering studying psychology at university, but she also seemed hesitant to classify this post-secondary area as "science," explaining, "I guess psychology kind of involves science? I

know you need Biology 12 for that, and it does look at the brain and the human mind and that kind of involves science?” These students bring up an interesting point as to what high school students consider to be “science” areas. The scope of scientific areas available at the secondary level is quite limited, so students are not likely to be aware of the wide array of scientific areas that are available at the post-secondary level.

Only three participants said that science was definitely going to be a part of their post-secondary or career choices. Elaine said that science would be a part of her goal to study sports medicine and Howard said that he would use scientific knowledge in his career as a wildlife photographer. Alan’s goal was to become a biochemist or a physicist, and when I asked him why he was interested in pursuing science, he replied, “because it’s one of my favourite courses and just, it’s fun.”

All of the participants had post-secondary or career aspirations that were inspired by courses taken at the secondary level, and some of these were science-related goals, while the majority were not. If it is a priority for more Aboriginal students to consider pursuing science-related areas, then more work needs to be done to pique or retain their interest in science at the secondary level.

Secondary Science Education: Participant Recommendations

The participants of this study all elected to take senior-secondary Biology, Chemistry or Physics and achieved high levels of academic success in these courses. The participants were also able to express what they liked and disliked about their secondary science education. For some of the participants, science will continue to be a part of their

future endeavours, but for several, their experience with science will end at the high school level. In order to inspire more Aboriginal students to pursue the sciences beyond high school, educators must re-evaluate secondary-science education programs and there is no better place to start generating ideas for change than listening to Aboriginal science students, like the ones who were a part of this research study, to hear and reflect on their recommendations for improving science education.

Improving Secondary Science: A Student's Perspective

Perhaps one of the most useful outcomes of this study were the recommendations that the participants made on how they believed that science education could be improved. These suggestions came from both the metaphor and literal interviews, though the responses from the metaphor interviews were particularly insightful in describing the changes that the participants would like to see. During the metaphor interviews, I presented participants with the metaphor options used in the previous questions and I asked each of them, "If the way that science is taught could be changed, which one of the above metaphors best describes the way that you would like to see it taught and why?" (The participants were also asked to make a second selection.) Half of the participants selected metaphors that would allow the way that science is taught to be more hands-on or creative:

- Elaine – *a sport*: "There is room to make science more interesting and fun than the way that it is being taught, so maybe doing more hands-on experiences and things like that."

- Russell – *a carving* and *a painting*: there’s more hands-on work..., so that people who actually do the stuff can learn a lot better with hands-on than just reading out of a textbook.”
- Tim – *a painting*: “It’s creative. It seems like a lot of science classes are just learning and remembering [but] painting takes a lot of creativity and it would be more fun to learn.”
- Maya – *a painting*: “you would have more creativity involved and you could maybe specifically focus on things that you are interested in and just go with what feels right.”
- Wendy – *a sport*: “A sport is so much more engaging and actively involved, so not just like sitting in class, like copying the page we are reading out of the textbook and copying down notes. That doesn’t really involve students and get them interested.”

During the literal interview, Tara made a very similar recommendation to the ones described above in how she would like to see science taught:

More hands-on things instead of just reading from a book and writing notes all the time; looking at pictures and to bring in things. Like, there are experiments, but not as many as there could be because in the books, they have a lot of experiments and a lot of labs and they [teachers] usually just skip over most of them.

Half of the participants also selected metaphor options that would change the way that science is taught to make it more open, flexible, and individualistic for students:

- Abby – *a painting*: “It’s your own interpretation, just like how a painting is anybody’s interpretation of what it is instead of it being one thing or the other.”
- Elaine – *a forest*: “It’s like a big area and there’s lots of little corners and things you don’t normally see or you can go exploring in. There’s more room for exploration and finding your own way around.” Elaine reiterated this idea in her literal interview when she said, “maybe not having a set curriculum and letting the students choose what they want to go into or even having more projects where they can explore something that they’re more interested in.
- Tara – *a garden*: “There’s many flowers and many fruits in the garden – and then there could be more of each thing [topics] in each science course, ... like in Grade 8 or whenever and you can learn little bits of everything instead of just one set thing.”
- Maya – *a boat*: “You’re going somewhere, but at the same time you’re kind of drifting around and you can go in different avenues and I don’t know, tangents.”
- Howard – *a forest* and *a boat*: “to let us explore what *we* choose to explore and go as deep as we choose” and “you can choose your path and explore the ocean, lake, or whatever.”

Alan and Wendy both said that they would like to see teachers change the way that they teach science. Alan said he would like to see science taught like *a calculator* because “a calculator makes it easier to do math – do science in a way [that is] more straight forward.” Wendy said in both parts of the interview that she thinks the only way that science can change is if teachers change their teaching styles to make science more

creative and interactive. Wendy explained why she thinks that science should be taught more like *a sport*:

I know some teachers definitely involve students and get them interested and do more active things, but in general, mostly the way that science is taught, it just doesn't involve people and engage them enough in a way that keeps them interested, even if they do think some of the aspects of science is interesting, it's just hard to be engaged sometimes with the way it is taught.

In the literal interview, Wendy stated, "I don't know how they could make [science] better. I guess it depends on the teacher than the actual system itself."

Fiona and Tara said that they would like to see other cultural perspectives included in the way that science is taught. Fiona said that she would like to see science taught more like *a garden* because this would "teach [students] that science isn't the only option" and also like a *medicine wheel* because this would "take in components more of a circle – it has different components but they are all kind of equal, so you don't really give more weight to one of them." Fiona expanded upon this idea during the literal interview, and what is exceptional about her response is that she expressed this opinion before I asked her if Aboriginal knowledge should be included in science. Fiona explained:

It would be interesting to see different perspectives – like not all science can be the same around the world; even the local perspective - like if you're teaching in B.C., maybe incorporate, like getting to know the trees and plants around you, and any sort of Aboriginal perspective, like in

terms of medicines or anything like you actually feel like you know your environment and you feel like you're part of it. I think it's pretty important for students.

Tara also recommended including an Aboriginal perspective in science, making reference to a guest speaker who had spoken to one of her classes, "someone came to my First Nations Studies class and was talking about the First Nations medicines and the way First Nations sciences could be included – that would be kind of cool."

All of the participant's recommendations on how to improve science education show an inverse relationship with the aspects of science that they dislike – namely that science education can be rote, restrictive, and conscribed, whereas the participants would like to see it taught in a much more interactive, creative, inclusive and individualistic way. If science does not engage or interest students, then they are less likely to invest in science beyond their high school years.

The Inclusion of Aboriginal Knowledge in 'Science' – Participant Recommendations.

When I asked the participants during their individual interviews if Aboriginal people have "science," all ten replied "yes." When I asked if Aboriginal knowledge had ever been included in their science courses, all ten participants said "no." Next, I asked if Aboriginal knowledge should be included in science, and all but one participant said "yes." (Russell was the only participant to answer "maybe.")

The participants were able to provide several examples of Aboriginal knowledge and reasons why they believed that this knowledge should be included in science courses.

Half of the participants listed traditional medicines as an example of Aboriginal scientific knowledge. Another popular example was traditional knowledge of the environment, including trees and plants. Elaine explained that tales told by elders related to nature and contained Biology. Regarding traditional environmental knowledge, Howard reasoned:

We knew more about the environment around us ... we learned how to move with it, so there's obviously science involved with that. I mean, you can't just wander around in the bush for 3000 years and not have some sort of science.

Tim said that the way Aboriginal people prepared and transported meat and salmon was an example of traditional scientific knowledge. It is remarkable that even though none of the participants had ever been exposed to traditional Aboriginal knowledge in their science courses, they were still able to give varied and succinct examples of what this knowledge would include.

In addition, several of the participants were also able to explain why Aboriginal knowledge should be included in secondary science education. Wendy suggested that this knowledge could help to protect the environment:

Especially with the medicine and stuff, just using the natural environment to actually help them, ... especially nowadays, people definitely abuse the resources we have. They [Aboriginal people] have more the ability to be, like one with nature as opposed to just stripping nature of everything and so..., just as far as their views were, they respected and utilized their environment in a more productive way.

Several participants said that including Aboriginal knowledge in science would give students a wider perspective of scientific knowledge and even of history. Regarding the inclusion of Aboriginal knowledge, Elaine stated, “it is an important part of being exposed to new things. I don’t think anything should be left out and it’s definitely evident in the world, so it should be put into the education system or science in general.” Along the same line, Maya said, “it is a different kind of knowledge. I think it would be pretty cool if it was involved in science courses.” Abby surmised, “I think it gives people more of an awareness of Aboriginal people’s land and all the things that happened before our time.”

Perhaps the most profound reason some participants gave as to why Aboriginal knowledge should be included in science is the benefit that would be derived by Aboriginal students. Elaine explained that science is “a really important part of education and everyone should be exposed to it, and maybe for certain people, there might be easier ways for them to relate to science if it was taught differently.” Tara stated that including Aboriginal knowledge in science:

Would be a good way to learn things, especially for Aboriginal students – they’d get more into it, instead of thinking, ‘oh, this is boring’ and they’d maybe want to explore more sciences if they were learning about their own people.

Wendy believed that incorporating Aboriginal knowledge in to science would be particularly beneficial “where there’s lots of Aboriginal students.” She continued to say, “I don’t know how it would be incorporated, but I think it’s important somehow – even if

it was extracurricular, ... Aboriginal science I guess.” Fiona said, “we only learn Western science, of a European sense, like what old European guys thought” and she said that Western science is “contradictory to what you’re taught at home, so it’s just reinforcing that ‘living in two worlds’ kind of thing.” These responses show that several of the participants are aware that the inclusion of Aboriginal knowledge will not only generate a stronger connection by Aboriginal students to science by reflecting their culture, but could also foster a greater sense of interest in the sciences, which could lead to more Aboriginal students pursuing the sciences.

Several of the participants also gave some cautions regarding the inclusion of Aboriginal knowledge in secondary science courses. Fiona said that it would be very important not to generalize Aboriginal knowledge, explaining:

A problem I could see is if you put all the Aboriginal perspectives under one umbrella cause definitely they are different. They are not all the same thing. If you go to a Blackfoot community and you compare with the Innu, it’s going to be different. At least identify who you’re talking about when you do it.

Tim also explained that he believed that Aboriginal people have ‘science’, but “but not now-a-days as much, but back traditionally”, so Tim thought it would be important to place Aboriginal knowledge into context. A few participants also explained that Aboriginal science is very different from Western science, as Abby explained:

When it comes to experiments and doing full research, I don’t think Aboriginal people do that cause my understanding [is that they leave]

things the way things are - just how they are; just leave it like that; you don't need to dissect every little thing in life - how it is just how it is.

Tara did not believe that Aboriginal people value Western science as they have their own way of doing science, as she explained, “[Aboriginal people] did their own things, like they came up with ways to perform experiments to get what they wanted, and ... they have their own medicines and they test them to figure out which works and not.” Tara continued, “I don't think most of them care about [science] because they have their own way of doing things and we're trying to push stuff on them and they just like their own way of trying to do things.” These participants emphasize the importance of planning how to appropriately incorporate Aboriginal knowledge into science because it is fundamentally different from Western science.

Some of the participants also wondered about how the inclusion of Aboriginal knowledge would be received by students in general. Alan said that “some [students] would be interested, but others would be on the fence.” When asked if students would enjoy learning about Aboriginal knowledge in science, Tim replied, “I think most of them would, except for the narrow-minded kids might not.” Howard also cautioned that learning “more about Aboriginal beliefs might be kind of interesting, but I'm not sure because I know for most people, they wouldn't care, but I'd find that interesting.” These students speculated that the level of interest students would have regarding Aboriginal knowledge would vary, but as Howard explained, even though many students would not be interested, he would be – as an Aboriginal student.

At the end of the interview, I asked participants what the value of “science is for Aboriginal people in general. Half of the participant’s stated that science can empower Aboriginal people. Fiona explained, “in a lot of ways, science is used against Aboriginal people,” but by having scientific knowledge, Aboriginal people will “understand why things are the way they are – mostly why anything happens is because of non-Aboriginal people – cause there is so many of them doing everything.” Fiona implied that issues in Aboriginal communities have the potential to improve if Aboriginal people have the knowledge to make decisions and do the work in their communities themselves, as opposed to relying upon non-Aboriginal people. Alan said that having scientific knowledge can help Aboriginal people better deal with diseases and illnesses that have a greater impact on Aboriginal people than non-Aboriginal people, explaining, “some ... diseases attack different races more and I think studying more ourselves [and] figuring out how we can help ourselves.” An example that Alan gave was cancer, which he said is prevalent on both sides of his family. Tim said that science is “under-valued in most communities, ... but I think it’s pretty important to learn it if you can – ... knowledge of anything could help communities.” Similarly, Maya explained:

There [are] so many aspects of science, but I think knowledge is power, as some people say, and that’s a good thing to have – [for Aboriginal people] to be able to make changes in their world that need to happen.

There’s so many different ways that it’s beneficial.

Howard’s answer was also about the potential for science to empower Aboriginal people when making decisions, “it’s just to be able to understand what’s around you more and

understand what's going on in the world so you can judge what actions you should make.”

A slightly different response was from Abby, who said that science can be useful for Aboriginal students if it is relevant to their post-secondary plans: “I think most Aboriginal people don't agree with science [but] it's a good source of education and in case any Aboriginal student wants to get into anything that requires science, that's the benefit to learn it.” Elaine said that having science means “having a bigger perspective of what's out there ... it's a part of everything we are around.” Wendy believed that science is valuable to all people, “I think everyone has the right to equal opportunity and it can just be useful to anyone, non-exclusively.” It is clear that the participants are aware of the many ways science can be of value to Aboriginal people, whether to empower Aboriginal people or communities, or to learn how to better deal with health issues that afflict Aboriginal people, or simply the overall benefit of having a more extensive knowledge base regarding the world.

The Group Interview

One month after the last of the ten individual interviews had been conducted, I invited all of the participants to a group interview. It was difficult finding a day that worked for all of the participants, and once the date was finalized, five out of ten participants made it to the group interview. I asked the same overall questions to the group as I had asked during the individual literal interviews. What I found was that the participants gave

almost the exact same answers in the group setting as they did in the individual interviews, showing reliability. The dynamics of the group did not cause the participants to change their answers, and nor did the passage of time, showing consistency of the data. The five participants who made it to the group interview included Fiona, Elaine, Russell, Tara and Howard. For each of these participants, I have provided two examples from the group interview which show great consistency with the individual interviews.

Fiona

During the group interview, I asked the participants why they believed that they did so well in senior secondary science. Fiona's response was almost exactly the same as responses that she gave during the individual interview:

A huge part of it was just the kind of environment that I was in at the time, just with the counselling that you get at the high school level with the First Nations counsellor. I just found it troubling that I was always basically told just to graduate ... whereas I had this goal of becoming, like doing something really great, so I thought that was the most bizarre thing and I basically wanted to prove that, you know, 'I can get a really good grade too! I can do better than just graduate!'"

When I asked the group to describe what they didn't like about secondary science, Fiona's response was very similar to the one that she gave during the individual interview:

What I didn't really like was that it's very surface level and it's given to

students as the only option. There are no other ways of looking at why things are the way they are. ... It's purely North American, or Eurocentric or European thought, so that's pretty annoying; ... but if there were more options, that would be a lot more interesting I think.

Elaine

In the group interview, Elaine reiterated that she took senior secondary science because she wanted to, and that she did well in it because she had the internal drive to do so:

I took the course because I wanted to take it. I didn't have to take it. It was something that I chose to do. Going into it, I wanted to succeed and I worked to get to the point where I would do well in the end. It was just my own motivation, pushing myself through.

When I asked the group to describe what they didn't like about secondary science education, Elaine stated, "it's taught so abruptly, like we go through so much in such a little amount of time that if something interests you, you don't really have time to stop and learn and go deeper into it." This answer was consistent with Elaine's responses throughout the individual interview when she said that there was not enough freedom for her to explore what she wanted to explore in secondary science courses.

Russell

As in the individual interview, Russell's responses in the group interview were very brief and non-descript. When I asked the group why they decided to study senior secondary science, Russell replied, "I'm going to become a carpenter, so in case I need a new job, I would be able to go back to school more easily." In the individual interview, Russell had also stated that he took senior secondary science as a back-up plan, should his career as a carpenter not work out. When I asked the group to explain their choices from the individual-metaphor interview questions which explored their relationship with science, Russell responded, "I just picked the one that is the least involved with science when you are learning about it." During the individual metaphor interview, Russell had also explained that he was intentionally picking the most passive of the responses available.

Tara

When I asked the group why they believed they had made it so far in their education, Tara said:

I wanted to set an example for my siblings. Mostly, I wanted my parents to be proud of me. My dad never graduated, so he was really happy when my sister did and I wanted to make him proud of me too.

Tara's response went into a little more detail during the group interview, but the essence of her answer was exactly the same as it was during the individual interview. Next, I asked the group what it means to be a successful student, and Tara replied, "finishing

what you set out to do. Like if you start something, I feel successful if I finish it, instead of leaving it in the middle.” Several times during the individual interview, Tara described science as being challenging, but she emphasized the feeling of personal accomplishment that she felt by finishing a science course.

Howard

Howard explained in the group interview why he believed he had made it far in his education: “it used to be just because I was bored and had nothing better to do. Now I just want to finish so I can get on with my life.” Howard’s answer was stated in a slightly different way than in the individual interview, but the overall meaning of his answer was the same. When I asked the group how they thought students would react to the inclusion of Aboriginal knowledge in secondary science classes, Howard answered, “I think because a lot of the students are very close-minded about how things should be, a lot of them wouldn’t like it, but some people would really enjoy it.” This was the same explanation that he gave during the individual interview.

Summary of the Group Interview

Though only half of the participants made it to the group interview, the responses given by all five of the participants who were present were so strongly consistent with the responses given by each of them during the individual interviews that it can be assumed that there would have also been similar consistency amongst the other participants had they made it to the group interview. The participant’s did not alter their responses due to

the group setting and in many instances, their answers were exactly the same as they were in the individual interviews. The group interview was important in establishing the validity of the data and served to triangulate the data. The individual interview started with the metaphor interview, assessing each participant's thoughts about and experiences in senior secondary science. The second part of the individual interview was the literal interview, again designed to assess each participant's thoughts about and experiences in senior secondary science. The group interview followed the same pattern as the individual interviews. The results of this study show tremendous consistency across all three formats and their word-for-word responses provided a true representation of what each of them thought about senior secondary science and their experiences in these courses, hence this study shows high validity, or truthfulness, or the participants' thinking.

CHAPTER 6: SUMMARY, IMPLICATIONS, AND FURTHER RESEARCH

Summary

In summarizing this study, I have addressed the three research questions that I established at the very beginning of this study to frame my research, based on my analysis of the data collected from the ten individual interviews and the group interview.

What are the experiences and perceptions of successful Aboriginal students with regard to senior secondary science?

This participant group has, for the most part, a positive and holistic understanding of what constitutes “science.” This observation is based on the metaphors that the participants created to describe science as an animal and as an object, their responses to metaphor choices, and their individual definitions of “science.” The participant who seemed to be the most critical of science was Fiona, who perceived science as something man-made, inconsistent, and constantly changing. She also viewed science as being very oppositional to an Aboriginal worldview and saw science as having a negative impact on Aboriginal people’s efforts to gain recognition of Aboriginal rights and title. Several of the participants perceived science from a Western perspective that did not allow for the inclusion of spirituality or content that was not fact-based.

The participants were able to describe aspects of senior secondary science that they disliked, particularly what they perceived to be as the repetitive, scripted, and passive nature of science education. Participants described senior-secondary science as

being driven by a prescribed curriculum that leads up to provincial exams with an extensive amount of content that is presented primarily from the textbooks and note-taking. Participants described the fast-pace of the science curriculum, leaving little room for increased hands-on learning opportunities or group work. Contrarily, participants described science as being a lot more creative, fun and interactive in their younger grades, but explained that much of this creativity is lost in higher-level science courses. All but one of the participants could recall a specific childhood memory of learning about science in a way that was interactive and hands-on. Senior-secondary science was also described as competitive with a lot of emphasis placed on test results. Almost all of the participants described having a very passive role in their science classes, with little opportunity to direct their own learning or explore topics that were of interest to them.

Despite their criticisms of senior-secondary science, the participants were also able to identify aspects about science education that they liked. The majority of participants enjoyed hands-on learning opportunities through lab-work, dissections, or field trips. All of the participants were able to identify specific knowledge from science that was either interesting or relevant to them. As a group, the participants seem to have an innate sense of curiosity, drawing them to the sciences and giving them a greater understanding of themselves and the world around them.

Though all of the participants in this study achieved high academic success in senior-secondary science, the majority did not plan to continue studying science at the post-secondary level or to pursue science-related careers. The three participants who did plan to pursue science in post-secondary or in their careers were inspired to do so by

experiences and courses taken at the secondary level. These results are similar to findings from a massive research report commissioned by the Canadian Council of Learning called *Who Likes Science and Why?* in which surveys were completed by approximately 23, 200 13 – 16 year-old students in Canada:

It is certainly discouraging to find that, although over 85% of students in this study agree that science is useful for society, too many remain disengaged from the process of science learning; in fact, less than 40% expect to use science in their careers [This study] builds on previous research which indicates participation and success in mathematics and science ... involves not only skills and knowledge, but is largely determined by positive attitudes towards these disciplines during school years.

(Adamuti-Trache, 2006, Abstract section)

It is important to make secondary science more engaging and interesting for Aboriginal students if we hope to inspire more of them to continue in science-related studies or careers. The participants made recommendations as to how they believe science education can be improved. Of utmost importance, the participants stated that science education must be more hands-on, creative and fun. They also recommended that science curriculum be more flexible, allowing for content to be more student-driven and individualistic. A few of the participants also said that it would be important to include more perspectives in science, other than the Western perspective, most notably the Aboriginal perspective.

What role, if any, does culture play for Aboriginal students who are successful in the senior-secondary sciences?

Cultural connection was not a significant contributing factor towards this participant group's success in senior-secondary science. All of the participants were living in Victoria, off-reserve, and away from their cultural communities. Aboriginal ancestry for most of the participants came from areas outside of BC. Most of the participants had mixed Aboriginal and non-Aboriginal ancestry and most described having a very weak level of cultural connection. For the most part, the participants represented a very urban group of Aboriginal students who had spent little if any time in their Aboriginal communities. Cultural connection for most of the participants was limited to connections with family. A few of the participants described being culturally connected through the study of Aboriginal courses or programs, and only one participant described returning to his Aboriginal community regularly to participate in cultural activities.

Based on his extensive experience working with a wide range of Aboriginal students at the secondary and beginning-college years, Indigenous researcher Gregory Cajete classifies students into three overall groups:

1. Rural traditional: students [in this group] are the least assimilated and have a strong orientation to traditional Native American patterns and personality configurations. They usually live in their tribal communities Their social and community orientations can be said to be nominally syncretised or

interwoven with non-Native perspectives Most expressed the desire to return and live on their reservations once they completed their education.

2. Transitional: students [in this group] are characterized by movement toward the assimilation of many American socio-cultural, economic and personal norms in preference to traditional Native American cultural patterns.

Members are from both rural or urban areas These students maintain close connections to their tribal culture and community, frequently visiting relatives and friends Students from this group expressed the desire to gain the best from both the traditional Indian groups and mainstream American society.

While they realized that there were many difference between these two cultural orientations, they expressed optimism about being able to achieve a balance between two worlds. These students can understand and speak some tribal language and have basic knowledge of tribal culture.

3. Urban assimilated: this group [of students] is characterized by an almost complete assimilation of American cultural norms. Members from this group are usually of urban orientations, however, a number can also come from small town or rural social environments Many members of this group are second or third generation “urban Indians” and have only a nominal relationship to their ancestral tribal community. The syncretization of Native American and non-Native cultural patterns is slanted toward American urban cultural norms. Yet “urban Indians” early took the lead in advocating

culturally-relevant education to “revitalize” their Native American tribal identities. (Cajete, 1999, p. 19 – 21)

Cajete’s work was with students in the U.S., but it is fair to say that his classification system for Aboriginal students is also applicable to students in Canada as the history that unfolded between Aboriginal and non-Aboriginal people in the U.S. and Canada was very similar. The contemporary social settings in the two countries are also basically the same: urban, small town, and tribal communities (or reserves). In looking at Cajete’s classification system, 9 out of the 10 participants in this study belong to the third group, “urban assimilated.” These students have very weak cultural connections to their Aboriginal identities or traditional communities. This is not to say that they do not have an interest in the Aboriginal worldview, though most of what they have learned about this perspective has come from studies at school or university. Some of these participants desire to “revitalize” their traditional Aboriginal identities, just as Cajete described above.

Only one participant in this study belonged to the second group, “transitional.” This would be Alan, who despite being born in his traditional Aboriginal community, but raised in a distant urban setting, has maintained a strong connection to his traditional community and continues to participate in cultural practices. At the same time, Alan is mostly assimilated into the mainstream, urban culture.

None of the participants in this study belong to the first group, “rural traditional,” which has some serious implications. The participants in this study did very well in a largely Western-based secondary-science education, but the majority of these participants were “urban assimilated.” Where does this leave Aboriginal students who are more

strongly culturally connected? Are they able to navigate through the mostly Western-based science education programs? I cannot offer any insight into the experiences of the most-culturally connected group as there were not any volunteers who came forward to participate in this study who belonged to this group, leaving me to wonder how many, if any, strongly-culturally connected Aboriginal students there are in this school district and beyond who are participating in and achieving academic success in the senior-secondary hard sciences.

The participants described their overall experience in school and in their science classes as being the same as that of non-Aboriginal students. A few participants described particular racist or discriminatory incidents at school, but said that overall, their experiences were the same as other students. One participant said that she would have looked just like any other student in her science classes from an outsider's perspective, but she was very aware from an internal perspective that she was usually the only Aboriginal student in her science classes.

Despite having an overall weak Aboriginal cultural connection, the majority of participants selected at least one predominantly Aboriginal-themed option during the metaphor interview to describe science. These metaphors included *feast/potlatch*, *story/legend*, *totem pole*, *longhouse*, *carving*, and *medicine wheel*. In explaining their metaphor choices, all but one of the participants demonstrated a cultural understanding of what these metaphors represented. Similarly, all but one of the participants was able to provide examples of Aboriginal scientific knowledge, even though all of the participants had said that Aboriginal knowledge had never been a part of their science education. All

but one of the participants stated that Aboriginal knowledge should be included in senior-science education and could explain why they thought science was valuable to Aboriginal people in general. Though most of the participants have a weak cultural connection, they still have an intrinsic understanding of Aboriginal culture and an affinity to learning more about it. Having Aboriginal ancestry is an important aspect of these participant's identities.

The influence of being exposed to Aboriginal knowledge cannot be denied. For one participant, her entire career path and perspective about science changed once she had the opportunity to take an Aboriginal-based elective in her first year of university. Now, instead of becoming a scientist or a doctor, she plans to continue with Aboriginal studies so that she can eventually bring more awareness to and empower Aboriginal people. Two other participants also planned to take Aboriginal programs at post-secondary, and both of them had been inspired to do this by taking First Nations Studies 12 during high school. One can only imagine the interest that could be generated amongst Aboriginal students if Aboriginal knowledge was made to be a fundamental part of science education. In order for a continued interest in science to happen, Aboriginal students must be able to see that "science" does not necessarily have to be oppositional to an Aboriginal worldview and that "science" can also help and empower Aboriginal people.

What are the factors that either contribute to or hinder success by Aboriginal students in science-related courses?

The participants of this study represent a highly successful group of Aboriginal students. Each of them was in the final stages of completing high school, or had already graduated and moved onto post-secondary studies. In reviewing their experiences in school, a few commonalities stood out. Firstly, all ten participants had a connection to high school outside of their regular classroom studies, meaning that each of them was involved with clubs, teams, or other extra-curricular activities. A report by the Canadian Council on Learning states:

Research shows that participation in recreational and cultural activities is linked to increased expectations for young people about their future education Young people who participate more frequently in recreational and cultural activities tend to complete college or university programs more often than those who participate less or never participate. (Canadian Council on Learning , 2009, p. 38)

Participation in extracurricular activities represents a genuine investment by students in their education and pursuit of self-interests.

Secondly, all of the participants had an individualized understanding of what it meant to be successful and could identify factors that had contributed to their success in school. The majority of participants said that internal motivation was an important factor in achieving school success, and several also stated the positive influence of role models or feeling a desire to please family. These students did well in school because they

wanted to and because they had supportive families who were interested in how they were doing in school. “Research shows that the quality of family relationships can significantly affect a child’s development and educational outcomes, largely because parenting styles and practices bear a strong influence on a child’s attitudes and efforts in school” (Canadian Council on Learning, 2009, p. 19). Also, the participants identified coping strategies that they could use when school became difficult.

Thirdly, all of the participants had long-term goals. Even if they were not exactly sure what they were going to study at post-secondary or what career path they would take, all of the participants had ideas of what they were going to do after high school. Having a vision of their futures seemed to be an important contributing factor towards school success. The post-secondary or career goals for the majority of the participants were inspired by experiences or courses taken at the secondary level.

All of the participants had achieved academic success in senior secondary science, but when I asked what made them “successful” science students, they gave a range of different indicators of personal success in science. The majority of participants felt successful in science because of their work ethic towards science, including the extra effort that they made to do well, practicing good study or work habits, or being able to help other students. Good grades, test marks, and report cards were also important, but not as important as the personal feeling of accomplishment that was associated with these results. Half of the participants also said that they felt successful in science because of the knowledge that they had gained from taking the courses. A few of the participants also said that they had a natural ability to do well in science, likely connected to their

overall interest in or affinity for the sciences. Adamuti-Trache (2006) states: “interests, values, beliefs, attitudes, and self-confidence are individual attributes that support achievement and success in any practice, be it science, sports, or writing” (p. 15).

Though the participants had all achieved academic success in senior secondary science, each of them could also identify times when they did not feel successful in science. Many of the participants felt unsuccessful when they struggled to do the work correctly, such as figuring out Physics or Chemistry equations, or if they had put their best effort into an assignment, test or course, but still did not get the expected results or grades. More than half of the participants stated poor marks as being an indicator of lack of success in science. There were several examples given in which participants described not doing well in science due to the teacher’s style of instruction or assessment. In one case, the participant ended up dropping a senior secondary Physics course because she was getting a poor mark in spite of making every effort possible to learn the material. A few participants also described feeling unsuccessful in science if they were exhausted by the amount of content or if they had difficulty staying focused. It is noteworthy that two of the participants said they did not ever feel unsuccessful in science because they had defined success for themselves, which was based on reaching personal goals, as opposed to reaching external indicators of success, such as grades or marks.

Recommendations for Science Education

As a result of this study, there are several recommendations that can be made regarding science education at both the teacher level and at the Ministry of Education level.

The participants of this study have reinforced the importance of teaching to a variety of different student-learning styles. The introduction of every secondary-level Integrated Resource Package (I.R.P.) states that:

1. Learning requires the active participation of the student.
2. People learn in a variety of ways and at different rates.
3. Learning is both an individual and group process.

(Ministry of Education, 2008, p. 11)

Yet, the major criticisms that the participants of this study voiced regarding senior-secondary science instruction indicate that these three principles of student learning are not always being met. Students described their involvement in senior-secondary science as being primarily passive with little opportunity for individualized learning. Students need to be given ample opportunities to explore topics that are of interest to them. The curriculum requirements of senior-secondary science courses can still be met with the inclusion of individualized learning. The importance of hands-on, participatory learning cannot be emphasized enough.

Learning from the textbook and from teacher-led lessons is important, but these are only two ways of presenting content. Content can also be addressed through hands-on learning opportunities, individual research, group work, field trips or guest speakers.

Students are more likely to develop a deeper interest in science if it is an interactive experience for them, rather than a passive experience which places an emphasis on rote methods of acquiring knowledge, including lectures, notes and memorization. Such methods of instruction are also in stark contrast with traditional Aboriginal ways of learning, and this may further alienate Aboriginal students who bring with them a strong sense of cultural connection. As Cajete (1994) explains:

For many Indian students, conventional science courses are seen as dry and mechanical, comprised of memorizing facts and formulas, taking tests and answering questions from the back of their textbook. The process has little to do with their lives. For the more traditionally raised students, school science is viewed as a tool for the desecration and exploitation of their reservations. Alienation from science, as it is conventionally taught, is widespread among Indian students This alienation from science has resulted in lack of scientific expertise among all tribes, leaving them vulnerable to exploitation and dependency on non-Indian consultants for decisions related to resource development, health, and other areas requiring scientific expertise. (p. 197)

Students should be able to describe their senior-secondary science experiences as being just as creative and interactive as their science experiences from their younger grades.

Cajete (1999) states:

Science is first, last and always a creative process and should be taught as such. Science is not merely a body of facts which must be memorized.

Its learning involves the development of creative potentials and the cognitive abilities of logic, observation and evaluation. (p. 71)

It is important to foster students' interest in science if it is our goal to have more students, in this case more Aboriginal students, plan to pursue science at the post-secondary level and science-related careers.

The participants of this study have articulated the tremendous impact that methods of assessment can have on their individual perceptions of success, or lack thereof, in science courses. Test results provide only one method of assessment, and other types of assessment should also be included as often as possible. The "Student Achievement" section at the beginning of every secondary-level I.R.P. states that:

Students benefit the most when assessment feedback is provided on a regular, ongoing basis. When assessment is seen as an opportunity to promote learning rather than as a final judgement, it shows students their strengths and suggests how they can develop further.

Science is challenging for many students, but assessment does not have to be unduly challenging and should be fair and allow students opportunity to be successful. Students who do not feel successful in a course are more likely to lose interest in the subject material, or even worse, drop the course altogether, as was the experience of one of the participants in this study. Assessment can be rigorous, as long as students know exactly how to prepare for an assignment or test. Positive assessment results can give students an immense sense of personal accomplishment, as evidenced by the participants in this study.

Wherever possible, it is also important at the senior-secondary science level to incorporate Aboriginal knowledge. Students in science should experience an equal representation of both Western and Aboriginal knowledge. According to Cajete (1999), “we are all capable of having more than one internally consistent mindset concerning reality. Western scientific schooling often makes it seem otherwise, and such conditioning eventually stifles creative learning” (p. 140). Aboriginal knowledge is not a part of the prescribed learning outcomes at the Grade 11 and 12 science levels, but the participants of this study have explained how important they believe it is to see Aboriginal knowledge included at the senior-secondary level. Grade 11 and 12 are formative years for students as they transition into adulthood. Hodson defined adolescence as “a crucial transition stage in the formation of lasting attitudes, aspirations, and viewpoints” (as cited in Mosconi & Emmett, 2003, p. 70). It is therefore essential for adolescents to continue seeing Aboriginal knowledge represented and valued beyond the Grade 10 year as this may have a major influence in their post-secondary or career goals.

It is also important that students have the opportunity to learn in science that Aboriginal knowledge and Western knowledge are not necessarily oppositional forces, but can co-exist to provide a wider understanding of the world. Three of the participants in this study had once considered pursuing science-related post-secondary studies, but once they had been introduced to the Aboriginal worldview, whether in BC First Nations Studies 12 or in first-year university courses, decided to pursue Aboriginal programs instead. Students should be made aware in their studies that they can still work towards the empowerment of Aboriginal people using science.

The results of this study provide grounds to make recommendations at the Ministry of Education level. First, it must be acknowledged that the inclusion of Aboriginal content in the K – 7 science curriculum in the revised I.R.P in 2005, and in revised 8 – 10 science I.R.P. in 2006 was a giant step in the right direction in terms of the inclusion of Aboriginal knowledge in science curriculum for all students. Now, all students, Aboriginal and non-Aboriginal, will experience a consistent, though minimal, representation of Aboriginal knowledge from kindergarten to Grade 10 – an experience that was not available for the participants of this study as they went through the public education system before these changes were made. One recommendation, however, would be to extend the inclusion of Aboriginal content into the I.R.P.'s of all senior-secondary science courses. It is important for students to experience both Western and Aboriginal perspectives right through to graduation. Again, this could have major implications in the decisions of Aboriginal students in whether or not to continue studying science beyond high school. If it is not feasible to integrate Aboriginal content into each senior-secondary science course, then a new course should be developed that focuses exclusively on Aboriginal knowledge and this course should be made an option for all students in satisfying their science graduation requirements.

The *Shared Learnings* resource by the Ministry of Education provides teachers with ideas on how to integrate Aboriginal knowledge into all subject areas from Kindergarten to Grade 10. Another recommendation, based on the results of this study, is that the *Shared Learnings* package also include Grades 11 and 12. As previously stated, the senior-secondary grades are formative years for all students and as such, the inclusion

of Aboriginal knowledge should not fade out beyond Grade 10. Students have the option of taking BC First Nations Studies 12 and English 12 First Peoples, but these are not required courses and they are not available at all schools, so Aboriginal content should be a component of all regular classes in addition to Aboriginal elective courses. *Shared Learnings* would provide teachers at the Grade 11 and 12 level with ideas on how to incorporate Aboriginal knowledge into their courses, in this case, senior-secondary science courses.

An authentic incorporation of Aboriginal knowledge into mainstream science programs would have wider, positive implications for our quickly-deteriorating environment. Knudtson and Suzuki (1992/2006) explain how Western science has contributed to the environmental issues of today:

Although scientists have been leading voices in describing the hazards we face, their fragmented acquisition of knowledge creates a mosaic of disconnected bits and pieces that does not provide an overarching context to guide our actions. In a shattered world, it is impossible to recognize how we are interacting with and affecting the parts. (p. xxv)

Knudtson and Suzuki (1992/2006) believe that widening the scope of science has the potential to “awaken human hearts to a visceral sensibility for the whole” (p. 161) and they state that an important part of this would be the inclusion of an Aboriginal worldview: “perhaps in Native perspectives on nature we will begin to find a morally responsible ‘sacred ecology’ to complement our conveniently human centered, ‘value-free’ secular and scientific one” (p. 161). It is becoming increasingly obvious to all of us

that we cannot continue to function in the world as we have been and that changing the ways in which we function in the world is no longer an option for consideration, but a dire necessity if the world and everything it encompasses is to survive. The inclusion of an Aboriginal worldview in science education would impart greater personal, social, and environmental responsibility on all students.

One final recommendation that can be made at the Ministry of Education level is to incorporate learning outcomes in the senior-secondary science curriculum which would require students to research post-secondary science areas and also science-related careers. All of the content in the senior-secondary science curriculum is content-based, and there is a need during these grades to establish much stronger connections between the secondary, post-secondary and career levels. According to Brown's value-based career theory, "a student must have career direction before she or he is motivated to set goals toward that end. According to this theory, a person's values are formed through continuous interaction with family, school, and other environmental influences" (as cited in Mosconi & Emmett, 2003, p. 76). For Aboriginal students, this type of learning outcome at the senior-secondary level would allow them to see that science education could help them empower or assist Aboriginal people or communities through healthcare, resource management, or research. At the Grade 11 and 12 levels, students should have greater opportunities to go to a local post-secondary institution to see what science education looks like there and also to meet Aboriginal role models who are in science-related careers.

Implications for Further Research

The participants of this study have provided much insight into the experiences and perceptions of Aboriginal students who are successful in senior-secondary science, but the results also raise many questions which could be addressed through further study and research. The participants are representative of one sub-sect of the general Aboriginal secondary population. All of the participants of this study were living in the large urban setting of Victoria, and the majority had spent minimal if any time in their Aboriginal communities. The participants described having an overall weak level of cultural connection, though they also articulated that having Aboriginal ancestry was an important aspect of their identities. These participants were able to navigate quite comfortably through their secondary education program and senior-secondary science courses. For the most part, they did not feel different from other students due to their Aboriginal ancestry. This study raises an important question: Do Aboriginal students who have stronger cultural connections perceive secondary science differently, and what impact does this have on their participation, achievement, and experiences in senior-secondary science? It would be valuable to conduct a similar study with Aboriginal students who are living in their Aboriginal communities to gauge their experiences and perceptions about science. In addition, it would also be useful to conduct a similar study with Aboriginal students who have an aversion to the senior-secondary hard sciences to find out what their aversion is rooted in.

In 2005, Aboriginal content was added to the K – 7 curriculum and in 2006, it was added to the 8 – 10 curriculum. Another area of research would be to investigate the impact that the inclusion of Aboriginal content is having on Aboriginal students. None of the participants in this study had experienced the changes in the science curriculum as these changes were made after they had completed Grade 10. Would the results of this study have been different due to the inclusion of Aboriginal content in the present-day science curriculum, or would the results have been the same? Further research could help to assess the impact of the new Aboriginal science curricula on Aboriginal students.

Lastly, it would also be valuable to conduct a similar research study with Aboriginal post-secondary science students and scientists. The results of this study have shown that for this group of Aboriginal participants, academic success in science did not necessarily translate into a desire to pursue studying science at the post-secondary or career levels. Conducting research with Aboriginal post-secondary science students and scientists would provide some insight into the reasons why these students were able to maintain a connection to science beyond their high school education. This information could help in finding ways to bridge the gap between secondary and post-secondary science education for Aboriginal students.

Ultimately, it is the goal of this research study and in the recommendations for further research to strategize ways to establish a stronger interest in the sciences for Aboriginal students. If this interest is not maintained at the secondary level, Aboriginal students are less likely to choose science-based post-secondary programs or career paths. Aboriginal science students are vital in taking on future endeavours which will allow

them to further protect Aboriginal communities, resources, and the overall health and wellness of Aboriginal people. As Aboriginal people work to empower their people and communities and to become more autonomous, the need for Aboriginal scientists and health practitioners could not be greater. In order to meet this need, we must re-evaluate our science education programs and means of delivery, learn from the elders, and listen to the advice from Aboriginal students in deciding what changes need to be made.

Closing Thoughts

Conducting this research study has allowed me to think back to my own experiences in high school as an Aboriginal science student. I realize that my experience was very similar to those of the participants of this study. In my grade 11 and 12 years, I too was living in Victoria and had never lived in my Aboriginal community. I felt a lot of uncertainty as to what it meant to be an Aboriginal person and I did not fully embrace this part of my identity until I became an adult. I do not remember why I decided to take Biology 11 in high school, but I do remember absolutely loving what I was learning in that class. So, I decided to take Biology 12 and loved it even more! When I started college, I was not exactly sure what I wanted to do in terms of a career choice, but I decided to continue studying the two subjects that I liked the most from high school: English literature and biology. I sampled as many different kinds of biology courses as I could, including microbiology, comparative anatomy, entomology, genetics, and cellular biology, just to name a few. As I neared the end of my undergraduate degree, a career

choice became obvious to me which would allow me to continue with my connection to English literature and biology: teaching.

In the past ten years, I have taught a wide range of courses, including English and science courses. But, my area of teaching focus shifted once I experienced teaching courses that emphasized an Aboriginal perspective – namely BC First Nations Studies 12 and English 12 First Peoples. I now specialize in teaching Aboriginal-themed courses and working as an academic counsellor for Aboriginal students. Like some of the participants in this study, my own perspective shifted as I became more connected to my Aboriginal identity and had increased opportunities to teach courses from this perspective.

Working with the ten participants of this study was an incredible opportunity. They embodied some of the most admirable qualities of successful students: they were motivated, resilient, goal-orientated, and dedicated to their education. They were also very perceptive and insightful with regard to their thoughts and opinions about secondary-science education. They were able to describe not only the qualities of good science education, but also the less desirable qualities of science education. They were able to make succinct recommendations about how to improve science education and explain why they felt these changes were important. The participants of this study have enlightened me, and I hope that impact of what they have shared is felt at a much larger level. If we as educators implement the changes that they have suggested, we could definitely help to shape and improve science education for Aboriginal students. In closure, I would like to go back to the words of Rita Joe, shared in her poem listed on the

first page of this thesis, as I feel that the participants of this study embody the essence of what this poem and this research study are about:

*To be great in all learnings,
No more uncertain.
My pride lives in my education,
And I will relate wonders to my
people.*

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APPENDIX A: Consent Letter to Local Chiefs

[Sample]

Chief _____
 _____ First Nation
 [Address]

[Date]

The Experiences of Aboriginal Students who are Successful in the Senior Secondary Sciences

Dear Chief _____,

My name is Anne Tenning and I am a graduate student from the University of Victoria in the department of Education. I am a member of the Chemainus First Nation and a visitor on your traditional territories. In addition to being a graduate student, I am a teacher and Aboriginal academic counselor at Victoria High School. I am writing this letter to ask for your consent to conduct a research study entitled, **“The Experiences of Aboriginal Students who are Successful in the Senior Secondary Sciences.”**

I am conducting this research study as part of the requirements for a degree in Masters of Arts. It is being conducted under the supervision of Dr. Lorna Williams. You may contact my supervisor at 472-5499 or by e-mail at lornawil@uvic.ca.

The purpose of this research project is to learn about the experiences of Aboriginal students who are successful (meaning final academic achievement of at least 67%) in senior secondary (Grade 11 or 12) Biology, Chemistry, or Physics.

Research of this type is important because the participation of Aboriginal students in senior secondary Biology, Chemistry, and Physics is significantly lower than that of non-Aboriginal students. The importance of this research study is to find out if there are any common themes in the experiences of the participants to explain why they succeed in senior secondary science courses. The majority of Aboriginal students avoid taking these courses altogether.

There will be ten Aboriginal participants in this study. The participants will be current students of the Greater Victoria School District or former graduates. The participants will self-identify as status, non-status, Métis, or Inuit. The students may be from a local community, a distant community, or it is possible that some of the students may not know what Aboriginal community he/she is from.

The participants of this study will participate in two interview sessions with me that will be audio-recorded. The first interview is a metaphor interview which will help me to learn about the participants' perceptions about science. The second interview will involve questions that allow the participants to describe his/her experiences as successful

science students. Lastly, all ten participants will attend a group meeting near the end of the study so that I can present my research findings to them. The participants will have an opportunity to respond to my conclusions.

There are no known or anticipated risks to the students by participating in this research. A potential benefit of this research study will be achieved when the findings are shared with educators. Educators can use the research results to encourage more Aboriginal students to take science courses at the senior secondary level.

The participation of participants in this research study will be completely voluntary. Whether or not the students participate will have no bearing on his/her grades or standing in school. Participants may withdraw from the study at any time without any negative consequences and he/she will not be asked to provide any explanation. If a participant withdraws from the study, his/her data will not be included in the study and his/her data will be destroyed.

The anonymity of the participants will be protected because each participant will be given a pseudonym that will be used to identify him/her in the research. The participants' real names will not be used in any of the published results.

The confidentiality of the research data will be protected by storing printed transcriptions of the interviews in a locked filing cabinet located in my work office at Victoria High School. My office is locked and only I have a key to the cabinet. All digital audio recordings of the interviews will be saved on my personal computer which is password protected. Only I use this computer.

It is anticipated that the results of this study will be shared with others in the following ways:

1. The results of the study will be shared with all ten participants in a group meeting.
2. The results of the study will be presented at my thesis dissertation.
3. The results will be summarized in an article to be published in an educational journal.

The participants' anonymity will be preserved by using their pseudonyms in all forms of results sharing.

Data from this study will be disposed of once I have presented my research to my supervisory committee at my thesis dissertation at the University of Victoria. All typed transcriptions of the interviews will be shredded in a paper shredder. Audio recordings and transcriptions saved in my computer will be deleted.

You may contact any of the following individuals if you have any questions or concerns regarding this study:

- The Researcher: Anne Tenning at atenning@sd61.bc.ca or at work at 388-5456.
- My U-Vic Supervisor: Dr. Lorna Williams at 472-5499 or lornawil@uvic.ca .

APPENDIX B: Consent Letter to Coordinator of Aboriginal Education

[Sample]

Ms. Nella Nelson
Greater Victoria School District
Coordinator – Aboriginal Nations Education Division
PO Box 700, 556 Boleskine Rd..
Victoria, BC
V8W 2R1

[Date]

**The Experiences of Aboriginal Students who are
Successful in the Senior Secondary Sciences**

Dear Ms. Nella Nelson,

My name is Anne Tenning and I am a graduate student from the University of Victoria in the department of Education. I am a member of the Chemainus First Nation and an Aboriginal academic counselor at Victoria High School. I am writing this letter to ask for your consent to conduct a research study entitled, “**The Experiences of Aboriginal Students who are Successful in the Senior Secondary Sciences.**”

I am conducting this research study as part of the requirements for a degree in Masters of Arts. It is being conducted under the supervision of Dr. Lorna Williams. You may contact my supervisor at 472-5499 or by e-mail at lornawil@uvic.ca .

The purpose of this research project is to learn about the experiences of Aboriginal students who are successful (meaning final academic achievement of at least 67%) in senior secondary (Grade 11 or 12) Biology, Chemistry, or Physics.

Research of this type is important because the participation of Aboriginal students in senior secondary Biology, Chemistry, and Physics is significantly lower than that of non-Aboriginal students. The importance of this research study is to find out if there are any common themes in the experiences of the participants to explain why they succeed in senior secondary science courses. The majority of Aboriginal students avoid taking these courses altogether.

There will be ten Aboriginal participants in this study. The participants will be current students of the Greater Victoria School Districts or former graduates. The participants will self-identify as status, non-status, Métis, or Inuit. The students may be from a local community, a distant community, or it is possible that some of the students might not know what Aboriginal community he/she is from.

The participants of this study will participate in two interview sessions with me that will be audio-recorded. The first interview is a metaphor interview which will help me to learn about the participants' perceptions about science. The second interview will involve questions that allow the participants to describe his/her experiences as successful science students. Lastly, all ten participants will attend a group meeting near the end of the study so that I can present my research findings to them. The participants will have an opportunity to respond to my conclusions.

There are no known or anticipated risks to the students by participating in this research. A potential benefit of this research study will be achieved when the findings are shared with educators. Educators can use the research results to encourage more Aboriginal students to take science courses at the senior secondary level.

The participation of participants in this research study will be completely voluntary. Whether or not the students participate will have no bearing on his/her grades or standing in school. Participants may withdraw from the study at any time without any negative consequences and he/she will not be asked to provide any explanation. If a participant withdraws from the study, his/her data will not be included in the study and his/her data will be destroyed.

The anonymity of the participants will be protected because each participant will be given a pseudonym that will be used to identify him/her in the research. The participants' real names will not be used in any of the published results.

The confidentiality of the research data will be protected by storing printed transcriptions of the interviews in a locked filing cabinet located in my work office at Victoria High School. My office is locked and only I have a key to the cabinet. All digital audio recordings of the interviews will be saved on my personal computer which is password protected. Only I use this computer.

It is anticipated that the results of this study will be shared with others in the following ways:

- The results of the study will be shared with all ten participants in a group meeting.
 - The results of the study will be presented at my thesis dissertation.
 - The results will be summarized in an article to be published in an educational journal.
- The participants' anonymity will be preserved by using their pseudonyms in all forms of results sharing.

Data from this study will be disposed of once I have presented my research to my supervisory committee at my thesis dissertation at the University of Victoria. All typed transcriptions of the interviews will be shredded in a paper shredder. Audio recordings and transcriptions saved in my computer will be deleted.

You may contact any of the following individuals if you have any questions or concerns regarding this study:

- The Researcher: Anne Tenning at atenning@sd61.bc.ca or at work at 388-5456.

- My U-Vic Supervisor: Dr. Lorna Williams at 472-5499 or lornawil@uvic.ca .
- In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President, Research at the University of Victoria at 250-472-4545 or by e-mail at ethics@uvic.ca .

Your signature below indicates that you understand the above conditions of this study, that you have had the opportunity to have your questions answered by the researcher and that you are giving your consent for the researcher to conduct this research study.

<i>Name of ANED Coordinator</i>	<i>Signature</i>	<i>Date</i>
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Please return your signed consent form to:

Victoria High School
 Attn: Ms. Anne Tenning
 1260 Grant St.
 Victoria, BC
 V8T 1C2

Sincerely,

Ms. Anne Tenning – Researcher

A copy of this consent will be left with you, and a signed copy will be held by the researcher.

APPENDIX C: Principal Form for Consent (GVSD)

PRINCIPAL FORM FOR RESEARCH

This form is to be filled out by the Principal and is to be submitted as part of the research application.

Principal's Name : _____

School: _____

Researcher's Name : _____

Project Topic : _____

Principal - please circle your answer

1. Yes/No The researcher has provided me with a copy of all materials to be used in this project. (surveys, consent forms, questions and/or methods)

2. Yes/No The researcher has provided me with a copy of the ethics approval document from the post secondary university/college.

3. Yes/No I am comfortable with the content of the materials. *(If No, please comment below)*

4. Yes/No
research. I support the timeline that the researcher would like to conduct
(If No, please comment below)

5. Yes/No/NA I have spoken to all staff who will be involved in this research and have the staff member(s) support.

6. Yes/No I have personally spoken with the researcher.

7. Yes/No I support this project in my school.

Comments:

Principal Signature : _____ **Date :** _____

*Any questions? Please contact Mandy Conrad, Administrative Services, phone 250-475-4158,
e-mail mconrad@sd61.bc.ca*

Revised November 25, 2008

APPENDIX D: Consent Letter to Principals

[Sample]

[Principal's Name]

[School]

[Address]

[Date]

The Experiences of Aboriginal Students who are Successful in the Senior Secondary Sciences

Dear [Principal],

My name is Anne Tenning and I am a graduate student from the University of Victoria in the department of Education. I am a member of the Chemainus First Nation and an Aboriginal academic counselor at Victoria High School. I am writing this letter to ask for your consent to conduct a research study at _____ High School entitled, "**The Experiences of Aboriginal Students who are Successful in the Senior Secondary Sciences.**"

I am conducting this research study as part of the requirements for a degree in Masters of Arts. It is being conducted under the supervision of Dr. Lorna Williams. You may contact my supervisor at 472-5499 or by e-mail at lornawil@uvic.ca.

The purpose of this research project is to learn about the experiences of Aboriginal students who are successful (meaning final academic achievement of at least 67%) in senior secondary (Grade 11 or 12) Biology, Chemistry, or Physics.

Research of this type is important because the participation of Aboriginal students in senior secondary Biology, Chemistry, and Physics is significantly lower than that of non-Aboriginal students. The importance of this research study is to find out if there are any common themes in the experiences of the participants to explain why they succeed in senior secondary science courses. The majority of Aboriginal students avoid taking these courses altogether.

There will be ten Aboriginal participants in this study. The participants will be current students of the Greater Victoria School Districts or former graduates. Participants will be from several different high schools in the Greater Victoria School District. The participants will self-identify as status, non-status, Métis, or Inuit. The students may be

from a local community, a distant community, or it is possible that some of the students might not know what Aboriginal community he/she is from.

The participants of this study will participate in two interview sessions with me that will be audio-recorded. The first interview is a metaphor interview which will help me to learn about the participants' perceptions about science. The second interview will involve questions that allow the participants to describe his/her experiences as successful science students. Lastly, all ten participants will attend a group meeting near the end of the study so that I can present my research findings to them. The participants will have an opportunity to respond to my conclusions.

Each high school with participants in the study will have a 'school contact'. The school contact at Spectrum High School is _____, the Aboriginal academic support teacher. _____ will recruit potential participants and arrange the date, time, and location of the two personal interviews. The researcher will not require participant contact information. If a participant needs to cancel or reschedule an interview, he/she may do this through _____ or the student may contact the researcher directly using the contact information provided at the end of the participant consent letter. Former graduates will communicate directly with the researcher to arrange interviews.

Interviews will be scheduled at times that are most convenient for the student, such as during lunch, after school, or during a spare block if the student has a spare. Every effort will be made to prevent the disruption of in-class time.

There are no known or anticipated risks to the students by participating in this research. A potential benefit of this research study will be achieved when the findings are shared with educators. Educators can use the research results to encourage more Aboriginal students to take science courses at the senior secondary level.

The participation of participants in this research study will be completely voluntary. Whether or not the students participate will have no bearing on his/her grades or standing in school. Participants may withdraw from the study at any time without any negative consequences and he/she will not be asked to provide any explanation. If a participant withdraws from the study, his/her data will not be included in the study and his/her data will be destroyed.

The anonymity of the participants will be protected because each participant will be given a pseudonym that will be used to identify him/her in the research. The participants' real names will not be used in any of the published results.

The confidentiality of the research data will be protected by storing printed transcriptions of the interviews in a locked filing cabinet located in my work office at Victoria High School. My office is locked and only I have a key to the cabinet. All digital audio recordings of the interviews will be saved on my personal computer which is password protected. Only I use this computer.

It is anticipated that the results of this study will be shared with others in the following ways:

- The results of the study will be shared with all ten participants in a group meeting.
 - The results of the study will be presented at my thesis dissertation.
 - The results will be summarized in an article to be published in an educational journal.
- The participants' anonymity will be preserved by using their pseudonyms in all forms of results sharing.

Data from this study will be disposed of once I have presented my research to my supervisory committee at my thesis dissertation at the University of Victoria. All typed transcriptions of the interviews will be shredded in a paper shredder. Audio recordings and transcriptions saved in my computer will be deleted.

You may contact any of the following individuals if you have any questions or concerns regarding this study:

- The Researcher: Anne Tenning at atenning@sd61.bc.ca or at work at 388-5456.
- My U-Vic Supervisor: Dr. Lorna Williams at 472-5499 or lornawil@uvic.ca .
- In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President, Research at the University of Victoria at 250-472-4545 or by e-mail at ethics@uvic.ca .

Your signature below indicates that you understand the above conditions of this study, that you have had the opportunity to have your questions answered by the researcher and that you are giving your consent for the researcher to conduct this research study in your school.

<i>Name of Vice Principal</i>	<i>Signature</i>	<i>Date</i>
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Please return your signed consent form to:

Victoria High School
 Attn: Ms. Anne Tenning
 1260 Grant St.
 Victoria, BC
 V8T 1C2

Sincerely,

Ms. Anne Tenning – Researcher

A copy of this consent will be left with you, and a signed copy will be held by the researcher.

APPENDIX E: Introductory Letter to Aboriginal School Contacts

[Date]

To: _____

From: Anne Tenning

Re: Anne's Master's Program Research Study

Hi Everyone,

I am sending you this letter to ask if you would be interested in assisting me in my research study that I am doing at U-Vic as a part of my Master's program by recruiting potential participants.

First, I'll tell you about my research study. I am exploring the experiences of Aboriginal students who were successful in the senior secondary 'hard' sciences – meaning final academic achievement of 67% or higher in Grade 11 or 12 Biology, Chemistry, or Physics (just one of these courses). The participation of Aboriginal students is significantly lower than that of non-Aboriginal students. The implications of this are tremendous as it means that very few Aboriginal students pursue science at the post-secondary level or go into science or health-related careers. I am hoping to see what can be learned from Aboriginal students who *are* successful in senior secondary science, even though the majority of Aboriginal students avoid taking these courses altogether. I'd like to see what it is that inspires/motivates these students to thrive in a science program that is predominantly Western-based. By learning from these students, it is hoped that we as educators can support/encourage more Aboriginal students to pursue the senior secondary sciences.

There will be ten participants in total in this study. They can be current students or former graduates. There are 3 criteria for participants: 1) they self-identify as Aboriginal (Status, non-status, Métis, or Inuit). 2) They achieved a minimum of 67% in grade 11 or 12 Biology, Chemistry, or Physics. 3) They are current students or former graduates of the GVSD.

If you agree to assist me in this study, your role will be to recruit potential participants. As there are only 10 participants, you would only need to recruit a few students/or former graduates. I will provide you with recruitment packages for potential participants that includes: 1) a recruitment letter (gives a very basic overview of the study), 2) a consent letter for students, and 3) a consent letter for their parents/guardians.

You would be known as the 'school contact' for your school for the research study. The ethics board at U-Vic prefers that students be recruited by a third party rather than the

researcher herself. That way, there is no potential awkwardness if I were to recruit students myself and the student didn't want to participate, but did not feel comfortable telling me. In addition to recruiting participants, students who are interested in participating in the study would return their consent forms and their parent/guardian consent forms to you. You would also arrange interview times and locations with the student.

The School Contacts that I have in mind are:

- _____: Esquimalt
- _____: Mt. Doug
- _____: Spectrum & Reynolds
- _____: Vic High
- _____: Oak Bay

There will be two interview sessions with each participant, with each interview session lasting approximately one hour. The first interview is a 'metaphor interview', - a creative way of exploring the student's perceptions about science. The second interview session is a more literal type of interview that explores the student's experiences as a successful science student. I will also be inviting all 10 participants to a group meeting once I have analyzed my results so that I can share my conclusions with them and allow them the opportunity to respond to my findings. I will likely host this group meeting at the school board office so that is a neutral location. You would also be welcome to attend as the school contact.

I submitted my application to the ethics board at U-Vic last week and I am waiting for their approval to go forward with my research. I am also going to ask Nella Nelson and the two local chiefs for permission to conduct this study as it exclusively involves Aboriginal people. In addition, I will be asking for permission from each school principal. I hope to be able to start interviewing participants sometime in March, hopefully before Spring Break, but it all depends on when my approval from the ethics board comes in.

I am only working half time this semester in order to have more time to work on my thesis. I am working on Mondays, Tuesdays, and Wednesday mornings. I am available to meet with students on Wednesday afternoons, or anytime on Thursdays or Fridays.

This letter that you are reading right now is an informal letter. If you are interested in participating in my research study as a school contact, please let me know via e-mail or you can phone me at Vic High. Once I hear from you that you are interested, I'll send you the official request for your participation as well as the recruitment packages.

If you have any questions, please do not hesitate to contact me. I would also be very happy to meet with you in person to further discuss this research study. I could come out to your school to meet you on my days off.

But, please keep in mind that you do not have to agree to participate in this study. You may decline to participate and you do not have to give me an explanation. If you would rather not participate, I will contact your school principal to ask for other staff members who could potentially serve as the school contact for this research study.

Thank you for taking the time to read this letter and for considering my request. Please let me know what your decision is and if you would like to meet with me in person.

Sincerely,

Anne Tenning

APPENDIX F: Consent Letter for Aboriginal School Contacts

Aboriginal School Counselor
[School & Address]

[Date]

**The Experiences of Aboriginal Students who are
Successful in the Senior Secondary Sciences**

Dear _____,

My name is Anne Tenning and I am a graduate student from the University of Victoria in the department of Education. You are being invited to participate as a school contact in a study that is being conducted by me entitled **The Experiences of Aboriginal Students who are Successful in the Senior Secondary Sciences**.

I am conducting this research study as part of the requirements for a degree in Masters of Arts. It is being conducted under the supervision of Dr. Lorna Williams. You may contact my supervisor at 472-5499 or by e-mail at lornawil@uvic.ca.

The purpose of this research project is to learn about the experiences of Aboriginal students who are successful (meaning final academic achievement of at least 67%) in senior secondary (Grade 11 or 12) Biology, Chemistry, or Physics.

Research of this type is important because the participation of Aboriginal students in senior secondary Biology, Chemistry, and Physics is significantly lower than that of non-Aboriginal students. The importance of this research study is to find out if there are any common themes in the experiences of the participants to explain why they succeed in senior secondary science courses, even though the majority of Aboriginal students avoid taking these courses altogether.

If you agree to voluntarily participate in this research study, your participation will include recruiting potential participants who are current students or former graduates from your school. You will give a copy of the recruitment letter, the parent/guardian consent form, and the participant consent form to potential participants. Please go over the participant consent form to potential participants. Students who are interested in participating in the study will return his/her consent form and the parent/guardian consent form to you. I will collect these forms from you. You may mail the recruitment letter and participant consent form to former graduates. Former graduates will be asked to mail his/her consent form directly to me.

Participants of this study will participate in two interview sessions. The first interview will be a metaphor interview to learn about the participant's perceptions of science. The

second interview will focus on his/her experiences as a successful Aboriginal science student. These two interviews will take approximately one hour each.

As the school contact, you will arrange the date, time, and location of the two interview sessions with the student. (Former graduates will contact the researcher directly to arrange the interviews). These interviews will be scheduled at times that are convenient for the student, such as at lunch, during a spare block, or after school. Students who need to cancel or reschedule an interview may inform you, the school contact, or he/she may e-mail or phone me using the information provided at the end of the participant consent letter. The location should be a quiet area in the school such as an office or empty classroom.

Near the end of this study, likely in May, 2007, there will be a group meeting that will bring all ten participants of this study together. This meeting will be held at the Victoria School Board office. The purpose of this meeting is so that I can present my research findings and to allow all of the participants the opportunity to respond to my conclusions. This meeting will take between one and two hours and the meeting will be held on a date and at a time that is suitable to all of the participants. I will require your assistance in setting the date/time of this group meeting.

There are no known or anticipated risks to you or to the students by participating in this research.

A potential benefit of this research study will be achieved when the findings are shared with educators. Educators can use the research results to encourage more Aboriginal students to take science courses at the senior secondary level.

The students' participation in this research study must be completely voluntary. Whether or not he/she participates will have no bearing on his/her grade or standing in school. He/she may withdraw from the study at any time without any negative consequences and he/she will not be asked to provide any explanation. Participants may tell you, the school contact if he/she decides to withdraw. If a participant withdraws from the study, his/her data will not be included in the study and his/her data will be destroyed.

Your anonymity will be protected because you will not be identified in the research study. Student identities will also be kept anonymous because each participant will be given a pseudonym that will be used to identify him/her in the research. Participants' real names will not be used in any of the published results.

Confidentiality of the participants' data will be protected by storing printed transcriptions of the interviews in a locked filing cabinet located in my work office at Victoria High School. My office is locked and only I have a key to the cabinet. All digital audio recordings of the interviews will be saved on my personal computer which is password protected. Only I use this computer.

It is anticipated that the results of this study will be shared with others in the following ways:

1. The results of the study will be shared with all ten participants in a group meeting.
2. The results of the study will be presented at my thesis dissertation.
3. The results will be summarized in an article to be published in an educational journal.

Participant anonymity will be preserved by using pseudonyms in all forms of results sharing.

Data from this study will be disposed of once I have presented my research to my supervisory committee at my thesis dissertation at the University of Victoria. All typed transcriptions of the interviews will be shredded in a paper shredder. Audio recordings and transcriptions saved in my computer will be deleted.

You may contact any of the following individuals if you have any questions or concerns regarding this study:

- The Researcher: Anne Tenning at atenning@sd61.bc.ca or at work at 388-5456.
- My U-Vic Supervisor: Dr. Lorna Williams at 472-5499 or lornawil@uvic.ca .
- In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President, Research at the University of Victoria at 250-472-4545 or by e-mail at ethics@uvic.ca .

Your signature below indicates that you understand the above conditions of participation in this study, that you have had the opportunity to have your questions answered by the researcher and that you are interested in participating in this research study as a school contact.

<i>Name of School Contact</i>	<i>Signature</i>	<i>Date</i>
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Please return your signed consent form to the researcher to the address below.

Victoria High School
 Attn: Ms. Anne Tenning
 1260 Grant St.
 Victoria, BC
 V8T 1C2

Sincerely,

Ms. Anne Tenning – Researcher

A copy of this consent form will be left with you, and a signed copy will be held by the researcher.

APPENDIX G: Recruitment Poster

Are you a Successful Aboriginal Science Student?

- Do you self-identify as Aboriginal (status, non-status, Métis, or Inuit)?
- Have you taken Grade 11 or 12 Biology, Chemistry, or Physics and achieved at least 67%?
- Are you currently attending high school in the or are you a recent high school graduate?

If you answered '**Yes**' to these three questions, you may be interested in participating in a research study that is being conducted by Anne Tenning through the University of Victoria.

The participation of Aboriginal students in senior secondary Biology, Chemistry, and Physics is significantly lower than that of non-Aboriginal students.

The purpose of this research study is to see what can be learned from the experiences of Aboriginal students who *do* participate in senior secondary or post secondary science courses and are *successful*.

If you are interested in participating in this research study, please read and sign the attached consent form.

Next, contact **Anne Tenning** at atenning@sd61.bc.ca or phone her at 388-5456 (work) to arrange an interview or ask any questions.

Thank you!

APPENDIX H – Participant Consent Form

[Date]

The Experiences of Aboriginal Students who are Successful in the Senior Secondary Sciences

Dear Student or Recent Graduate,

My name is Anne Tenning and I am a graduate student from the University of Victoria in the department of Education. You are being invited to participate in a study that is being conducted by me entitled **The Experiences of Aboriginal Students who are Successful in the Senior Secondary Sciences**.

I am conducting this research study as part of the requirements for a degree in Masters of Arts. It is being conducted under the supervision of Dr. Lorna Williams. You may contact my supervisor at 472-5499 or by e-mail at lornawil@uvic.ca.

The purpose of this research project is to learn about the experiences of Aboriginal students who are successful (meaning final academic achievement of at least 67%) in senior secondary (Grade 11 or 12) Biology, Chemistry, or Physics.

Research of this type is important because the participation of Aboriginal students in senior secondary Biology, Chemistry, and Physics is significantly lower than that of non-Aboriginal students. The importance of this research study is to find out if there are any common themes in the experiences of the participants to explain why they succeed in senior secondary science courses. The majority of Aboriginal students avoid taking these courses altogether.

You are being asked to participate in this study because you are an Aboriginal student who was successful in a senior secondary Biology, Chemistry, or Physics course. There will be ten participants in this study. The participants will be current high school students or recent graduates. You were recruited for this study by

If you agree to voluntarily participate in this research, your participation will include participating in one interview session consisting of two parts. I will ask for your permission to audio record the interview. The first part of the interview will be a metaphor interview to learn about your perceptions of science. The second part of the interview will focus on your experiences as a successful Aboriginal science student. You may decline to answer any question that you are not comfortable with. The interview will take approximately an hour and a half. We will do the interview at a time that is convenient for you. If you need to cancel or reschedule the interview, please inform your school contact or e-mail or phone me using the information provided at the end of this letter.

Near the end of this study, likely in June, 2007, there will be a group meeting that will bring all ten participants of this study together. This meeting will be held at the Victoria School Board office. The purpose of this meeting is so that I can present my research findings and to allow all of the participants the opportunity to respond to my conclusions. This meeting will take between one and two hours.

You will be identified by your first name only at the group meeting. All participants who attend the group meeting will be asked to sign an agreement letter not to share any personal information that is discussed. This is one potential limitation to your anonymity and confidentiality.

There are no known or anticipated risks to you by participating in this research.

A potential benefit of this research study will be achieved when the findings are shared with educators. Educators can use the research results to encourage more Aboriginal students to take science courses at the senior secondary level.

Your participation in this research study must be completely voluntary. Whether or not you participate will have no bearing on your grades or standing in school. You may withdraw from the study at any time without any negative consequences and you will not be asked to provide any explanation. You may tell your school contact if you decide to withdraw. If you withdraw from the study, your data will not be included in the study and your data will be destroyed. The same rights and methods to withdraw apply to both current students and recent graduates.

To make sure that you continue to give consent to participate in this research, I will ask you at the beginning of the personal interview and the group discussion if you continue to give your consent to participate in this study.

Your anonymity will be protected in published materials because you will be given a pseudonym that will be used to identify you in the research. Your real name will not be used in any of the published results. As the interviews will be in person, you will not be anonymous to the researcher.

Your confidentiality and the confidentiality of your data will be protected by storing printed transcriptions of the interviews in a locked filing cabinet located in my work office at Victoria High School. My office is locked and only I have a key to the cabinet. All digital audio recordings of the interviews will be saved on my personal computer which is password protected. Only I use this computer.

It is anticipated that the results of this study will be shared with others in the following ways:

- The results of the study will be shared with all ten participants in a group meeting.
- The results of the study will be presented at my thesis dissertation.
- The results will be summarized in an article to be published in an educational journal.

Your anonymity will be preserved by using your pseudonym in all forms of results sharing.

Data from this study will be disposed of once I have presented my research to my supervisory committee at my thesis dissertation at the University of Victoria, likely in August 2007. All typed transcriptions of the interviews will be shredded in a paper shredder. Audio recordings and transcriptions saved in my computer will be deleted.

You may contact any of the following individuals if you have any questions or concerns regarding this study:

- The Researcher: Anne Tenning at atenning@sd61.bc.ca or at work at 388-5456.
- My U-Vic Supervisor: Dr. Lorna Williams at 472-5499 or lornawil@uvic.ca .
- Your School Contact:

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President, Research at the University of Victoria at 250-472-4545 or by e-mail at ethics@uvic.ca .

Your signature below indicates that you understand the above conditions of participation in this study, that you have had the opportunity to have your questions answered by the researcher and that you are interested in participating in this research study.

<i>Name of Participant</i>	<i>Signature</i>	<i>Date</i>
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Your signature below indicates that you give permission for the personal interview and the group discussion to be audio recorded.

<i>Name of Participant</i>	<i>Signature</i>	<i>Date</i>
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Please return your signed consent form and your parent/guardian consent form (if you are currently attending high school) to your school contact or bring both forms to the interview session.

If you are a recent graduate, please bring your signed consent form to the interview session or mail it to me at:

Victoria High School

Sincerely,

Ms. Anne Tenning – Researcher

A copy of this consent will be left with you, and a copy will be taken by the researcher.

APPENDIX I – Parent Consent Form

[Date]

**The Experiences of Aboriginal Students who are
Successful in the Senior Secondary Sciences**

Dear Parent or Guardian,

My name is Anne Tenning and I am a graduate student from the University of Victoria in the department of Education. Your child is being invited to participate in a study that is being conducted by me entitled **The Experiences of Aboriginal Students who are Successful in the Senior Secondary Sciences**.

I am conducting this research study as part of the requirements for a degree in Masters of Arts. It is being conducted under the supervision of Dr. Lorna Williams. You may contact my supervisor at 472-5499 or by e-mail at lornawil@uvic.ca.

The purpose of this research project is to learn about the experiences of Aboriginal students who are successful (meaning final academic achievement of at least 67%) in senior secondary (Grade 11 or 12) Biology, Chemistry, or Physics.

Research of this type is important because the participation of Aboriginal students in senior secondary Biology, Chemistry, and Physics is significantly lower than that of non-Aboriginal students. The importance of this research study is to find out if there are any common themes in the experiences of the participants to explain why they succeed in senior secondary science courses, even though the majority of Aboriginal students avoid taking these courses altogether.

Your child is being asked to participate in this study because he or she is an Aboriginal student who was successful in a senior secondary Biology, Chemistry, or Physics course. There will be ten participants in this study. The participants will be current high school students or recent graduates.

If you agree that your child can participate in this research, your child's participation will include participating in one interview session consisting of two parts. I will ask for your child's permission to audio record the interview. The first part of the interview will be a metaphor interview to learn about your child's perceptions of science. The second part of the interview will focus on your child's experiences as a successful Aboriginal science student. Your child may decline to answer any question that he or she is not comfortable with. The interview will take approximately an hour and a half. The interview will be scheduled at a time that is convenient for your child, such as at lunch, during a spare block, or after school.

Near the end of this study, likely in June, 2007, there will be a group meeting that will bring all ten participants of this study together. This meeting will be held at the Victoria School Board office. The purpose of this meeting is so that I can present my research

findings and to allow all of the participants the opportunity to respond to my conclusions. I will ask all of the participants for permission to audio record the meeting. This meeting will take between one and two hours and the meeting will be held on a date and at a time that is suitable to all of the participants.

Your child will be identified by first name only at the group meeting. All participants who attend the group meeting will be asked to sign an agreement letter not to share any personal information that is discussed. This is one potential limitation to your child's anonymity and confidentiality.

There are no known or anticipated risks to your child by participating in this research.

A potential benefit of this research study will be achieved when the findings are shared with educators. Educators can use the research results to encourage more Aboriginal students to take science courses at the senior secondary level.

Your child's participation in this research study must be completely voluntary. Whether or not your child participates will have no bearing his/her grades or standing in school. Your child may withdraw from the study at any time without any negative consequences and he/she will not be asked to provide any explanation. You or your child may tell your school contact if your child decides to withdraw. If your child withdraws from the study, your child's data will not be included in the study and the data will be destroyed.

To make sure that your child continues to give consent to participate in this research, I will ask him/her at the beginning of the personal interview and the group discussion if he/she continues to give consent to participate in this study.

Your child's anonymity will be protected because he/she will be given a pseudonym that will be used to identify him/her in the research. Your child's real name will not be used in any of the published results.

Your child's confidentiality and the confidentiality of his/her data will be protected by storing printed transcriptions of the interviews in a locked filing cabinet located in my work office at Victoria High School. My office is locked and only I have a key to the cabinet. All digital audio recordings of the interviews will be saved on my personal computer which is password protected. Only I use this computer.

It is anticipated that the results of this study will be shared with others in the following ways:

- The results of the study will be shared with all ten participants in a group meeting.
 - The results of the study will be presented at my thesis dissertation.
 - The results will be summarized in an article to be published in an educational journal.
- Your child's anonymity will be preserved by using his/her pseudonym in all forms of results sharing.

Data from this study will be disposed of once I have presented my research to my supervisory committee at my thesis dissertation at the University of Victoria. All typed

transcriptions of the interviews will be shredded in a paper shredder. Audio recordings and transcriptions saved in my computer will be deleted.

You may contact any of the following individuals if you have any questions or concerns regarding this study:

- The Researcher: Anne Tenning at atenning@sd61.bc.ca or at work at 388-5456.
- My U-Vic Supervisor: Dr. Lorna Williams at 472-5499 or lornawil@uvic.ca .

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President, Research at the University of Victoria at 250-472-4545 or by e-mail at ethics@uvic.ca .

Your signature below indicates that you understand the above conditions of your child's participation in this study, that you have had the opportunity to have your questions answered by the researcher and that you are giving permission for your child,

_____ to participate in this research study.

(Child's Name)

Name of Parent

Signature

Date

Please return this signed consent form to Anne Tenning by mail or send it with your child to the interview session.

Anne Tenning
Victoria High School
1260 Grant St.
Victoria, BC V8T 1C2

Sincerely,

Ms. Anne Tenning – Researcher

A copy of this consent form will be left with you and the signed, returned copy will be held by the researcher.

APPENDIX J: Metaphor Interview Questions

Part 1: The Metaphor Interview

1. What is your personal definition of ‘science’? Please write it down.

The Metaphor Questions:

2. If science was an animal, what animal would it be? Explain.
3. If science was an object, what object would it be? Explain.
4. If science were one or more of the following, what would it be? Why? (The same question will be asked at the beginning of each set. “Why” will be asked after each question).

SET #1

- A car
- A totem pole
- A circle
- A tree
- A drum

SET #2

- A puzzle
- A medicine wheel
- A garden
- A story/legend
- A court case

SET #3

- Pyramid
- A forest
- A feast or potlatch
- A song or dance
- An experiment

5. Of all the metaphors listed above, which is your favorite metaphor for science and why? What is your second favourite metaphor? Which metaphor is your least favourite? Please explain. Please generate your own metaphor for science and explain.
6. I am to science as ... (explain) [your experience, role, or relationship in/with science)

- A driver is to a car a mechanic is to a car a passenger is to a car
 - An author is to a book a reader is to a book a character is to a book
 - An inmate is to a prison a warden is to prison a guard is to prison
 - A chief is to a community a child is to a community an elder is to a community
7. Which one of the following images best describes how science is taught in school? Why? (The same question will be asked at the beginning of each set. “Why” will be asked after each question).

SET #1

- a car
- a boat
- a garden
- a forest
- a factory

SET #2

- a prison
- a longhouse
- a computer
- a carving
- a tree

SET #3

- a painting
- a medicine wheel
- a church
- a calculator
- a sport (such as hockey, basketball, etc)

8. Of all the metaphors listed above, which is your favorite metaphor for how science is taught and why? What is your second favourite metaphor? Of the metaphors listed above, are there any that the way science is taught would not be? Please explain. Please generate your own metaphor for how science is taught and explain.
9. If the way that science is taught could be changed, which one of the above metaphors best describes the way that you would like to see it taught? Why? Is there a metaphor that you would select second?

APPENDIX K: Literal Interview Questions

Background:

1. How long have you attended this school? Where else have you gone to school?
2. How long have you lived in Victoria?
3. Where did you grow up?
4. Describe your current family and living situation. Has it changed over the years?

Interests, Work, Goals:

5. What are your hobbies or interests? Are you involved in any special programs or teams at school?
6. Are you currently employed? Do you volunteer anywhere?
7. What are your future educational and career goals? Why did you decide on these areas?

Aboriginal Ancestry:

8. What is your Aboriginal ancestry?
9. Please describe your connection to your Aboriginal culture or people.

Experiences in School:

10. Please describe the reasons why you think you have made it so far in your education.
11. What (or who) inspires you or motivates you regarding school?
12. What sorts of challenges or difficulties, if any, have you faced in your education? How did you deal with these? Have you faced any difficulties as an Aboriginal student?
13. Do you consider yourself to be a successful student? What does 'success' mean to you?

Thoughts about Science:

14. Please tell me what you think about science.
 - What do you like about it?
 - What do you dislike?
 - Is there anything that you would like to see changed in science education?
 - Is there anything you would like to see included in science education?
15. What is the significance of science to you?

- Is there anything that you have gotten out of taking science that might be helpful to you elsewhere?
- Are you or have you considered studying science at the post-secondary level? Explain why or why not.
- Are you or have you considered a career that uses science? Explain why or why not.

Experiences in Science:

I am going to ask you to tell me about your experience in studying science. You may answer these questions based on any of your experiences from elementary school through high school.

16. Describe some of your earliest memories about studying science.
17. What are some of the most memorable or positive experiences you have had in science?
18. What have you found to be the most interesting aspects or topics in science?
19. Please describe any challenges or difficulties that you have experienced in studying science. How did you deal with these challenges?
20. Where did your inspiration to study science come from? Please list everything you can think of.

Achievement:

21. What science courses have you taken at the grade 11 or 12 level? What was your achievement or mark in these courses?
22. Why do you think you did so well in senior level science? What motivates you to do well
23. Do you consider your self to be a successful science student? Please explain.
24. Please describe examples of when you felt successful. Please describe examples of when you did not feel successful in science.

Experiences as an Aboriginal Student:

25. What has your experience been like as an Aboriginal science student? Has it been different or is it the same as other students? Have you experienced any conflicts within yourself studying science as an Aboriginal person?
26. Do Aboriginal people have 'science'?
27. Has Aboriginal knowledge or science been included in your science courses? If so, please describe. If not, should it be? Give examples.
28. Have you ever connected to science using Aboriginal knowledge or culture?
29. What do you think is the value of science for Aboriginal people in general?

APPENDIX L: Focus Group Questions

1. Why did you decide to take senior secondary science?
2. What are some of the reasons why you think you did so well in your senior secondary science courses?
3. What are some of the most important reasons why you think you made it so far in your education?
4. Let's talk about what 'success' means to you in general. What does it mean to be 'successful'?
5. Let's talk about what you really liked about secondary science, or what you didn't like about it, or what you'd like to see changed – any of those questions that stand out to you the most.
6. What do you think would be some good ideas or good solutions to try to increase Aboriginal participation rates in senior level science?
7. What do you think are the wider implications of Aboriginal students not taking senior secondary science? Or are there any implications?
8. [Next, participants were provided with a summary of all ten participant responses to each of the metaphor questions]. When you look at everyone's answers in the metaphor questions, are there any themes or ideas that jump out at you?
9. [Next, participants were provided with a summary of all ten participant responses to some of the literal interview questions]. Do you see any theses amongst these responses?