Aboriginal Students’ High School Mathematics Experiences:  
Stories of Opportunities and Obstacles

by

Kate Fisher

B.A., University of Toronto, 1982
B. Ed., University of Victoria, 2008

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Abstract

The mathematics education experiences of Aboriginal high school students has received little research attention. Ten urban Aboriginal high school students in Victoria, BC facilitated a narrative qualitative inquiry. Bandura’s (1986) four sources of self-efficacy and social cognitive theory were used to examine the students’ stories. Performance mastery experiences were found to dominate the formation of students’ sense of competence. Experiences were centrally impacted by students’ affective domain. The importance of relationality and an inter-connection between all four sources of self-efficacy are also noted. Implications for future research and practice are provided.
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Preface

“I must introduce myself, in keeping with Indigenous discourse”

(Steinhauer, 2002, p. 69)

I wish to follow an Indigenous protocol I learned while living in Canada’s north, and begin by introducing myself to shed light on my identity and cultural location. By sharing my story I wish to enable others to begin to make connections with me by placing my story culturally, politically and socially.

As a woman, a mathematics educator, 49 years old, I have done well in many mathematics courses. I am very fortunate to have had only a few extreme mathematics anxiety experiences, but they remain crystal clear. At age nine I was at a complete loss with multiplication. My father confidently calmed me and said he and I would work on it. In spite of his best intentions, after repeated efforts, I remember standing by my father’s desk, with tears streaming down my face, still completely bewildered. It was a horrible experience that is still with me.

Years later, as an adult learner, I returned to university and mathematics after a 25 year absence. As my second year got underway, my goal to be a mathematics teacher suddenly seemed ill conceived; I felt out of place and overwhelmed. My classmates were in their early twenties and appeared to grasp the material quickly and with ease. I was struggling with each concept, had no idea how to tackle the homework and assignments, and in one linear algebra course in particular, suspected that I was in well over my depth.

My experiences leave me with an understanding of how devastating it is to “not get math.” I want to help students avoid such experiences. I want students to know these experiences can be overcome. I want to be a role model for female students. I hope to
help students enjoy mathematics by experiencing it in a positive way. As a mathematics educator, I see students disengaged, or resistant to engagement, with mathematics. I see other students who are experiencing failure in mathematics. I want my teaching and research in mathematics to make a difference to these students.

I am deeply saddened by the lack of academic success in British Columbia’s schools of our Aboriginal peoples, both past and present. “The performance of Aboriginal students in BC… remains at a significantly lower level than that of non-Aboriginal students” (Neel, 2008, p. 4). I am not of Aboriginal ancestry. I did live for seventeen years in the traditional territory of the Taku River Tlingit First Nation, in BC’s north-west corner, in the small community of Atlin, BC. Across a range of experiences from my time in Atlin, in my personal and professional experiences, I came to understand just how different the Canadian Aboriginal experience can be from my privileged Canadian experience, someone of English, Irish, and Welsh ancestry. As just one example, working as Chair of the Parent Advisory Council for the Atlin Elementary School, it was consistently apparent to me that although Native Residential Schooling had closed many years earlier, the parents of the current generation, and in turn their children, were deeply affected by the experience. Complex multi-generational trauma hampered Aboriginal families in their efforts to support and advocate for their children. In contrast, I am privileged and benefitted from having at-ease and involved parents who could comfortably advocate for my education when appropriate, which in turn helped me be at ease in the educational arena.

It is my sincere hope that as a non-Aboriginal individual there is a place for me to work with, for, beside and behind Aboriginal peoples in a positive way to help change the
educational reality of Aboriginal students in mathematics. I do not want to do any harm. I want to better understand the opportunities and obstacles Aboriginal high school students experience in mathematics. I would like to support students in the telling of their own stories. By guiding students through a process of making meaning from their experiences, my research aims to help students develop their own agency. I would like my research to facilitate students articulating their own goals and hopes in mathematics for the future. By giving voice to Aboriginal students’ mathematics stories I want the research to be catalytic. This research therefore, will address policy makers, curriculum developers and classroom teachers themselves. In order to have the research inform program development in concrete and culturally respectful ways, recommendations will be made to each of these audiences.
Chapter I – Introduction

The Issue

“Over the years, many national, provincial, and local Aboriginal education studies have indicated the inability of public schools to meet the needs of Aboriginal learners, especially in mathematics education” (Neel, 2008, p. 4).

Math Makes Sense, or so Pearson Education Canada states with this title for its grade 9 Western Canada high school text book (Baron, Brown, Davis et al., 2009). The reality is that mathematics does not make sense for far too many students. “Few Aboriginal students take higher-level courses in mathematics, attend post-secondary programs that require mathematics and [Aboriginal students] are generally underrepresented in careers that use mathematics” (Nielsen, Nicol & Owuor, 2008, p. 33). “High school mathematics achievement acts as a critical filter” effectively limiting opportunities in the world of work (Sells, 1976, p. 1). Mathematics has wide renown as a gate-keeping subject. Skills in mathematics are recognized as essential for entry into science, technology and engineering careers (Bieschke, 1992; Hackett, 1985; O’Brien, Martinez-Pons & Kopala, 1999). Mathematics also prevents many students from pursuing post-secondary programs in the humanities and the arts as they lack general university admission requirements. Less widely noted is that inadequate skills in mathematics similarly form a barrier for students interested in business, office management, health related fields such as dental hygiene and nursing, as well as entry into numerous trades including automotive, carpentry, electrician, sheet metal, plumbing, and welding (Math Admission Requirements for Camosun College, 2008; Nielsen, Nicol & Owuor, 2008).
The Research Questions

How can we better understand the Aboriginal students’ experience in mathematics? How can we better address the low achievement of Aboriginal students in high school mathematics? I believe the answer lies at the nexus of culture and education. As an educator and adult whose childhood was deeply shaped by an alcoholic parent, I am drawn to Eber Hampton’s analogy, “the educator who sees education as culturally neutral is similar to the spouse of an alcoholic who denies the alcoholism” (Hampton, 1995, p. 36). Sadly for many students, “the belief that mathematics is a body of truth independent of society is deeply embedded in education and research” (Martin, 1997, p. 168). All ideas, including mathematical ideas, do not exist independent of culture, but “mathematics in particular was the subject, more than any other, that [is] considered to be value- and culture-free” (Presmeg, 1998, p. 317). Numerous authors now point to the culturally deprived conceptualization of mathematics as part of the reason that Indigenous peoples are severely underrepresented in careers that require higher-level mathematics (Bishop, 1988; Grignon, 1991; Nelson-Barber & Estrin, 1995; Oakes, 1990; Secada, 1992; Trumbull, Nelson-Barber, & Mitchell, 2002).

The foundation therefore, upon which the present research rests, is an understanding of mathematics as a cultural product. Mathematics as a cultural product is analogous to the mortar binding the research’s foundation blocks. The foundation blocks are formed from two overarching principles. One is a theoretical framework of social constructivism where human meanings are “constructed frameworks rather than direct reflections of the real” (Raskin, 2008, p. 16). Under this theoretical framework, individuals make meaning of their world through their experiences. An additional
overarching principle that underlies the research is one of cultural respect. Indigenous peoples’ own understanding of the educational journey in mathematics must be investigated. My view arises from national shame that “the schools have been, arguably, the most damaging of the many elements of Canada’s colonization of this land’s original peoples and, as their consequences still affect the lives of Aboriginal people today, they remain so” (Milloy, 1999, p. xiv). A lasting legacy of residential schooling is its ability to turn “schooling” into a pejorative term. It is my deepest hope that my research will not further contribute to Aboriginal peoples being “subjected to a combination of unquestionably powerful but profoundly debilitating forces of assimilation and colonization” (Battiste, 1998, p. 4). Many scholars (Cobern & Loving, 2001; Hermes, 1998; Kenny, 2004; Long & LaFrance, 2004) caution researchers to understand the implications of being an “outsider.” Battiste clearly delimits my potential as a non-Indigenous researcher; I may “be useful in helping Indigenous people articulate their concerns, but to speak for them is to deny them the self-determination so essential to human progress” (p. 26).

In my research, I have listened to the stories of mathematics experiences of Aboriginal students. I believe that a student-centered dialogue may be a way to better understand the Aboriginal students’ experience. I examined the following questions:

1) What stories, including opportunities and obstacles, have Aboriginal students experienced in mathematics education?

2) What do students’ stories and experiences reveal about their self-perceptions in mathematics? Specifically, what do the students’ stories reveal about what shapes their mathematics self-efficacy?
3) In what ways do male and female Aboriginal students’ experience self-efficacy?

The answers to these questions can inform classroom teachers. The description of the research process can inform researchers. Only Aboriginal students are involved in the inquiry process, but recommendations may also help non-Aboriginal students. These questions reveal the purpose of this study: To explore the stories of Aboriginal students’ experience in mathematics.

*Definitions*

The Canadian Constitution Act of 1982 recognizes three groups of Aboriginal peoples in Canada: the First Nations, the Inuit and the Métis (*Canadian Charter of Rights and Freedoms*, ¶35, 1982). In this thesis, the terms Aboriginal and Indigenous are used to indicate the groups of people who inhabited this land prior to the arrival of Europeans. Various authors cited in this work have chosen the terms Aboriginal, Indigenous, First Nations, Native, or Indian, and I have preserved each author’s choice of words when citing their research.

“Students” and “youth” are terms used in this thesis. Some research cited, in keeping with the United Nations Convention on the Rights of the Child, ratified by Canada in 1991, use the terms “child” or “children,” and as with “students” and “youth” indicates young people under the age of 18.

Self-efficacy is a central construct in Albert Bandura’s (1977) social cognitive theory. “Bandura (1977) introduced the concept of self-efficacy in his attempt to conceptualize a unifying theory of behavioral change” (Luzzo, Hasper, Bibby, & Martinelli, 1999, p. 233). Self-efficacy impacts behavior as a dynamic set of self-beliefs specific to particular performance domains (Lent, Brown & Hackett, 1994). Bandura
(1997) defines self-efficacy as “a judgment of one’s ability to organize and execute given types of performances” (p. 21). The context of performances in this thesis is self-efficacy in mathematics.

The Research Context

Indigenous Research

Undertaking research with Indigenous participants demands consideration of Indigenous research literature prior to all other topics. *A Holistic Framework for Aboriginal Policy Research* developed in 2004 by Status of Women Canada (Kenny, 2004), suggests that “Aboriginal research must begin with a serious examination of the historical and political influences that have guided research up to this point” (Kenny, 2004, p. 3). A discussion of Canada’s residential schooling for Aboriginal peoples, and its legacy, is beyond the scope of this thesis, but it is none the less crucial to acknowledge that while “the residential school has disappeared from the Canadian educational landscape, its legacy endures” (Barman, 1997, p. 103). The educational history of Canada’s Aboriginal peoples was a “training for self-destruction” (Sellers, 1993, p. 131). Schooling was the principle tool of cultural destruction and assimilation (Barman) and was designed to silence and suppress Indigenous ways of knowing. “Native children in Canada were sent to residential schools at an age designed to systematically destroy their language and memories of home” (Smith, 1999, p. 69).

All Canadians should be cognizant of this history and saddened by it. Smith (1999) describes this legacy as both a history and a “herstory,” a story that needs “rewriting” and “rerighting” (p. 28). This is true for educational practice and for Indigenous research. Smith cautions that research has been a dirty word in the Indigenous vocabulary,
process that merely “stirs up silence” (p. 1). It is a practice that has extracted and wrongfully claimed ownership of Indigenous ways of knowing and being. In contrast, this thesis seeks to respect Indigenous ways of knowing and being, and while not appropriating such knowledge, wishes to be shaped and informed by its respectful, relational, and inclusive positioning. The 2004 *A Holistic Framework for Aboriginal Policy Research* outlines guidelines to direct research principles. Research must include:

- honouring past, present and future in interpretive and analytical research processes including historical references and intergenerational discourse;
- honouring the interconnectedness of all of life and the multi-dimensional aspects of life on Earth and in the community in research design and implementation; and
- honouring the spiritual, physical, emotional and mental aspects of the person and the community in research protocols, methodologies and analyses (Kenny, 2004, p. 8).

Steinhauer (2002) similarly outlines key features for responsible Indigenous research including the need to “privilege the voices, experiences, and lives of Aboriginal people and their lands” (p. 72). Research must also “identify and redress issues of importance to Aboriginal peoples” (p.72). These principles have guided this research. In keeping with the *Holistic Framework*, I began by acknowledging the history of education for Aboriginal peoples in Canada. To honour the interconnected nature of life and a holistic view of the world, an Indigenous paradigm is considered in the following section. To privilege the voices of Aboriginal people, a participatory narrative methodology is chosen for the research. Additionally, as Morrow and Richards (1996) note “in some areas of
social research there has been a growing recognition that children’s views and perspectives can and should be elicited on a range of issues that affect them” (p. 91). Aboriginal communities have identified a “great need for scientific and technological skills,” (MacIvor, 1995, p. 74) which positions mathematics education inquiry as an issue of importance to Aboriginal peoples. On a local level, the school community and Aboriginal staff affiliated with the school community in the present study, expressed an interest in exploring the mathematics experiences within their community.

**Indigenous Paradigm**

In order to authentically situate and honour Aboriginal students’ voices and experiences, discursive space must be created for an Indigenous paradigm and it must shape the research (Smith, 1999). My goal is for this research and thesis to not further colonize Aboriginal people. Colonization of Aboriginal peoples has been relentless; colonization spans historic Eurocentric misconceptions and actions against Indigenous people, to present-day policies which are oppressive whenever a deficit-thinking model frames social and education issues serving only to blame victims for societal related and created issues (Bishop, 2008). This research alternatively aims to contribute to a decolonizing journey.

Smith (1999) notes that the decolonizing process must include centering concerns and world views to enable a coming to know and understanding of theory and research from an Indigenous person’s own perspective and for their own purposes. I believe this is possible while acknowledging that “there really is no monolithic ‘Aboriginal culture’ to contrast with non-Aboriginal culture” (Oberg, Blades & Thom, 2007, p. 128). None the less, there is a need to be “aware of the particular lens through which we view other
cultures” (Gerdes, 1997, p. 257). Gerdes cautions us that “even when that lens is respectful, it can be static and false” (p. 257).

This research adopts “the Aboriginal worldview [that] asserts that all life is [sacred] and that all life forms are connected. Humans are neither above nor below others in the circle of life. Everything that exists in the circle is one unity, one heart” (Henderson, 2000, p. 259).

By embracing an Indigenous paradigm the research seeks to better understand Aboriginal students’ experiences, and give agency to their understandings. It is worth repeating that the work is with, for, beside and behind those who participate. Wilson (2007) suggests that “it is the use of an Indigenist paradigm that creates Indigenous knowledge. This knowledge cannot be advanced from a mainstream paradigm” (p. 194). Wilson further cautions against comparing paradigms, as “to do so would mean falling into a mainstream, positivist trap by creating a binary…any comparisons will inevitably lead to judgment and subjugation, an us and them dichotomy” (p. 194) [emphasis in original]. Alternatively, this research has sought to open up space for Aboriginal experiences.

Summary of Chapter I and Overview of the Thesis

Chapter I introduced the issue and background to the thesis. The research questions have been identified and pertinent definitions established. In addition, an Indigenous research context has been detailed, and the overarching theoretical foundation of social constructivism has been noted. Chapter II provides a selected review of relevant literature including mathematics performance of Aboriginal students, mathematics as a cultural product, and social cognitive theory. Chapter III presents the methodology of the
research. A qualitative design with narrative methodology is used in a context of respect, relationality and reciprocity. The role of the investigator is explored and the research setting detailed. Data collection, analysis and credibility issues are discussed. Chapter IV presents the results of the research. Participant backgrounds are presented first, followed by evidence of four sources of self-efficacy. Chapter V discusses the complex interrelationships between these sources of self-efficacy. To conclude, chapter VI summarizes the major findings of the research and notes the limitations of the research. Implications of the research, researcher growth through the research process, and implications for practice are also identified.
Neel (2008) notes “the proliferation of research documents, government reports, and task force papers in recent years” (p. 3) that detail the “disturbingly low educational success rates for Aboriginal students” (p. 3). “Aboriginal education attainment lags significantly behind the Canadian population” (White, Beavon, Peters & Spence, 2009, p. 3). The Province of British Columbia, Ministry of Education’s (2003, 2009) How are we doing? Demographic and performance of Aboriginal students in BC public schools shows improvement in the six-year high school completion rates (entering grade 8 to Dogwood) of Aboriginal students. This rate improved from 39% of Aboriginal students completing in the 1999/2000 school year, to 47% in the 2007/08 school year. In spite of this improvement, Aboriginal students still fall far behind their non-Aboriginal counterparts who demonstrate a 81% six year completion rate in the 2007/08 school year as depicted in Figure 1 - Six year completion rates for students entering grade 8 in 2002.

The educational attainment improvements of Aboriginal students in Canada has not been continuous over time. While there was a narrowing of the gap between Aboriginal and non-Aboriginal students in Canada between 1981 and 1991, the gap in

![Progress of Students Entering Grade 8](image-url)
terms of the proportion of people with high school or higher levels of education in Canada widened between 1991 and 2006 (White et al., 2009).

A disparity similarly exists between Aboriginal students and non-Aboriginal students in mathematics participation and performance. The Province of British Columbia’s 2005 How are we doing? annual report on Aboriginal education identifies an Aboriginal student participation rate in Principles of Mathematics 12 of 5.7% of Aboriginal students, in contrast to 25% of non-Aboriginal students. For those students who do choose to take Principles of Mathematics 12, there is also a disparity in the success rates of these students. Across the years 1994 to 2004 Aboriginal student mean grades spanned 63 to 79%, compared to grades of 82-88% for non-Aboriginal students. Similar achievement gaps are evident in earlier grades as demonstrated by Foundation Skills Assessment data. Numeracy results at the grade 4 level, as determined in 2007/08, showed that 35% of Aboriginal students were “Not Yet Meeting” numeracy expectations compared to 21% of non-Aboriginal students. At the grade 7 level, 39% of Aboriginal students were “Not Yet Meeting” numeracy expectations in contrast to 20% of non-Aboriginal students (Province of British Columbia, 2009).

Mathematics as a Cultural Product

“Mathematics is one way of understanding, interpreting and describing our world” (Western and Northern Canadian Protocol, 2008, p.11). As has been noted, as an academic subject, it is censured as “the worst curricular villain in driving students to failure in school…[it] acts as a filter, it not only filters students out of careers, but frequently out of school itself” (National Research Council, 1989, p. 7). As we have seen above, Aboriginal students are all too often among those students who are filtered out and
fail to succeed in mathematics (Neel, 2008; Nicol, Archibald, Kelleher & Brown, 2006). Fasheh (1997) links students’ failure to succeed in mathematics, to the misconception that mathematics can be taught “effectively and meaningfully without relating it to culture or to the individual student” (p. 281). Culture and mathematics has been viewed as an oxymoron, a combination of incongruous words. Alternatively, conceptualizing mathematics as a cultural product may be a keystone for Aboriginal student success. Indigenous worldviews contrast sharply to dominant Western worldviews. These worldviews are rarely made explicit to students, but the resulting conflicts reveal themselves in the beliefs, attitudes and values of learners. A reconceptualization of mathematics is indicated, one that acknowledges the culture-laden nature of mathematics, and one that requires an understanding of the cultural border-crossing students must navigate to succeed in mathematics.

*Mathematics as Culture-free*

The beliefs and attitudes prevalent in today’s mathematics classrooms include a conception of mathematics as value-free, as rational and objective (Martin, 1997). Bishop (1994) notes that mathematics is “generally assumed to be culture-free and value-free knowledge” (p. 15). Students describe mathematics as “rigid and inflexible,” mathematics is seen as a subject that leaves no room for negotiation of meaning (Boaler, William & Zevenbergen, 2000, p. 1). This rigid and absolutist view of mathematics “tends to produce a passive acceptance of mathematics in the abstract, with little connection being made by pupils between their work and real life” (Nickson, 1992, p. 110). These reactions influence students’ affective responses to mathematics, which play “a significant role in mathematics learning” (McLeod, 1992, p. 575). McLeod
(1992) highlights that anxiety and frustration impede students’ progress in mathematics. The American Association for the Advancement of Science (1990) describes mathematics as the chief language of science, it “provides the grammar of science—the rules for analyzing scientific ideas and data rigorously” (p. 34). These ideas create a sense of mathematics as existing outside of culture (Powell & Frankenstein, 1997). A view of mathematics as culture-free reflects the dominant ontological assumptions (underlying worldviews), and epistemological beliefs (understandings of the nature of knowledge) of mathematics. Fasheh (1997) goes beyond censuring those who believe “that math can be taught effectively and meaningfully without relating it to culture,” to note this stance is “the main reason why math is considered meaningless, [and] incomprehensible” (p. 281) to so many students. An alternative perspective recognizes that “culture affects the ways we acquire and use our own mathematical knowledge” (Orey & Rosa, 2007, p. 4). Hollings, cited in Ezeife (2002), defines culture as “the essence of who we are and how we exist in the world. It is derived from understandings acquired by people through experience and observation…[and includes] knowledge or beliefs about…relationships or positions within the universe” (p. 179). To reconceptualize mathematics as richly infused by culture, we must examine and contrast further the dominant Western worldview with an Indigenous worldview.

Western Worldview versus Indigenous Worldview

Western mathematics and science emerge from a worldview that seeks to understand the order of the world. “Western science is seen as knowledge that is valued for its own sake,…[it] eradicates mystery, magic, and spiritualism in favour of physical causality”, it invokes “cause-effect and mechanistic explanations” (Yore, 2008, p.10-11).
With similar philosophical underpinnings, the modern conceptions of mathematics are deeply influenced by Plato’s idea that mathematics exists outside of the human mind (Dossey, 1992). Western Science, as part of the dominant worldview, “appears to be aggressive and analytical and is generally guided by the proposition that the physical universe is knowable through rational, empirical thought” (Snively & Williams, 2008, p. 122). Western science is credited with many insights, but Indigenous scholars lament that the Western worldview of science has been “caught up in an almost fanatic drive to objectify and fragment all of human experience” (Cajete, 2000, p. 285).

Dichotomous comparisons are simplistic and limited, but serve to highlight differences. “Knowing in the [I]ndigenous world has an integrated spirit, emotional, cognitive, and physical dimension” (Snively & Williams, 2008, p. 120). The universe is mysterious, a stark contrast to the Western ontological assumption (Aikenhead, 2006). The dominant Western worldview of living things embraces a Linnean hierarchy that situates humans atop plants and animals, humans are the most evolved, complex, intelligent beings (Snively & Williams). In “sharp contrast, an Aboriginal system places plants, animals, and all of creation in balance” (Snively & Williams, p. 116). This simple overview of science serves to illuminate the different cultural lenses students may bring to their mathematics classroom, and the need to anticipate conflicts students may experience.

Border Crossings

The Western and Northern Canadian Protocol’s (WNCP) (2008) curriculum documents for mathematics stress that “the learning environment should value, respect and address all students’ experiences and ways of thinking” (p. 8). Connecting to
backgrounds, experiences, goals and aspirations is a “key component in developing mathematical literacy” (p. 8). The WNCP recognizes that Aboriginal students often have a whole-world view of the environment and as a result, “live and learn best in a holistic way…students look for connections in learning and learn mathematics best when it is contextualized and not taught as discrete content” (p. 9). These statements acknowledge the importance of students’ culture and its influence on ways of thinking. Learning is situated within a process of enculturation for students, a process of learning the content of a culture’s beliefs and assumptions. Students, such as Aboriginal learners, may be navigating conflicting enculturation pressures as they contrast Western worldviews experienced at school and an Indigenous worldview experienced outside of school.

Giroux (1992, p. 28) proposes a “border pedagogy,” where students understand multiple cultural identities; border crossings are required to move between different cultural narratives. Aikenhead and Jegede (1999) develop the construct of cultural border crossing to describe how students move between the different cultural conceptions of the world implicitly present in their classrooms. The term border crossing is purposely a politically neutral phrase that acknowledges two different cultures (Aikenhead & Huntley, 1999). Aikenhead and Jegede describe a continuum of border crossing experiences characterized as smooth, manageable, hazardous, or impossible. A number of challenges appear to impede affecting smooth border crossings for Aboriginal students in mathematics classrooms.

**Cautions and Challenges**

In British Columbia there are 198 distinct First Nations identified, speaking more than 30 distinct languages, each with unique traditions and histories (First Nations, n.d.).
It is essential to acknowledge that multiple perspectives exist within various cultures and within individuals. Additionally, classrooms are increasingly multicultural. How can educators value and connect with the cultural lenses of students when multiple perspectives exist? The first step is an examination of one’s beliefs and attitudes. By acknowledging that mathematics and science have traditionally focused on “tkodwm…the knowledge of dead white men” (Cole & O’Riley, 2008, p. 58), educators can begin by making room for, connecting with, and exploring, broader understandings of what constitutes valuable mathematical and scientific knowledge. Educators can infuse their instruction with the achievements of world cultures to demonstrate valuing different cultures.

Culture must be viewed as a dynamic, not as a static, entity (Eglash, Bennett, Jennings & Cintorino, 2006). A student’s cultural background will shape their ontological assumptions and epistemological beliefs in different ways throughout their education. The Aboriginal worldview of “respect, responsibility, and reciprocity with nature” (Snively & Williams, 2008, p. 123) can inform a philosophy of tolerance and acceptance for a broad range of cultural lenses. Snively & Williams (p. 126) suggest a “Two-Row Wampum or Two-Way Knowing” model to empower students to “feel at ease in each culture, to engage their prior experience and knowledge...to be successful in school science, and to not lose their cultural identity” (p. 129). The educator’s role is to assist, not assimilate. Neel (2008) chooses the “metaphor of a Haida canoe as a means of visualizing the connectedness of…two worldviews in the learning of mathematics” (p. 256). His metaphor elegantly captures a sense of moving forward, which can only be achieved in a canoe when you paddle on both sides.
The present research is informed by a reconceptualization of mathematics as a cultural product. Aikenhead and Huntley (1999) examined challenges encountered by educators’ teaching science to Aboriginal students. Many of the spheres of challenges identified by these authors may have direct parallels in mathematics learning. One problematic sphere was conceptual; teachers did not see their subject as richly cultural. Another problematic sphere emanated from pedagogical problems; teachers did not recognize that students’ prior knowledge shapes their learning and they were not able to provide cross-cultural instruction. School culture issues were also found to be problematic; some educators promoted memorization not deep understanding of subjects, and others did not support Aboriginal knowledge in the classroom or felt that some students felt disconnected from their Indigenous culture. Practical challenges were also identified; teachers and students had insufficient resources and support. Lastly, ideological conflicts were characterized by teachers demonstrating deficit thinking. These teachers blamed students for their inability in the subject; “not one teacher broke through [a] wall of excuses to see a more fundamental issue of cultural conflict” (p. 170) that might explain a student’s lack of engagement and subsequent achievement.

Examining teachers’ cultural views, or lack thereof, of mathematics, is beyond the scope of this research, but Aikenhead and Huntley’s findings can serve to broaden understandings of the cultural challenges some students may face in their mathematics experience.

Social Cognitive Theory

Social Cognitive Theory (SCT) provides a theoretical framework, a lens within social constructivism, through which to consider the mathematics experiences of
students. Bandura (1977, 1997), the seminal voice of SCT, identifies a triadic reciprocal relationship between behaviour, the environment, and personal factors, that form a complex interconnected system that shapes human action. Individuals filter their experiences and understandings in domain specific arenas (Lent, Brown, & Gore, 1997). Self-efficacy, a primary mechanism of SCT, is “a set of personal beliefs regarding one’s capabilities in specific situations and performance domains (Lent, Brown & Gore, 1997, p. 307). Self-efficacy is “not a passive, static trait” but a dynamic set of self-beliefs (Lent, Brown & Hackett, 1994, p. 83). It is not a measure of a skill, “it is a perception about task-specific competence” (Hauk, 2005, p. 37). As a theoretical mechanism, self-efficacy “may account for the relation between past and future behavior (Lent, Brown & Hackett, 1994, p. 86). Self-efficacy is seen as a “cognitive feedforward” (Ibid., p. 87) mechanism. Within constructivism, self-efficacy emphasizes the importance of anticipation, forethought, and the active construction of meaning as one interacts with one’s environment. Individuals “are not seen as mere passive repositories of past or present environmental influences” (Lent, Brown & Hackett, 2000, p. 37). Mathematics self-efficacy has been shown to have “a direct effect on the development of interests [in mathematics]” (Bieschke, 1992, p. 123) in high school students and ages beyond (Lent, Brown & Hackett, 1994). Interest in mathematics in high school students “in turn [leads] to increased consideration of math/science occupations” (Bieschke, 1992, p. 131). As a result, self-efficacy has often been used to investigate career-choice paths (Blieschke, 1992; Fouad & Smith, 1996; Hackett, 1985; Schoon, 2001).
Four Sources of Self-efficacy Identified

Bandura (1997) hypothesized that “efficacy beliefs are based on cognitive processing of multiple sources of information” (p. 61). He identified four principal sources of information that contribute to self-efficacy beliefs:

(1) enactive mastery experiences that serve as indicators of capability,
(2) vicarious experiences that provide modeling of competencies and comparisons with others,
(3) verbal or social persuasions of one’s competency obtained from others, and
(4) physiological and affective states from which people “judge their capableness, strength, and vulnerability to dysfunction” (p. 79).

Enactive mastery experiences, also referred to as performance accomplishments, or authentic mastery, is argued to be the most influential source of efficacy information (Bandura, 1997; Lopez & Lent, 1992; Luzzo, Hasper, Albert, Bibby & Martinelli, 1999). Bandura asserts that it is the most influential source of efficacy information because it provides “the most authentic evidence of whether one can muster whatever it takes to succeed” (p. 80). It is important to note that it is the “cognitive processing” (p. 81) regarding performances that is important, not the performances itself. Correll (2004) similarly highlights that the “perceptions of their own competence” are central to enactive mastery. Usher and Pajares (2009) also stress that perceptions of mastery are better predictors of self-efficacy than objective results. In the domain of mathematics, this implies that it is not the grades students receive that determine their sense of mastery, but what they make of the grades they receive. For example, a B grade for one student may serve to enhance their self-efficacy, while that same level of performance might serve to
reduce another student’s self-efficacy. Many factors contribute to the student’s perceptions of their competency. Enactive mastery judgments take into account a student’s preconceptions of their capabilities, the perceived difficulty of the tasks, the amount of effort they expended, the amount of external aid they received, and their pattern of successes and failures over time (Bandura, 1997).

Bandura’s (1997) second principle source for self-efficacy beliefs arises through the vicarious experience of observing others. “Students gauge their capabilities in relation to the performance of others” (Usher & Pajares, 2008, p. 753). Although “vicarious experiences are generally weaker than direct ones…modeling influences do much more than simply provide a social standard against which to appraise personal capabilities” (Bandura, 1997, p. 88). Some individuals actively seek proficient models who possess the competencies they aspire to. Others benefit from seeing models overcome difficulties. Vicarious experiences typically raise efficacy beliefs by facilitating “seeing or visualizing people similar to oneself perform successfully” (p. 86).

“The verbal and social persuasions that students receive from others serve as a third source of self-efficacy” (Usher & Pajares, 2008, p. 754). Bandura (1997) felt that “verbal persuasion alone may be limited in its power to create enduring increases in perceived efficacy” (p. 101). None the less, “encouragement from parents, teachers, and peers whom students trust can boost students’ confidence in their academic capabilities” (Usher & Pajares, 2008, p. 754). Usher and Pajares also note that when students are not yet proficient at making accurate self-appraisals, they may depend on others to provide evaluative feedback regarding their competency.
The fourth source that informs self-efficacy beliefs is physiological arousal. The emotional and physiological states such as anxiety, stress, fatigue and mood influence students’ perceptions of their personal competency (Usher & Pajares, 2008). Bandura (1997) hypothesized that physiological arousal may be related to self-efficacy through a curvilinear relationship, “as for example, when moderate arousal is regarded as optimal activation for effective performance, but low levels of activation are viewed as demotivating and high levels as disrupting” (p. 114). High levels of anxiety with mathematics are known to have a debilitating effect on mathematics performance (Ho, et al., 2000).

**Self-efficacy: Patterns, Comparison to Self-concept, and Predictive Utility**

“Self-efficacy research has been overwhelmingly quantitative” (Zeldin & Pajares, 2000, p. 219). Much of the self-efficacy research has not investigated the contributions of the four sources of the construct, but has looked for overall patterns related to self-efficacy and its applications. Panoura, Gagatsis, Deliyianni and Elia (2009) report that mathematics self-efficacy decreases in students measured across primary to secondary grades. In their research, young students demonstrated a tendency to overestimate their capabilities; over time students became more precise in their self-evaluations. The students’ self-efficacy diminishing over time was attributed to increasing comparisons to others as the grades progressed, and an increase in task difficulty with reduced performances as a result. These insights allude to vicarious experiences in the form of social comparisons with peers and the importance of enactive mastery. This study did not explicitly discuss the students’ various sources of their mathematics self-efficacy. Pajares and Graham (1999) similarly found decreasing self-efficacy over time. Their
study examined middle school students in their first year beyond elementary school. The middle school students demonstrated a marked decrease in self-efficacy across their school year. The students also showed less effort and persistence in mathematics as well, perceiving mathematics to be less valuable. Overall, looking beyond the domain of mathematics, researchers have found that “self-efficacious students undertake difficult and challenging tasks more readily than do inefficacious students” (Zimmerman, 2000, p. 86).

Parallel results have been found with the construct of self-concept; self-concept has been found to decline across the high school years (Ma & Kishor, 1997). Self-concept differs from self-efficacy. It is a broader concept, one that is a mixture of self-beliefs and feelings regarding general academic functioning (Lent, Brown & Gore, 1997). Self-efficacy is context specific and has been found to not be subsumed by self-concept (Ibid.). Lee (2009) similarly explored self-concept and self-efficacy and reports the two constructs are empirically distinguishable. Lee and Pietsch, Walker and Chapman (2003) note that with respect to mathematics, mathematics self-efficacy is a better predictor of academic performance than mathematics self-concept. Results like these have led to an emphasis in the self-efficacy research on the construct’s predictive utility towards students’ future actions.

Betz and Hackett (1981) were the first of many researchers over the last 25 years to examine self-efficacy in college-aged students to look at its predictive utility in the career-choice field. Hackett (1985) averred that self-efficacy was much more important with regard to occupations and career-related domains than measured ability. Fouad and Smith (1996) modified Betz and Hackett’s (1983) mathematics self-efficacy instrument
for use with middle school students and reported that self-efficacy played a significant role in the development of students’ interests. Mau (2003) studied 8th graders in science, who were followed across a 6-year longitudinal study. Self-efficacy and academic proficiency were found to be the two strongest predictors of persistence in pursuing science and engineering careers.

The Relative Influence of the Four Sources of Self-efficacy

Of particular interest to this research are the studies that have investigated the four hypothesized sources of self-efficacy and the relative influences of each of the sources on self-efficacy belief development. Usher and Pajares (2008) recently reviewed 27 investigations into the sources of self-efficacy. Ten of the studies focused on college students, encompassing both graduate and undergraduate students. Two studies used adult participants reflecting on their journey into mathematics and science-related fields. Eight studies focused on high school students, five on middle school students, and an additional two studies spanned across elementary and high school participants. The majority of the research specifically looked at self-efficacy in the domain of mathematics, while a few considered writing, one engineering specifically, another science, and another three considered students’ overall academic picture. Of the eight studies from a high school setting, six had a mathematics focus. Only five of these studies are particularly pertinent, as one examined learning disabled students. The five quantitative studies were done between 1992 and 2007, examining 50, 481, 296, 292 and 438 students respectively. Three of the studies were done by a small group of researchers: Lopez and Lent, (1992); Lent, Lopez, Brown and Gore, (1996); and Lopez, Lent, Brown and Gore, (1997). Two more recent studies were done by Özyürek (2005) and Stevens, Wang,
Olivárez and Hamman (2007). Only Özyürek’s work, done in Turkey, was done outside of the United States.

Lopez and Lent (1992) did a correlational study with 50 high school students. Consistent with studies across all age groups, they found mastery experiences to be the most important contributor to self-efficacy beliefs. Mastery experiences, physiological indexes, and semester grades taken together were found to predict students’ self-efficacy. Additionally, girls were found to have stronger social persuasions. Lent, Lopez, Brown and Gore’s 1996 study used confirmatory factor analysis to build a five-factor model that best fit the high school data. Their five factors, or sources of self-efficacy beliefs, broke vicarious experiences into two categories: vicarious experiences with peers and those with adults. The study found the vicarious experiences with adults were more instrumental than vicarious experiences with peers to students’ sense of self-efficacy. The more traditional four-factor model using mastery, vicarious experiences, social persuasions, and physiological arousal, had fit data best with a college sample. The 1996 study reports strong correlation amongst personal performance, social persuasion and emotional arousal factors, which “may be understandable,” as “these three primary efficacy sources tend naturally to occur together” (p. 304). As an example, a student who does well on a mathematics test, may receive praise for their accomplishment and subsequently face future tests relatively free of worry. This study found small gender-source correlation, although women did demonstrate “somewhat more” (p. 303) social persuasion and vicarious experience.

Lopez, Lent, Brown and Gore (1997) in their next study again found mastery to be the most significant contributor to self-efficacy beliefs. “Collectively, the efficacy
sources explained 45% of the self-efficacy variation” (p. 49). This study also examined self-efficacy’s link to students’ interests. In keeping with studies of self-efficacy in other populations, the authors suggest that “people’s interests in an activity may be a reflection more of their perceived capability than of their measured talent,” (p. 50) confirming the predictive link of self-efficacy and student interests. Gender differences amongst the sources of self-efficacy were again not found to be significant, but again women perceived somewhat more mathematics related social persuasions and vicarious experience.

Özyürek’s (2005) Turkish study of 292 students used structural equation modeling to produce results in keeping with the previous studies. This study’s results departed from the earlier studies in two ways, which appear to be unique to the study’s setting. Regarding students’ interests, “mathematics-related self-efficacy and mathematics interest did not predict mathematics-weighted preferences” (p. 154). The author suggests this is related to the complicated university and course-choice mechanism that is unique to Turkish schooling. Also departing from earlier results, Özyürek did not find evidence for vicarious experience contributing to self-efficacy beliefs. The details of the Turkish setting are unclear, but the author provides by way of explanation, that “students cannot observe their peers’ study techniques in school or in a class environment” (p. 152). Such a setting would preclude contributions of vicarious experiences.

The most recent of the high school mathematics self-efficacy sources research reviewed by Usher and Pajares (2008) was done in Texas by Stevens, Wang, Olivárez and Hamman (2007). This research did not look at physiological arousal, but using
structural equation modeling found the combination of mastery experience, vicarious experiences and social persuasion accounted for 18% of boys’ self-efficacy and 15% of girls’ self-efficacy. In contrast to the earlier studies there were no gender differences noted, significant or otherwise, between sources of self-efficacy.

All five studies are reflective of a broader sampling of self-efficacy research. Mastery experiences have consistently been found to be the dominant contributor to self-efficacy beliefs (Lent, Lopez & Bieschke, 1991; Lent, Lopez, Brown & Gore, 1996; Lopez & Lent, 1992; Lopez, Lent, Brown & Gore, 1997; Luzzo, Hasper, Albert, Bibby & Martinelli, 1999; O’Brein, Martinez-Pons & Kopala, 1999). The correlations between mastery experience and self-efficacy in the 27 studies reviewed by Usher and Pajares (2008) range from .29 to .67 with a median of .58. In contrast, vicarious experience and self-efficacy correlations have been inconsistent, ranging from .09 to .58. “This source is the least likely to predict self-efficacy across studies” (p. 772). Likewise, social persuasion’s correlations with self-efficacy extend across a large range, from -.05 to .62, but with fewer non-significant correlations. Usher and Pajares conclude that “social persuasions have not proven predictive of self-efficacy across all contexts” (p. 775).

Results for physiological arousal are more consistent. “Physiological state has been found to negatively predict self-efficacy in mathematics,” with correlations of -.08 to -.57 (p. 775).

**Methodological Shortcomings**

Usher and Pajares (2006, 2008, 2009) discuss at length the methodological limitations in self-efficacy source research that are likely responsible for a variety of conflicting and inconsistent results. Quantitative studies across a 20-year time span have
used a variety of mathematics self-efficacy scales making comparisons difficult. Some were written for college samples (Betz & Hackett, 1983; Lent, Lopez & Bieschke, 1991; Matsui, Matsui, Ohnishi, 1990) and later modified for younger populations (Fouad & Smith, 1996; Hodges, 2009; Klassen, 2004a). Other studies have failed to publish their scales or provide samples from their scales (O’Brien, Martinez-Pons & Kopala, 1999).

Usher and Pajares (2008) point not just to the variability between self-efficacy scales, but to the problems within some of the scales. In particular some researchers (Klassen 2004a; Matsui, Matsui & Ohnishi, 1990; and Chin & Kameoka, cited in Ushers & Pajares, 2008) have failed to measure students’ perceptions of their competence and have substituted performance outcomes (standardized mathematics scores, self-reported grades) as an indication of mastery experiences. This practice departs from Bandura’s (1997) hypothesis and is not supported by the empirical evidence of Lopez, Lent, Brown and Gore (1997) showing mastery experiences are better predictors of self-efficacy than objective results. Other problematic practices include scales using too few items to evaluate a source; Panagos and DuBois (1999), reported in Usher and Pajares (2008), used just one item to assess physiological arousal. Other scales used inappropriate items for their assessment of sources. Hampton and Mason (2003), as reported in Usher and Pajares, examined mathematics and English self-efficacy and used items such as “my teachers encouraged me to listen carefully in class,” as a measure of social persuasion. A more appropriate item from another scale was “my teacher often encouraged me by praising my math ability” (used by Matsui, Matsui & Ohnishi, 1990).

an experiment for undecided-major college students to compare the effects of a mastery and vicarious experience intervention. They only found support for mastery experiences for increasing student mathematics self-efficacy. Upon closer inspection however, the vicarious intervention seems weak at best. Participants viewed a 15-minute video presentation of university graduates who spoke of previously being undecided regarding their majors but had carried forward with mathematics or science careers. This research draws attention to an important aspect of the four hypothesized sources of self-efficacy. Bandura (1997) notes that “information that is relevant for judging personal capabilities – whether conveyed enactively, vicariously, persuasively, or physiologically – is not inherently enlightening. It becomes instructive only through cognitive processing… and through reflective thought” (p. 79). For all sources of self-efficacy, in this case with vicarious and social persuasion experiences, it is important how the individual assesses the information, in this case the source of the encouragement. Input from a random observer will be assessed differently from feedback given by a trusted other. Zeldin and Pajares’ (2000) qualitative investigation into women’s sources of self-efficacy report “that women were especially attentive and susceptible to the encouragement of those about whom they cared and with whom they felt a relational bond” (p. 238). Encouragements, validations and modeling from significant adults, which we describe here as social persuasion and vicarious experience, from role models and mentors, has been noted in other areas of research as powerful and affirming supports in the learning environment (Packard and Nguyen, 2003). From the arena of engineering and self-efficacy, Marra, Rodgers, Shen and Bogue (2009) echo the importance of the mentoring
relationships within social persuasion. The variety of methodological shortcomings in the existing literature underscore the need to clearly operationalize all variables in research.

**Gender Comparisons and Cross-Cultural Studies**

In spite of these methodological limitations in the literature, two other areas in quantitative self-efficacy research are important to review for the present research: gender findings and self-efficacy research in cross-cultural settings. Although results stem from a small number of studies, some suggestions have been made regarding gender differences. Males have been found to rely more strongly on mastery experiences in the formation of their self-efficacy beliefs (Hampton & Mason, 2003; Lent, Lopez, Brown & Gore, 1996). Men have also been found to have weaker aversive physiological arousal (Lent, Lopez, Brown & Gore, 1996). Both of these findings are echoed in a science setting (Britner & Pajares, 2006). Women’s stronger social persuasion and vicarious experiences have already been noted. Numerous studies have noted women display lower mathematics self-efficacy (Hackett, 1985; Lent, Lopez & Bieschke, 1991, 1993; Phillips & Zimmerman, 1990). In terms of physiological arousal, women are reported to have stronger physiological reactions than men, although no significant difference was noted in how influential individuals considered this source (Lent, Lopez, Brown & Gore, 1996).

There is a paucity of high school setting cross-cultural self-efficacy research and one must look beyond high school samples and mathematics for insight. One of the earliest studies was done by O’Brien, Martinez-Pons and Kopala (1999) who used a high school setting to investigate mathematics self-efficacy beliefs of 415 students, of whom approximately 40% were White, 30% Hispanic, 23% Black, and 7% Asian. This study reported ethnic minority students displayed lower self-efficacy compared to White
students. Earley, Gibson and Chen (1999) studied adult managers from the United States, China and Czechoslovakia. Their research used an experimental design to delve into issues of individualism versus collectivism across cultures and the resulting impact on self-efficacy formation. “The most important finding from this study is that a collectivist’s sense of efficacy is not derived simply from his or her group’s success; rather, it is based on a unique combination of individual and group referenced feedback” (p. 614). Their findings suggest that self-efficacy beliefs are most strongly influenced by personal, not group-based factors. Never the less, Klassen (2004a) conducted a review of cross-cultural perspectives on academic self-efficacy and reports that overall collectivist cultures report lower measures of self-efficacy without a corresponding reduction in performance levels. Klassen’s review compared Western and Asian research studies, as well as contrasting American with Eastern and Western European studies. Klassen (2004b) also carried out research in Canada with 270 grade 7 mathematics students divided among Indo Canadian immigrants, and Anglo Canadian non-immigrants. This research reports Anglo Canadian students were found to rely more heavily on mastery experiences and physiological arousal, and Indo Canadian immigrant students were more “other” oriented and demonstrated that vicarious and social persuasion sources were significant contributors to self-efficacy formation. Unfortunately, Klassen’s (2004b) study did not measure mastery experiences in a way that reflected students’ perceptions of their performance; instead it drew only upon their prior performance outcomes.

Other cross-cultural studies, like research summarized above, reported heavy reliance on mastery for White students (Smith, 2001; Usher & Pajares, 2006). Stevens, Olivárez and Hamman (2007) reported Hispanic mathematics students sampled across
grades 4 to 12 demonstrated more emphasis on vicarious experiences than White students. Usher and Pajares (2006) contrasted African American middle school students with White middle school students. The authors report mastery and social persuasions predicted self-efficacy for African American students in contrast to mastery and physiological arousal predicting self-efficacy for White students. Lee (2009) drawing on culturally diverse data from 41 countries from the Program for International Student Assessment (PISA) 2000 test results cautions that self-efficacy beliefs may have “fundamentally different meanings across different cultures” (p. 357). Lee asserts that self-efficacy in individualistic cultures draws heavily from performance mastery, while individuals in more collectivist cultures draw more heavily from a sense of belonging and social persuasions. Klassen’s (2004a) concluding implications for cross-cultural research seem particularly important. He notes that “in multicultural educational settings, it is important to understand that for some students, expressions of efficacy may be somewhat muted, and related more to different cultural practices and beliefs than lack of confidence” (p. 227). The lack of studies in different cultural settings, and the varied results of the studies that have been done, point to the need for further investigations. Usher and Pajares (2006) comment “sources of self-efficacy…have scarcely been explored by race or ethnicity” (p. 126). Creed, Patton and Watson (2002 and Lee (2009) similarly press for further research suing the self-efficacy construct with high school participants from different cultural contexts.

The Need for Qualitative Investigations

Further investigations utilizing qualitative designs are also indicated. Zeldin and Pajares (2000) acknowledge that “quantitative methods do not provide the opportunity
for rich description” and that “self-efficacy theorists have argued that deeper insights must come from qualitative research” (p. 219). Usher with Pajares (2006) assert that “qualitative studies would provide a phenomenological lens through which to view the development of students’ efficacy beliefs” (p. 139). Three qualitative self-efficacy studies with these authors address this gap in the research: Zeldin and Pajares’ (2000) study of 15 women with successful mathematics/science careers; Zeldin, Britner and Pajares’ (2007) study of ten men with successful mathematics/science careers, including a cross-case comparison to the earlier female study; and Usher’s (2009) study of eight middle school students (and their parents and teachers) some of whom were African American.

Zeldin and Pajares’ (2000) qualitative study delves into previously unexplored territory by seeking a holistic picture of the intricacies of self-efficacy development. The authors also sought to understand ways in which self-efficacy beliefs influenced academic and career choices for women working in male-oriented mathematics, scientific and technological careers. Two key results emerged from the study: (1) social persuasions and vicarious experiences made important contributions to the women’s sense of self-efficacy, and (2) self-efficacy beliefs helped the women be more resilient to the academic and social obstacles they had encountered. Zeldin et al. (2007) report that for men, authentic mastery experiences are a powerful source of self-efficacy beliefs. Men also spoke of vicarious learning and social persuasion, but in a “substantially different manner than did the women” (p. 10). Men expressed these elements as important reinforcers of their self-efficacy beliefs in contrast to the central role these elements played in women’s self-efficacy development. The female sample, without
exception, mentioned teachers in a key catalyst role in their self-efficacy development and subsequent career direction choices. Only one half of the male sample mentioned teachers, and again, in a substantially different manner, this time stressing teachers as models of enthusiasm and passion for their subject areas. Men did not report any of the academic and social obstacles noted by women in the earlier study, and did not report any struggles with social identity issues in the mathematics, science, and technology arenas.

The two studies linked their combined findings to additional theoretical frameworks. The authors drew parallels between their findings and Erikson’s (1968) identity framework which stresses the importance of outer-space references for men and inner-space references for women. They further connect the social comparison importance in self-efficacy belief development in women to Gilligan’s (1982) research that argues that women use relationships in their lives as a foundation to ground their behaviour.

The most recent qualitative study, Usher (2009), responds to calls for self-efficacy research in younger populations. Lent, Brown and Hackett as early as 1994 urged for such investigations because revisions of self-efficacy beliefs is a “process [that] repeats itself continuously over the lifespan, although it is perhaps most fluid until late adolescence or early adulthood. Some of Usher’s findings are in line with previous studies: students “with high mathematics self-efficacy also reported having high levels of achievement in mathematics, and students with low self-efficacy recounted their poor performance and struggles,” and “mastery experiences…emerged as a powerful source of self-efficacy…in this academic domain” (p. 307). The research revealed a more in-depth understanding of vicarious learning and the importance of models, noting “students do not uniquely rely on their own experiential repertoire in mathematics to refine their
efficacy judgments” (p. 308). Usher reports “one new and potentially important finding” (p. 308) with respect to students’ physiological arousal. Students with strong self-efficacy “framed their bouts of heightened arousal in ways that were motivating; those with low self-efficacy experienced a level of distress that left them feeling disheartened and often paralyzed” (p. 308). This qualitative study also shed light on students’ internal dialogues, their visualizations of their own coping, which Usher identifies as part of their vicarious experiences. Lastly, the research looked for gender and race differences amongst the students. Unlike the earlier qualitative studies, few differences across gender emerged. Usher does note an increased emphasis on social persuasion in three African American students, in line with the quantitative findings of Usher and Pajares’ (2006) examination of African American middle school students.

*A Canadian Indigenous Perspective*

Usher’s (2009) most recent study concludes with an important caution — the research reports from a specific context. The literature demonstrates the need for a more nuanced understanding of how students process information from the four sources of self-efficacy. There is a lack of research data from a Canadian Indigenous perspective. Bandura (1997) discusses the growth of self-efficacy through adolescence, and notes that “self-efficacy development can play a key role in setting the course” of life paths (p. 177). He further asserts “the task of choosing what lifework to pursue…looms large during adolescence (p. 184). In spite of the significance of youths’ experiences, most examinations of self-efficacy, interests, and career choice, have focused on college age participants (Bieschke, 1992; Rottinghaus, Larson & Borgen, 2003). Schoon (2001) raises the importance of studying self-efficacy development in high school students as
“there is evidence that occupations are chosen at an early age” (p. 124). It is, however, long before admission to post-secondary institutions that students make the mathematics course choices in high school that determine their options for post-secondary study. Since mathematics choices made in high school shape future post-secondary pathways in mathematics and science, along with business, health and trade careers, it is important to explore students’, and Aboriginal students’ in particular, experiences in mathematics education to gain insights into their self-efficacy development.

*Summary of Chapter II*

Chapter II has provided a selected review of literature pertinent to the research. The performance of Aboriginal students was contrasted to non-Aboriginal students. Mathematics as a cultural product was reviewed including challenging the notion that mathematics can be successfully taught in a culture-free manner. Western and Indigenous worldviews were contrasted and the resulting border crossings and challenges that may be faced by Aboriginal students were highlighted. Lastly, the literature review examined social cognitive theory and the current understandings of mathematics self-efficacy and the sources that contribute to its formation.
Chapter III - Methodology

Qualitative Research with Narrative Methodology

The research questions focus on the mathematics experiences of Aboriginal youth which requires in-depth data. Accordingly, the research needs to be qualitative in nature. This approach is suitable as “qualitative research seeks depth over breadth and attempts to learn subtle nuances of life experiences” (Whittemore, Chase & Mandle, 2001, p. 524). A strength of qualitative inquiry is its ability to retain the context of an exploration (Priest, Roberts & Woods, 2002), and qualitative inquiry can meet the need to “emphasize the social, historical, and political contexts as these shape experiences, lives, positions and futures for Aboriginal peoples” (Steinhauer, 2002, p. 72).

Within a qualitative approach, a narrative methodology was selected as a way to gain insight into Aboriginal youths’ experiences in mathematics. The Holistic Framework notes “narrative inquiry is a research method that is particularly suitable for Aboriginal research, because it is predicated on the importance of story” (Kenny, 2004, p.28). Smith (1999) speaks favourably of story as “story telling… ha[s] become an integral part of all Indigenous research…each individual story is powerful. But the point about the stories is not that they simply tell a story, or tell a story simply. These new stories contribute to a collective story in which every Indigenous person has a place” (p. 144). It is my hope that, by exploring the stories of Aboriginal youths, the research can contribute to “legitimizing the under-represented narratives of students within the curriculum [which] may allow for new discourses to arise and for these discourses to become engaged in the curriculum conversation” (Krocker, 2004, pp. 27-28).
Respect, Relationality and Reciprocity

In addition to using narrative methodology, the research is shaped by Steinhauer’s (2002) overarching framework of the ‘3 R’s,’ respect, relationality and reciprocity, to guide the research in a culturally respectful manner. The research context and the opening up of space for an Indigenous paradigm have already been discussed and demonstrate the principles of respect and relationality. Relationality is further supported by the use of narrative methodology and the focus on story. Frank (2000) notes that “Stories as acts of telling are relationships” [emphasis in original](p. 354). Clandinin and Connelly (2000) and Cottle (2002) echo that narrative inquiry is a human, relational inquiry. It is important to use “dialogue in its authentic form…[with] a mutual speaking and hearing” (Borba, 1997, p. 268). Archibald (2008) writes that it is more than simple listening that is important, we must listen with three ears: two on the sides of our head and one that is in our heart. Research reciprocity is also critical and aims to provide a two-way exchange of information, not an exploitation or extraction of knowledge accountable only to an academic environment. Hermes (1998) and others (Smith, 1999; Steinhauer, 2002) stress the importance of being accountable to the researched community.

The Role of the Investigator

My preface sheds light on my motivation as an investigator. Through the research journey a number of multilayered relationships were navigated including an adult to youth positioning, and a non-Aboriginal to Aboriginal person positioning. I was also aware of gender and socioeconomic status issues. These categories and positionings contain complex and multilayered relationships within them, as no category was one dimensional or static.
Being an “adult” was just one aspect of how I was viewed by my research collaborators. Two students knew me from my teaching practicum during my B.Ed., as a social studies teacher at the school, and from my various stories, knew me as a mother. Others were aware of an academic and interest dichotomy, as I was known to them as a mathematics teacher, and they in contrast often expressed a dislike of mathematics, and also suffered from mathematics anxiety. At other times a social filter was at work and a privileged versus vulnerable divide was evident. Multiple layers here included being schooled, a graduate student, employed, emotionally supported, and having life experience to draw upon. O’Kane (2000) alerts researchers that “the biggest challenge for researchers working with children are the disparities in power and status between adults and children” (p. 136). O’Kane’s cautions are noted and it may be that my participants may have felt powerless and vulnerable in an institutional setting; some may lack emotional support, and may feel that their thoughts and feelings are not taken seriously in their lives.

My first step towards ameliorating these divides, to make them bridgeable, was to focus on the relational potential within narrative inquiry (Clandinin & Connelly, 2000). My goal was to minimize power differentials, to let go of being in charge, to allow the potential for dialogue to emerge. It was essential to emphasize that what the student had to share was important, to frame and name their involvement as vital to the research. The school setting suffers from “a cultural reluctance to take children’s ideas seriously…adults tend to trivialize and devalue children’s acts” (Morrow & Richards, 1996, p. 98). Despite intentions articulated in letters of consent, “children who are
required to participate in research in schools may not feel in a position to dissent, simply
because most (if not all) tasks and activities in school are compulsory” (Morrow &
Richards, 1996, p. 101). As a mother of three emerging adults I have experience
minimizing the adult/youth divide. I am aware of body language, clothing, tone of voice
and choice of words, that can all help move one closer to a student’s world. Sensitivity in
these areas and a non-judgmental receptive stance hopefully enhanced my opportunity to
be privileged by students’ stories.

*Non-Aboriginal / Aboriginal*

I have introduced the overarching framework of respect, relationality and
reciprocity for my research, alongside the opening up of space for an Indigenous
paradigm including the valuing of Aboriginal viewpoints and experiences. The spaces
opened up by the research require an acceptance of experiencing a cultural tension. The
goal in the presence of an Aboriginal/non-Aboriginal divide is to facilitate a cultural
border awareness, not to ignore differences, but also not to attempt to resolve them
(Oberg, Blades & Thom, 2007). My research participants share with me many cultural
features: urban living, being British Columbians, sharing movie memories (*Twilight*).
Cultural differences can take many shapes beyond Aboriginality. I tried, in the words of
Josselson (1995), to overcome distance wherever possible, not create it. I employed a
listening openness that includes a suspension of assumptions and certainty, it “leads to a
space that allows for power balances to shift, and cross-cultural meaning making to
occur” (Williams & Tanaka, 2007). I wish to legitimize the under-represented narratives
(Krocker, 2004) of Aboriginal youth. By supporting the development of youths’ voice, it
is more than merely representing students’ beliefs, it is “the essence of students’ forming
a sense of identity” (McFeetors & Mason, 2005, p. 16). As Giroux (1999) notes, “if we take the experiences of our students as a starting point for dialogue and analysis, we give them the opportunity to validate themselves, to use their own voices” (p. 18).

Regardless of the good intentions of the research, there is nevertheless, the potential for doing harm. Gudmundsdóttir (2001) cautions that narratives are not always emancipatory, they can be coercive if they reproduce gendered, hierarchical, or patriarchal structures of the dominant culture, thereby further silencing an already silenced group. Frank (2000) believes storytelling can be therapeutic. In instances where life is hard, “stories can provide those in the storytelling relation with some distance from whatever threatens them” (p. 354). In contrast, as noted earlier, Smith (1999) warns that research can “stir up silence” (p. 1). Neumann’s (1997) work with post-holocaust stories examines silences and can inform the researcher to be particularly cognizant of inward gazes, looks and gestures, or simply the feelings evoked in others. Cole and O’Riley’s (2008) conversational-styled response to Nielsen, Nicol and Owuor’s (2008) insightful discussion of complexivist thinking and culturally-responsive mathematics pedagogy, can serve to discourage non-Aboriginal researchers across many fields. Cole and O’Riley’s playlet-conversations spar fiercely and effectively, demonstrating that what seems like excellent ideas and intentions can still serve to evoke anger and resentment amongst Aboriginal populations. Cole and O’Riley’s commentary illuminates the potential to do harm by non-Aboriginal researchers researching Indigenous peoples. In my research setting, I heeded Rosenthal’s (2003) caution and took “into consideration the considerable psychological effects telling one’s life story can have” (p. 915). I contacted the school’s counseling department to ensure they were aware of the research process and
asked for their support in the event that any students felt the research conversations had prompted the need for further support. In the end, none of the participants expressed such a need.

I made every effort to enact Williams and Tanaka’s (2007) listening openness to achieve “an active silence that honours the presence of others. It involves observation, critical reflection, and awareness” (¶21). I was guided by Williams and Tanaka’s tone in an effort to avoid assuming a position of familiarity and control. I used a listening openness, positioned myself as a learner, in an attempt to disrupt traditional power structures that all too often exist between researcher and participant.

**Gender and Socioeconomic Status**

I was cognizant of gender issues throughout my research. As a woman mathematics educator I have experienced people’s surprise that I am interested in mathematics, as prevailing perceptions of mathematics are masculine: “Most mathematicians are men, and mathematics like the rest of natural science is seen as masculine: a subject for those who are rational, emotionally detached, instrumental, and competitive… The teaching of pure mathematics as concepts and techniques separated from human concerns, plus the male-dominated atmosphere of most mathematics research groups, make a career in mathematics less attractive for those more oriented to immediate human concerns, especially women” (Martin, 1997, p. 165). Mathematics educators are beneath career mathematicians on the intellectual food chain, but nonetheless, women as senior mathematics educators are in a male domain. My research provides me with an opportunity to be a role model for young women, but my gender may also have made it difficult for young men to relate to me.
In a similar vein, I may have been perceived by a range of positionings in the socioeconomic realm. My actual and my perceived socioeconomic status differed from my research collaborators and this difference may have created distance for some students. The school community where the research occurred is a relatively affluent high school, but not all of the students enjoy economic privilege. I am privileged economically and I strive to not allow my socioeconomic status to be apparent, or to be a statement made with jewelry, clothing, or language. Conversely, it was also essential to not show any judgments of students with a higher socioeconomic status than myself.

The Research Setting

The research was conducted at a large high school in Victoria, BC where I have numerous existing relationships. My history with this school community provided me with an opportunity to successfully research using a respect, relationality and reciprocity lens. My three sons attended this school during which time I volunteered extensively supporting the school’s music program. I completed my teaching practicum for my B.Ed. at the school between January and April 2008, and more recently I have been substitute teaching regularly at the school. Prior to receiving formal human ethics approval (see Appendix A: Human Ethics Approval) from both the University of Victoria and School District 61, I met with school administration, and both school and district Aboriginal staff, regarding my proposed research and received an encouraging, supportive, and welcoming response. At the time of the research the school had 32 students, spanning grades 9 – 12 (ages 14-18), who self-identified as Aboriginal. The recruitment process began with contact through the Aboriginal Support Teacher who is at the school one day a week. (see Appendix B: Information Letters.) This Aboriginal support teacher
suggested I attend the welcome pizza luncheon the school hosted for their Aboriginal students in mid-October and make a presentation to the students regarding the research. Information and consent letter packages, for students and their families including a brief background to the research, was provided at the luncheon for the ten students who attended (see Appendix C: Consent Letters). Over the following two weeks, I made contact with the remaining Aboriginal students to deliver the consent letters. I was available in person, by email, and by phone to answer any questions students or their families had regarding the research. Ten students chose to participate in the research. Interviews were conducted at a time convenient to the participants in small private unused offices at the school. Missed appointments and repeated rescheduling extended the data collection process across a four-week period. Students were given a small honorarium of $15.00 and chocolate bars to show my appreciation for their willingness to take the time to contribute to the research.

The research site school, with only 32 Aboriginal students, is a school with only a small population of urban Aboriginal students (none of the students lived on reserve lands). The Aboriginal students make up only 2.5% of the school’s student population of 1,300 students. The ten students who volunteered to participate in the research made up 31.2% of the 32 self-identified Aboriginal students at the school. Relative to the school’s Aboriginal population, the three boys who participated constituted 38.8% of the Aboriginal boys, the seven girls constituted 21.4% of the female Aboriginal students. This data is summarized in Table 1 – Gender of Participants.
Table 1 - Gender of Participants

<table>
<thead>
<tr>
<th>Gender</th>
<th>Participants</th>
<th>School Aboriginal Population</th>
<th>Participants as a Percentage of School Aboriginal Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>3</td>
<td>14</td>
<td>38.8</td>
</tr>
<tr>
<td>F</td>
<td>7</td>
<td>18</td>
<td>21.4</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>32</td>
<td>31.2</td>
</tr>
</tbody>
</table>

Data Collection Procedures

To foster relationality, by supporting dialogue and conversations, the sharing of storied experiences in a narrative inquiry, I used a participatory tool as part of my interviews. A number of authors (Ennew, 1994 as cited in Morrow & Richards, 1996; Johnson, Hill & Ivan-Smith, as cited in Morrow & Richards, 1996; Punch, 2002) suggest the use of creative methods to engage youth in research. I developed a “math experience map” (see Appendix D) to augment narrative interviews. The math experience map was inspired by Possible Selves mapping techniques used by Marshall and colleagues (Marshall, 2007; Masrshall & Guenette, 2008), based on Markus and Nurius’ (1986) Possible Selves conceptual framework. Possible Selves mapping is a process that guides participants as they brainstorm, categorize and reflect upon hoped for and feared possible selves. Two aspects of Possible Selves mapping guided the development of the math experience map: the tangible hands-on characteristic of the mapping and distinguishing between positive and negative aspects of one’s experience. The math experience map constituted a visual representation of aspects of the students’ experiences. The students identified things that have supported them in their efforts to succeed in mathematics, and the obstacles to their efforts to succeed in mathematics, by placing ideas on different coloured sticky-notes on the math experience map (one colour for obstacles, another colour for supports). The map (see Appendix D: Math Experience Map) served as a
participatory tool to help students organize and reflect upon their experiences. The map was useful as it diffused the intensity of interviews by allowing the researcher and the participant to focus on the tool, not each other. The map provided a reason for the researcher and the participant to sit side-by-side, not across from each other, hopefully diluting the power differential of an interviewer-interviewee interaction. The map also provided participants with personal space to develop their thoughts before being asked to elaborate on their experiences, a benefit of task-based tools noted by Punch (2002). Youths’ voice and agency was fostered, the map facilitated engagement and reflection with the students’ own stories. Further agency was supported as students engaged in the analysis of their own stories as they grouped and ranked the impactfullness of their experiences. Using the map was one way to go beyond a do no harm research intent; by providing a visual overview of their experiences to the students and supporting a reflective experience, the map aimed to assist youths in making meaning from their story.

The interviews lasted from 25 to 75 minutes, with most sessions lasting approximately 45 minutes. I intended our sessions to begin with a narrative segment, prior to using the math experience map (see Interview Protocol in Appendix D). This was the case for most of the interviews, but in two instances the students inquired about the map right at the start of our time together and we began by focusing on it. More often, I began by asking students to share some background information about themselves: their family situation, their interests, what was in their lives outside of school. To begin an exploration of their experiences with mathematics I then asked the students to “tell me a story from your math experiences that paints a picture for me about you and math.” I then responded to their stories with probes asking them to tell me a little more about some
aspect of what they had shared. For some of the interviews, I did find a limited sense of flow from the students and moved fairly quickly to introducing the math experience map. This eased any pressure of silence between the student and myself and gave us a new target for our attention. I had a list of notes for myself to scan prior to the interview’s end. I anticipated each participant would mention their feelings around math, whether they suffered with test anxiety, and how they got extra help and encouragement, but had a check list for myself with these questions in case these items had not arisen.

As I transcribed my first interview, and then a few days later, after my next two interviews, I returned to my researcher journal and reviewed my notes as I felt my methodology was evolving. I was initially very critical of myself as a researcher. I was concerned I was talking too much for a narrative interview. As I reviewed the interview transcripts, I examined the content of my contributions. I realized my listening openness did not feel genuine and caring without me sharing with the students my reactions to their experiences. This changed somewhat the nature of the narrative experience I was co-creating with my participants. Once I could identify the reasons behind my behaviour, I also knew it was an important evolution I wished to embrace as a researcher. Guillemin and Gillam (2004) in their discussion of ethically important moments, note “adopting a reflexive research process means a continuous process of critical scrutiny and interpretation, not just in relation to the research methods and the data but also to the researcher, participants, and the research context” (p. 275). My methodology and my role as researcher were moving the research towards a relational methodology. As Broom, Hand and Tovey (2009) stress, “the individual biography of the qualitative researcher is recognized to have a major impact on a research project” (p. 51), including shaping its
methodological foundations. I had not anticipated the strength of my need to enter into a “relational approach to learning” with the students (Buck, Mast, Macintyre and Kaftan, 2009, p. 506). I felt my discussions with the students, evolved from Williams and Tanaka’s (2007) concept of listening openness, and was a vital part of the research process, one I did not wish to avoid or minimize. Barton (2004) presents “the process of co-participating and co-constructing stories inherent in narrative inquiry” (p. 519) as relational methodology. She notes “the horizon of the interpreter and the horizon of the interpreted become enmeshed and create meaning in [a] context. Through dialogue each person gives up a little of the self to the other and the new horizon that is co-created becomes a piece of the interpretive process” (p. 521). Insight into the relational aspect of the co-created reality of the interviews, demonstrating social constructivism in action, enabled me to proceed with the remaining interviews without self-criticism as I had formed a new understanding of relationality, an aspect of my inquiry process I deemed essential.

Ellis (2007) describes methodological evolution in terms of relational ethics. This ethic emerges after formal procedural ethics and “recognizes and values mutual respect, dignity, and connectedness between researcher and researched” (p. 4). My methodological evolution towards a relational methodology, a narrative methodology with a greater emphasis on responding to participants and discussing their experiences, although unexpected was welcomed. This shift created new borders in the process Gubrium and Koro-Ljungberg (2005) describe as the inter-relational space. Clandinin and Connelly (2000) frame this relationality within the terminology of narrative inquiry, noting “as narrative inquirers we work within the space not only with our participants but
also with ourselves” (p. 60). For Clandinin and Connelly “narrative inquiry is a relational inquiry” (p. 60).

When the students and I focused on the math experience map, the students were asked: what things would you identify that have helped, or supported, you in math, and what things have hampered, or were barriers, to you being successful in math? Students were also asked to reflect on what they had written, to see if they noticed any themes or groupings. Finally, to conclude our sessions, students were asked if they felt our time together had been worthwhile.

The interviews were audio-taped. I took pictures of completed math experience maps at the interview when students wished to keep the map; other maps were photographed at a later time. I made notes immediately after each interview and transcribed the interviews myself.

Data Analysis

“In qualitative research, there is a particular ethical responsibility, on the part of the researcher, to honour stories” (Kenny, 2004, p.35). In this research, to honour stories I took notes immediately after interviews, reviewed math experience maps, listened to the audio-taped interviews, transcribed interviews, read and re-read the transcripts. Analysis was shaped by the works of McCormack (2004), Storying stories: A narrative approach to in-depth interview conversations, and Rhodes’ (2000), Ghostwriting research: Positioning the researcher in the interview text. These authors provide an alternative method to reductionist coding and subsequent reconstruction of interviewee’s stories. McCormack’s alternative reviews data through multiple lenses: active listening, narrative processes, language, context and moment. By using these lenses, I created student
profiles to highlight the individuality and complexity found in each youths’ story. This method considers the researcher’s emotional and intellectual response to the participant, as well as an in-depth reflection with the data. It is important to consider not just what was said, but how it is said: What metaphors or images are invoked, and how do they shed light on the interviewee’s experience? What remains unsaid? The silences, tone and speed of speech delivery, hesitations and other performance features helped me understand more deeply the research participants. By not coding texts, McCormack aims to grasp the complexity of everyday lives, to not lose the features of the language, and to capture the contextual, structural and performance aspects of the story. Rhodes emphasizes that language does not transparently reflect reality, it produces reality. Following the in-depth review of the interview information, I wrote brief paragraphs of the youths’ experiences in an effort to encapsulate the nature of the stories they shared with me. The stories are not intended to replicate the interview transcript, but were crafted to create a written narrative that captures the feel and content of the youths’ experience (Rhodes, 2000). McCormack’s emphasis on what is said, alongside how it is said, and what remains unsaid, shaped the writing of the stories, in order to retain the situated nature of the various experiences. The stories aim to reflect individuality, and the multi-voiced complexity found in personal experiences.

By creating a paragraph reflecting each youth, the students had another opportunity to reflect upon their story and refine its presentation. Each of my research collaborators accepted the invitation to review the written narratives. All participants expressed that they felt what I had written was congruent in feel and content to their experience. One student emailed me her reaction, saying “it summarizes my math
achievements and struggles really well.” I will be inviting my participants and their families to an evening presentation at the school where I can share with them the findings from the research. I will also discuss and present the research to the teachers, support staff, and administration at the school, as well as including the district’s Aboriginal education staff.

All ten students were comfortable with their stories. A few minor details have been altered in the stories to ensure the anonymity of the participants. The interview data was then further analyzed through a self-efficacy lens. I wished to gain a nuanced understanding of the relative importance of the four sources of self-efficacy information for the students: performance mastery, vicarious experiences, social persuasions, and physiological arousal (Bandura, 1977). I reviewed sample items Usher and Pajares’ (2008, 2009) provided from numerous mathematics self-efficacy scales to identify what comments would constitute evidence of each source of self-efficacy. Mastery experiences are indicated by scale statements such as “I have always had a natural talent for math” and “I knew how to solve math problems” (2009, p. 756). Vicarious experiences are indicated by scale items such as “seeing adults do well in math pushes me to do better” and “when I see how another student solves a math problem, I can see myself solving the problem in the same way” (2009, p. 98). Social persuasions scale items include “my math teachers have told me that I am good at learning math” or “adults in my family have told me what a good math student I am” (p. 98). Sample scale items indicating physiological state include “I was always anxious about math” and “I noticed my heart pounding when I took tests” (2008, p. 756).
I re-read each transcript identifying and selecting quotations I felt indicated evidence of a particular source of mathematics self-efficacy. I made a summary sheet for each student listing the evidence I had identified for each source of self-efficacy. I then adopted the presentation style found in Usher’s (2009) qualitative investigation into source of middle school students’ mathematics self-efficacy by reviewing my sources of self-efficacy summary sheets and categorizing the strength of my participants’ self-efficacy along a strong, moderate and weak continuum. Like Usher, I present the students’ stories first, before presenting further data analysis organized by self-efficacy source and relative strength. Lastly, the evidence of self-efficacy sources was reviewed across participants to identify patterns and commonalities. In summary the data analysis steps included:

1) making researcher notes following interviews

2) listening to audio files of interviews

3) transcribing verbatim the interviews

4) a holistic, naive first reading of the transcripts

5) reviewing math experience maps to review supports and barriers identified by the participants

6) rereading transcripts, crafting a story or profile for each participant

7) rereading transcripts, identifying evidence of sources of self-efficacy within each interview, and creating summary notes of self-efficacy sources for each participant

8) reviewing evidence of sources of self-efficacy and identifying students’ strength of self-efficacy along a strong, moderate and weak continuum
9) identifying cross-participant self-efficacy source patterns and commonalities.

Data Credibility

Whittemore, Chase and Mandle (2001) note the difficulty of establishing validity criteria in qualitative research. Freeman and associates (2007) aver “there is no single marker of validity in qualitative inquiry” (p. 29). The authors further assert that “validity can not be defined in advance by a certain procedure but must be attended to at all times as the study shifts and turns” (p. 29). Bruner (1990) comments that validity is subjective, an interpretive concept. To make the research as authentic and credible as possible, I aimed to achieve triangulation and face validity as defined by Lather (1986). Towards Lather’s triangulation, I drew on multiple sources of information (interview notes, math experience maps, interview recordings and transcripts, and other observations). To achieve face validity I employed member checking: I asked students to review the stories I crafted and asked them if my interpretations captured the feel and content of their experiences. Lather further identifies catalytic validity where research leads to insights or increased activism for the participants. Catalytic validity is desired with this research. It is not traditionally part of what makes research authentic or credible, but it is a form of validity that may best serve the participants. The insights the students gained are presented in Chapter VI – Conclusions, within the Limitations section.

In Lather’s (1993) more recent writings, she uses “scandalous categories” to disrupt and redefine the boundaries of research validity (p. 683). Lather’s rhizomatic validity outlines a space this research seeks to inhabit. “Rhizomatics are about the move from hierarchies to networks” (p. 680). They move away from linear thinking to “a journey among intersections” (p. 680). It is akin to a complexity science lens that seeks
to “explore the depth, richness, and thickness of the complex relationships that exist in any given situation” (Doll, 2008, p. 76). This focus for the authenticity and credibility of the present research, presented in chapter V – Discussion, is in keeping with the relationality of narrative methodology. An attention to relationships is respectful for any research but is particularly in keeping with Aboriginal research. Oberg, Blades, and Thom (2007) in their Aboriginal work were careful to “represent the nonlinear, recursive pathways…avoid[ing] imposing a typically dominant mode of tightly reasoned conclusive argument[s]” (p. 113).

Lather’s rhizomatic validity demands a reflexive stance in the researcher. I have attempted to maintain reflexivity throughout the research process, with an examination of my own positioning and interpretations. Keeping a researcher journal helped me to actively maintain reflexivity. Two additional features of Lather’s rhizomatic validity were maintained: avoiding inaccessible language and paying “particular attention to discrepant data” (p. 681). Discrepant data may create untidiness but it allows contradictions to remain in tension and contributes to more authentic research.

Striving to maintain Lather’s (1986, 1993) sense of validity contributes to the quality of the research. Brickhouse (2006) frames research quality, as an ethical question, not merely a methodological question. Exploring science education, directly relevant to mathematics education, Brickhouse focuses on whether the research speaks to important educational aims, if there is a careful and honest description of who is and who is not benefitting from the research, and if there is a potential for influencing policy and practice. Simon (2004) delimits his discussion of what constitutes quality research specifically to qualitative inquiry and mathematics education research. As with
Brickhouse (2006), Simon stresses the importance of attempting “to answer significant questions” (p. 158). Simon draws a parallel between quality research and mathematical proofs: quality research must construct and present a justified and warranted argument.

_Social Cognitive Theory lens and the temporal nature of the data_

Bauer (1996) reminds researchers that in narrative interviews accounts of events are selective. Similarly, listening to stories from a social constructivist’s perspective and filtering interpretations through a social cognitive lens creates a particular perspective. The choice of theoretical framework has shaped the nature of my insights and perspectives throughout the research. Barton (2004) writes about Aboriginal epistemology, locating it within a narrative inquiry and relational methodology. She notes “the horizon of the interpreter and the horizon of the interpreted become enmeshed and create meaning in a context” (p. 521). It should be noted that the constructed reality of the present research occurred in a specific time and place and is unique to the researcher and individuals involved.

_Summary of Chapter III_

Chapter III has presented the methodology of the research. The in-depth, qualitative inquiry strives to maintain a relationality focus using narrative methodology. The role of the investigator was explored, the research setting was introduced, and an overview provided of the data collection procedures. The evolution of the methodology into a relational methodology was also presented. Finally, data analysis methods, data credibility and quality issues were outlined. Chapter IV will present the results of the research.
Chapter IV – Results

Chapter IV begins by providing background information for the ten students who participated in the research including their interests, and the obstacles and supports they describe as impacting their experiences in mathematics. Next, evidence is identified from the students’ stories that appears to be related to the four sources of self-efficacy as hypothesized by Bandura (1977, 1997). Additional information regarding the students gleaned through substitute teaching observations, and a group session conducted with the students for another University of Victoria research project, aided the data analysis by providing further context for the students’ remarks. The stories of the ten participants displayed a range of self-efficacy beliefs spanning from very strong and confident beliefs, to extremely weak beliefs displaying a lack of mathematics self-efficacy. Although the students cannot be easily put into discrete categories, their interviews led me to identify the strength of their self-efficacies along a continuum. This chapter presents the student with strong self-efficacy first followed by five students in descending order with dramatically more moderate mathematics self-efficacy and finally the last four students, again in descending order, who displayed the weakest mathematics self-efficacy. Each section concludes with a summary and a brief discussion of the general trends across participants.

Background of Participants

Student with Strong Mathematics Self-efficacy.

Sue is 16 years old, has an older brother and an older sister, is in grade 11, and comes across as calm, somewhat quiet, and confident. I taught Sue social studies for
three months during my teaching practicum when she was in grade 9. Sue describes math as having “always been my strong suit;” she generally does her homework right away, and acknowledges that she tries hard, is dedicated, and in addition to wanting to do well, also wants to make her parents proud. Sue’s life is busy; she plays field hockey and her passion is dance. Sue sees any anxiety she feels before a hockey match or a math test as a sign that she cares.  She describes ‘time’ as her only obstacle in mathematics; her other interests and the homework demands of other subjects can mean math doesn’t get the attention necessary to do even better. When asked to identify what supports her efforts to succeed in math, Sue identifies a good teacher, her motivation to do well, and her support from both family and peers.

Students with Moderate Mathematics Self-efficacy.

Abigail is also 16, has one older sibling (a sister), is in grade 11, and again met me in social studies in her grade 9 year during my teaching practicum. Abigail loves music, basketball, and hanging out with her friends. Interviewing Abigail I was struck by her growing maturity; she is blossoming, and is increasingly at ease with who she is. Abigail feels grade 11 is significantly more stressful than last year. She acknowledges that she isn’t fully committed to school, but realizes she does want to do well and is thinking and talking about how her ability to focus now directly impacts her future post-secondary options. She describes herself as someone who really struggles initially with math, she “is not one of those people who just get it,” but articulates that she is increasingly motivated to do well and is seeing some results from her increased efforts. Abigail identifies dips in her motivation to do well, and dips in her confidence, as two of the obstacles to her mathematics success. She also describes limits in her willingness to be vulnerable, a
personal opening up to herself, as another obstacle to success. As we discussed this further, Abigail touched on a range of experiences to illustrate her point: these included admitting to herself when she really didn’t understand something and needed extra help, and overcoming embarrassment and being willing to ask questions in class when everyone else appears to understand whatever concept is at hand. Abigail feels the things that support her in math include organizational skills, personal confidence, a good relationship with her teacher, and her support network. She describes her support network as including family, the teacher, and herself.

Alice too is 16, in grade 11, and has an older sister. I had not met Alice prior to our interview time. She describes interests in ballet, volleyball and basketball, but this year has kept her time less scheduled and involved. Alice says she usually catches on pretty quickly in math, just doesn’t want to do it, and tends to rely on memorization to cope with tests. She doesn’t dread math class, but finds it “kinda boring” and was particularly deflated last year when a friend and classmate consistently was ahead in the homework load and she found she “just stopped caring”. Absences particularly derail Alice. She feels despite efforts to catch up, she never really grasps the missed information, and that the information missed always seems to play an important role later in the course. Alice identifies absences and missed information, not understanding concepts, too much memory focused learning and failing to complete homework, as her obstacles to greater success in mathematics. She feels taking good notes in class, working on math with a friend, and a positive attitude alongside caring about how she does, are the things that support her towards success in math.
Heather is a very busy youth; she helps organize numerous school clubs, and takes flute and art lessons outside of school. Heather is 15 and in grade 10. She and her mom moved to Victoria recently. While her sister still lives up-island, Heather is pleased to be in Victoria where there is more to do. Heather doesn’t like math, finds it boring, and describes it as “something to just get through”. She comments that math isn’t that hard once it is taught to her, but she’s easily discouraged by the volume of homework she’s presented with, tends to not get around to it, and finds herself behind in math. In stark contrast, Heather enthusiastically describes her start in education. She attended a small alternative elementary school with a holistic and artist approach. She found it fun and “didn’t even realize” she was learning. Heather describes her obstacles as stemming from the increasing emphasis on quizzes and tests, limited instructional time per math class, and the volume of homework expected. Support for her success comes from her organizational skills (her binders are immaculate!), being in a stress-free learning environment, having had an alternative education foundation, and having friends in math class.

Jen works part-time in retail and is less involved at school. She too is in grade 10 at age 15. Although Jen doesn’t like math, she doesn’t dread class like she did last year. While she struggles to memorize formulas, so far this year she has found success with an organized binder, the structured note taking system in her class, following the step by step instructions and tackling her homework promptly. So far it is in stark contrast to a very poor performance in grade 9 where she felt put off by large booklets without timely feedback where she fell into a pattern of putting off and avoiding homework. Jen describes the obstacles to her success in math as teachers, memory focused learning,
distracting classmates, and putting off homework. As she peers out behind face covering
bangs, she describes the things that support her in math: step-by-step instruction,
organization skills, immediately addressing homework, and having on-task friends in
class.

Lily is a bit older than the previous students. At 17 she is in her grade 12 year and
takes Applications of Mathematics 12. Lily describes Applications as “common level”
math. She has no use for the more abstract stream Principles level courses as she prefers
to know how a task in math will be used. Lily’s passion is film and music. Her family
has moved a lot, but she finds positive ways to view the changes, describing having
different friends to anchor to with each move. Lily enjoys having a unique name, one
with important connections to her grandparents. While “math isn’t really [her] strong
point”, she suffers less anxiety with math tests than she does with English essays. Lily
notes that the obstacles that creep up for her are when she feels there is a lack of
instruction, if there are distracting friends, having to be sedentary, and when she doesn’t
know the connections between math task A and math task B. Lily also describes a sense
of isolation at times, a lack of communication, that is also one of her obstacles to success
in math. In contrast, what helps Lily succeed in math includes structured instruction,
knowing how the math is relevant, the use of novel teaching strategies including games,
being given clear due date expectations with assignments, and having friends in class to
help catch up after any absences.

Students with Low Mathematics Self-efficacy.

Andrew is a very personable, easy to meet, chatty 14 year old. In grade 9, he has
a warm smile and is quick to point out that he can talk to anyone. He has never really
liked math, and it can take awhile for him to really understand it. Andrew notes that he is a champion procrastinator and his attendance record indicates that he has had very little time in math so far this year. He describes himself as a visual learner and also needs to see the relevance of his math before he is willing to tackle it. Besides distractions and procrastination, Andrew described his obstacles to success in terms of recent and specific math topics – order of operation questions (bedmas) and decimal/fraction conversions. Both are the most recent content items he has encountered. He notes that limiting his efforts to exactly what he needs to know is important to his success in math. He also stressed learning short cut techniques and “having someone there for you” as his important supports.

*Sara* is a calm, centered 17 year old in grade 12. She loves to read and write and also works part-time. She completed Principles of Math 11 last year, which she took to ensure her English-focused aspirations at a post-secondary level would not be thwarted, but math has always been her “enemy.” She is “so happy” now that math is behind her, as she has “struggled with it [her] whole entire life.” Sara has many memories of being left with her hand up for help for 15 minutes before becoming discouraged and giving up. These experiences led Sara to identify class size and fast pacing as her biggest obstacles to success. Sara did recall one year, her grade 9 year, that was an exception to her universally dreadful experience with math. In grade 9 she remembers a joking atmosphere, a lack of stress, and even having fun a few times. Sara highlighted one-on-one time with teachers, in-class teaching assistant help, and receiving regular mark updates and feedback on how to improve, as the key things that support her in mathematics.
Henry is 18, he self-identified as half native, and can’t wait for grade 12 to be behind him. Although he describes himself as shy with classmates he doesn’t know, I found him quite open and I was very appreciative of how openly Henry seemed to answer my questions. Henry also describes himself as lazy and focused on social time with his buddies. Nevertheless, Henry is anxious to pass the Essentials of Mathematics 11 he is taking; it is what stands between him and high school graduation. His plan is to upgrade his mathematics after high school at Camosun College, as he needs Applications of Mathematics 11 to enroll in a criminal justice program that would enable him to be a prison guard. Henry is looking forward, as his “life is about to begin.” Unfortunately, in math Henry “never really understands;” he’s ok with the basic operations, but beyond that, he is “shitty at it.” Henry readily attributes the obstacles he has encountered to himself: he copied from friends to make his way through French immersion elementary school, not thinking at the time that it would later come back to bite him. Now he hates math, and a number of absences have left him feeling particularly disjointed. He has often sat through an hour-long class, pretending to do math, waiting for it to be over. He notes that the style of teacher, “just trying to pass”, and managing the necessary supplies characterize his obstacles. The supports he identified included having a partner in math class, knowing his mark and what missed information he is responsible for, and a slow pace of instruction.

Scott is also in grade 12, taking Essentials of Mathematics 11, and he’s 17 years old. Scott is passionate about sports, writing, and music. He describes himself as spending a lot of time alone. Scott takes hatred of math to a new level; he says that he would prefer to cut off his pinky rather than do math. As with Henry, Essentials of
Mathematics 11 is what stands between him and high school graduation. He describes really suffering at the hands of math. It is the “greatest difficulty” in his life and he realizes he is very short tempered and quickly angry about math. He associates it with “bad things,” “really upsetting things,” and gets particularly angry when he does not see the relevance to a math task. Over time he feels he has understood less and less of what is explained to him. Scott itemizes lack of relevance, excessive volume of work expectations, and being compared to others, as the obstacles to his success in math. When pressed to consider what supports his efforts in math, Scott identified that a good dose of patience in his teacher helps him get through it.

Interpretations of Performance Experiences

_Mastery Experiences of Students with High and Moderate Self-efficacy._

Sue finds math tough, but once she learns it “inside and out” it becomes “second nature almost” and she “can just do it…. I know it really well.” Sue’s comments stand out as the most confident regarding performance of all the participants. When she does not do as well as she would like on a test, she notes that it makes her “try even harder.” In contrast, the students I have characterized as having more moderate mathematics self-efficacy, place themselves midway along a mastery continuum. Alice notes that she usually catches on pretty quickly but sometimes “it takes a lot to understand it.” Heather describes herself as “kind of in the middle with math… I’m not really good or really bad at math.” Abigail too expresses a midway position: “it is a real struggle for me in the beginning, but in the end, I’m ok… I’m not one of those people who just get it.” While Lily comments that “math isn’t really my strong point,” she also notes that “some days I’m good at it.” Jen described discarding images of herself as good at math, when
discussing her memory of fraction learning in grade 4; “I thought I was really good at it, and then I had to get extra help at it because I was so bad at it.” For Jen, it seems that any need for extra instruction represents a lack of capability. Jen went on to talk about how her poor performance in one recent year, evident from lower grades, led her to conclude “I guess math is not my thing anymore.”

*Non-Mastery Experiences of Students with Weak Mathematics Self-efficacy.*

Andrew, Sara, Henry and Scott all spoke strongly about their lack of mastery experiences. Andrew noted that a big obstacle for him was not knowing “how to do stuff.” Sara did not think she was “a mathematical person at all… I don’t deal well with numbers.” She found the material “so dense… for me it was, it was hard.” Sara identified failing her final exam, her parting memory of her high school math, as her most crushing memory. She saw it as “the final blow.” Preparing for tests throughout the year also brought Sara to confront her lack of mastery. Tests were often scheduled for Fridays, so she remembers Thursday nights as stressful. She would try and study, but quickly reach her “wits end and then sort of gave up.” She would attend extra help the following morning, but found the sessions overcrowded and ended up “sort of winging the test.” Henry used coarse language a number of times describing his experience, noting that he’s “not that good at math,” indeed has “never been good at math,” and can only handle the basic operations of addition, subtraction, multiplication and division. Scott used the most extreme language of any of the students. He repeatedly spoke of his hatred for math, how it is “one of the greatest difficulties of my life right now,” and how his level of understanding seems to be decreasing over time. He seemed to sum up his self-positioning in math when probed if there was ever a time when he could remember
feeling differently about math: “I just always remember not having much luck with math.”

**Summary of Performance Experiences.**

The more self-assured students all drew upon their record of performance mastery when describing themselves. These students interpreted their performance successes positively, as favourable and self-affirming experiences. The experiences of students without a track record of performance mastery stand in stark contrast. These students seemed to find no reprieve from their misery. As course content grew in difficulty it seemed to reveal their limitations and weaknesses. The amount of effort math required was deemed to be an insurmountable challenge. For the senior students, currently taking a less demanding curriculum, there was still no mention of rewarding performance experiences.

**Interpretations of Vicarious Experiences**

*Vicarious Experiences of Student: High & Moderate Mathematics Self-efficacy.*

Modeling experiences from adults were mentioned by five of the six students I have identified as having high or more moderate mathematics self-efficacy. Sue, Abigail, Alice, and Jen all spoke about having a parent or older sibling at home who could help with math. Sue additionally shared a story from five years earlier that she drew upon to bolster her self-efficacy. Her older brother was tackling Calculus, and she was intimidated by his mathematics text filled with variables (x, y, and z’s), now the experience serves to raise her estimation of herself: “I thought it looked so hard, but now, with the stuff I’m doing, I know it isn’t so bad.” Lily did not speak of having a parent
conversant in high school mathematics, but did identify the importance of modeling in her estimation of her capabilities. Lily’s father is proficient in drafting, and she noted “if he can do it, then I think, I can do it too.”

All of the students in this group, without exception, mentioned the importance of the modeling they receive from their teacher. Some students mentioned “good teachers” others were more specific about step-by-step guidance, or structured note taking, while Jen chose the words “she shows us” capturing the essence that math teachers model mathematics skills.

This group of students also noted vicarious experiences with peers. Sue shared that she was competitive with one particular friend: “we would have a competition to see who could get the better mark,...it sounds a bit geeky, but it makes you want to do really well.” Other vicarious experiences were noted for their negative impact. Alice felt deflated last year when a friend was consistently ahead in homework and she “just stopped caring about it as much.” Abigail also found vicarious experiences with peers could be difficult. She found it “embarrassing when all your friends are saying they are doing so well.” Sue was bothered if she studied hard for a test only to see people do well who claimed they did not study. Jen struggled when she did not have friends to turn to in her class last year: it “brought me down.” Alice was weary of the wrong kind of modeling experience. She did not like sitting with a whole bunch of people who did not care about math. Lily and Jen echoed this sentiment by identifying “distracting classmates” as obstacles to their success in mathematics. Lily described herself as someone who doesn’t follow the crowd, but never the less suffered for lack of peer modeling. She articulated that she struggled with feelings of isolation.
Vicarious Experiences of Students with Weak Mathematics Self-efficacy.

Andrew, Sara, and Henry’s stories stand in contrast for the lack of modeling experiences from adults. None of these students identified an adult or sibling at home that could help them tackle their math. Scott’s experience was at times unclear and included contradictory elements. At one point he indicated his mother worked with numbers and “she helps me out a lot,” yet later in the interview noted “she doesn’t help me so much.” Sara’s family had regularly tried to help her in her earlier grades, but in high school it was “too advanced and [mom] couldn’t help me anymore.” The other weaker mathematics self-efficacy students did not mention parents or family members’ influences in reference to any of the earlier grades. Scott’s feelings with math moved him to foreclose on adult modeling. He readily acknowledged that he quickly becomes short tempered and angry around math. He and his family discussed getting him a math tutor, but Scott has rejected the idea, saying that “I realized I didn’t want to have another person hate me.” Andrew did include a vicarious experience in his story, one with an elementary teacher. She stood out in his recollections as someone who “would show me how” to do math.

Andrew also discussed a positive vicarious experience with a peer. A visiting German student showed him an alternative method for long division, and he was pleased to find “it clicked” with him. Henry identified “having a partner in math” as “the biggest” support; it is “a friend in class who can help you out.” Scott struggles with peer modeling. Of a classroom setting he says “I hate that there are other people there who do it better than me.”
Summary of Vicarious Experiences.

The range of experiences shared by the students illustrate that vicarious experiences impact them in a range of positive and negative ways, and span influences from family, teachers and peers. Every student interviewed demonstrated a sensitivity towards peers in the classroom. The student with a strong mathematics self-efficacy used vicarious experiences positively and developed a competitive drive. The students with the weakest mathematics self-efficacy were typically discouraged by vicarious experiences with peers. The vicarious experiences of both groups of students indicate the importance of teacher modeling including a heightened need following school absences. From the strongest self-efficacy position, Sue noted that she struggles when she’s been absent and cannot see how the teacher does something. She does not like to just read the notes as a way of learning. Abigail recently had an extended absence for medical reasons and had to teach herself, she said “I’m not like that, I need someone to go over it.” Alice spoke more strongly about absences. When she misses the teacher’s modeling, she feels she never really picks up the information properly. For Alice it seems the missed modeling has a way of repeatedly causing a problem for her; “it just keeps coming back to that thing [that I missed] and I never really get it.” Later in the interview Alice mentioned this obstacle again, saying “it is really big and hard to overcome.”

These insights from stronger mathematics self-efficacy students underscore the difficult reality of Henry’s experience. By his own admission he has “been away so much.” When I asked him to forgive my choice of words, but to tell me what comes to mind as a particularly deflating experience, Henry immediately mentioned the challenge of absences. The worst scenario appears to be when he returns to a quiz or test, and “I
just wouldn’t know what to do, so I just sit there and wait for the test to be over and hand it in and hope that I get something correct.”

*Interpretations of Social Persuasions*

*Social Persuasions for Students with High & Moderate Mathematics Self-efficacy*

The students I have identified as having high or moderate mathematics self-efficacy mentioned social persuasions with reference to adults, peers and themselves. Sue, with the strongest mathematics self-efficacy, demonstrated all three forms of social persuasion within her story. She was clear that she personally wants to do her best, also wants to make her parents proud, and notes that all her friends want to do well. She is aware that “it’s good to be around people who want the same things as you.” Sue articulated that her motivation has increased, and become a more important ingredient for her success, over her senior years. Abigail is aware of her self and adult social persuasion. She notes that “I actually do care.” Regarding her care and commitment to succeed, Abigail says that “my parents really notice too, they are really happy about it, especially my mom.” Abigail discussed her self-encouragement at greater length, using the words “being vulnerable” and “opening up to yourself.” She explained that she needed to be honest with herself, both about caring about her success, and being willing to acknowledge when she needed support to achieve her goals. Abigail provided a rare glimpse into her self-talk when she shared her story of returning after her lengthy medical absence. At first she was overwhelmed, panicked, and teary. She had to retreat home part way through a first foray back, unable to cope with her rocketing anxiety. The next day, while she was unable to “control [her] feelings,” she could “keep them to [herself]”
and she talked herself through the experience by saying “I can do this, you’re not going to die!”

Alice’s story focused on the social persuasion of peers. She likes it “better when it’s with a group” rather “than working by myself.” Alice also spoke about a math club she enjoyed in middle school. Although she could not remember who the teacher of the club was, she attributed its success for her, to her peers: “I’m pretty sure I liked it cause I liked the kids.” Heather also focused attention on her peers. When asked where she turns to for extra help in math, she replied “friends usually.” Jen echoed a similar sentiment: “this year the friends in my class are good at math, so I’d probably get help from them.”

Lily’s experiences, including her social persuasion experiences may suggest my identification of her as having moderate mathematical self-efficacy is somewhat optimistic. Lily seemed to display the weakest sense of self-efficacy within this grouping. Lily’s story illustrates that self-competency beliefs are not discrete entities but exist along a continuum. Lily expressed needing a lot of adult social persuasion to stay on track in mathematics. She explained “I like to ask the teacher [if I’m doing it right]…even if I think I know it, I still ask the teacher. I might be like this…” Lily used her hands to demonstrate being on-track, on a straight-ahead path. Next she said, “I check to see if I might be like this…” and Lily demonstrated being off track taking a winding path. Lily also spoke of peer social persuasion in a favourable light. “If the whole class is doing homework…[it] doesn’t feel like pressure [to tackle homework]. An unexpected expression of the power of social persuasion for Lily, gave me my biggest laugh across all the interviews. Earlier in her interview Lily and I had already shared one laugh when Lily noted that “if I don’t have anything else to do, I will do math” but then in stark
contrast, as we were nearing the end of our time together, I asked Lily if our exploration had been helpful for her, she replied, “I kinda want to do math now!” and we both laughed again. It was one of my favourite moments.

*Social Persuasions for Students with Weak Mathematics Self-efficacy.*

This group is noteworthy for their paucity of empowering social persuasion experiences. The one elementary teacher who stood out in Andrew’s story as someone who “would show me how” to do math, also told him he could “do more, do better.” Social persuasion clearly has importance for Andrew who identified having “someone there for you” as one of the things that support him towards success in mathematics. Sara shared the most demoralizing of all the social persuasion experiences. Last year the students’ marks in Sara’s class were appropriately posted by student number in order to protect student privacy. Unfortunately, they were always printed out in descending order by performance, so she found she would “always be on the very bottom.” In her own words, the experience “kinda brought me down.”

Henry’s strong aversion to mathematics lead him to look for social persuasion that directed attention away from the subject matter. In an earlier year he had a “really really tough teacher” that he “couldn’t follow… all he focuses on is math.” Henry was more comfortable with his current teacher as “he’s like cracking jokes and [is] not always on the topic of math.”

Scott presented two dimensions of social persuasion within his story. Scott acknowledged that he needed constant adult encouragement, saying “I need someone to hold my hand the whole way through or I just get so lost.” Scott also spoke at great length about needing to see the relevance of the mathematics he was being given.
Relevance was also important to Lily, Heather, Andrew and Henry, but was presented in its most extreme context for Scott. For Scott, he forecloses on the mathematics at hand when he sees little relevance: “I just get mad at it when I don’t see it applying to me in real life.” We explored this idea in greater depth and Scott was able to share an example with me. He is currently tackling financial math problems that use the formula \( I = PRT \), where \( I \) represents interest earned on an investment, \( P \) represents the principle amount invested, \( R \) represents the rate of return for the investment, and \( T \) represents the duration of time for an investment. He did not mind the problems that had him calculate what interest he would earn given a specific scenario: $5,000 invested at 8% per annum, invested for 5 years. Scott saw this problem as valid and relevant to his life. Some of the questions however, were worded differently. As a mathematics teacher, I see that they were designed to develop algebraic skills by asking students to solve for the principle amount, as it is a more difficult algebraic manipulation if the unknown value is not readily isolated by a given equation. Scott had no tolerance for these questions and quickly became angry. Instead of seeing the value of more advanced algebraic manipulation skills, he would only interpret the question from a personal point of view, and within his thinking, he would be the one depositing the principle amount, “so it’s like as if, …I have forgotten how much money I put in the bank!” Lily and Heather touched on the same sentiment in their mathematics wondering “how do you use this?” and “why do I have to learn this?” Henry had used a similar lens and had already decided much of mathematics was of no use to him: “I don’t really care, I’m not going to be a carpenter or anything, I can add it up whenever I have money, it’s not that important to me, unless I wanted to be like a math teacher.”
Summary of Vicarious Experiences.

The ten participants reported a variety of social persuasion experiences. For the strong and more moderate mathematics self-efficacy students there were more empowering or affirming experiences related to social persuasion. The encouragement from friends and group work was noted. The students with weaker mathematics self-efficacy more often reported demoralizing or limiting social persuasion experiences. The need for someone to be there for you was expressed. One student appeared to be encouraged in a setting that did not have a singular focus on mathematics. Finally five of the students identified relevancy of material as a key factor in their self-persuasions regarding mathematics. Of these five students, four identified relevance as important, while one student used relevance in a self-handicapping manner.¹

Interpretations of Physiological Arousal

Physiological Arousal: Strong & Moderate Mathematics Self-efficacy Students.

Sue was the only student who expressed eagerness towards mathematics. She said that “there were some aspects of it” which she liked. In the previous year in math, Sue described her teacher as strict, as one who did not tolerate socializing. She found that while the environment discouraged some students, who complained about the teacher, it motivated Sue. Abigail shared a different kind of positive feeling with mathematics. Abigail described the good feeling she felt when she understood something that had initially been confounding her: “then you feel so good and it’s like, Yes!” Alice echoed this sentiment with her comment that “it’s a good feeling to know what you are doing.”

¹ Midgley and Urdan (2001) describe strategies likely to undermine performance as self-handicapping.
Abigail also noted another positive feeling she experienced in mathematics class: “it’s really good too when the teacher can relate to you.” She linked her bond with the teacher to her motivation to try in class; “having that good bond helps, otherwise you don’t give a hoot.” Alice’s connection with the teacher appears to help minimize her negative feelings, but it was expressed less strongly than by Abigail. Regarding math class, Alice said, “I didn’t dread it, I liked the teacher a lot.”

The importance of feelings were evident to Abigail in her interview. After she had identified obstacles to her success in mathematics, I asked her if any themes seemed to present themselves to her. Abigail noted that all of her obstacles, motivation, being vulnerable, and her confidence, “are about feelings.” A range of other feelings were noted by students in this group: anxiousness for Abigail returning to school after an absence; test anxiety experienced by Alice, Heather, and Jen; dislike of math expressed by Heather and Jen; a sense of pressure and stress, again expressed by Heather and Jen; and boredom experienced by Heather and Lily.

As with Abigail’s story, Heather’s story had many references to her feelings. Heather felt her math classes weren’t fun, that “they are so boring.” She valued her alternative education background from elementary school, noting in particular that there was no pressure, one “didn’t even know one was learning.” Heather also liked that prior to grade 3, everything in this school involved group activities. She noted that she didn’t have to speak out or raise questions on her own, instead she felt protected, she described it as, “nothing was away from the safe group.” In contrast, she now found school stressful, including the pressures self-inflicted by her involvement with extra-curricular
activities. In addition to mentioning the stress she experiences with math tests, Heather identified stress-free learning as a key feature that supports her in mathematics.

Lily’s story was noteworthy for its lack of physiological arousal. She was “ok with tests if I know what I’m doing” but struggled with boredom. Lily didn’t like the sedentary nature of math class, longed for novel or inventive teaching techniques and said she leaves “almost every class” to get a drink, or to use the washroom, something to get her moving. She identified being sedentary as one of her obstacles to success, as well as novelty and games, as something that supports her in math.

*Physiological Arousal for Students with Weak Mathematics Self-efficacy.*

The physiological arousal for students in this group was interpreted from a range of negative words including stress, dread, and hatred. Andrew’s positive assertions that he knew he was good at math, that math “was always [his] best subject,” remain in contrast to his record. Andrew recently crumpled up an answer sheet to homework problems instead of correcting his work, and during a recent class I substitute taught, he was reluctant to do any math and needed considerable cajoling and assistance to make small bits of progress. From his own words we learn that “before a test, it is kind of jumbled with me.”

In contrast to Andrew, Sara spoke very openly about her feelings. She repeatedly mentioned stress, feelings of panic, and being “frantic” in reference to mathematics. Sara described her pre-test mindset as “super-anxious.” Unlike Lily’s hope for games and novel teaching strategies to bring her a positive experience, Sara’s positive experience, the calm, non-agitated memory of her grade 9 year, was not about games or activities. Sara recalled she “got to laugh a little bit” in this class she recalled as fun. Sara noted
that it was an overall light atmosphere that made her feel more comfortable; she didn’t remember the class doing any games particularly. In keeping with wishing to minimize her negative feelings, Sara identified fast pacing of material as an obstacle to her success.

Henry’s negative physiological arousal was evident from his use of the phrases “boring” and “I hate math.” Like Sara, Henry identified pacing as a key issue for him in mathematics; he chose a slow pace as a support for his mathematics. Henry did mention more positive feelings in reference to his teacher who has an ability to make jokes and connect with him beyond the world of mathematics. Henry expressed that with this teacher, “I don’t feel like an idiot when I talk to him, cause he understands.” Henry acknowledged that he pretends to be busy to survive a math class, a behaviour I have seen through substitute teaching. Henry, like Lily, also frequently leaves the room during math class, which minimizes the time available to do math.

Scott is again the student whose story provides the strongest language, in this case to describe his feelings about math. Anger, hatred, and boredom were mentioned many times. Scott felt he “never really had a positive experience with [math].” He was however, “fine with test anxiety,” as he trusted his “own ability to know what I need to know.” Scott’s story did reveal one positive experience. As has been noted, Scott identified “patience in the teacher” as what supports him towards success in mathematics. As Scott spoke in more detail about his experience, he noted that he can take his cue from the tone of a patient teacher and “if they are calm, I’m calm.”

_Summary of Physiological Arousal Experiences._

The students’ stories revealed minimal evidence of positive physiological arousal. There was some evidence of eagerness and contentment, and some students were not
agitated by test anxiety. Impatience, agitation, anger and stress capture the more
dominate experience of the participants. Lily, and to a stronger degree, Andrew, Henry
and Scott, all avoided or minimized time on-task with mathematics. Behaviours and
choice of words illustrate the depth of discomfort many of the students experience with
mathematics.

Summary of Chapter IV

Chapter IV has provided background information for the ten participants.
Evidence has been identified from the students’ stories that relate to Bandura’s (1997)
four sources of self-efficacy. One student displays very strong and confident self-
efficacy. Five students demonstrate considerably weaker self-efficacy and have been
categorized as exhibiting more moderate mathematics self-efficacy. Four other students
demonstrate very weak self-efficacy. Further discussion of the significance of the
students’ comments and the complex inter-relationships between the four sources of self-
efficacy will be examined in chapter V.
Chapter V – Discussion

Introduction

Chapter V presents the across participant and gender analysis of the data. The presence of all four sources of self-efficacy information is noted in all participants. The dominant role of mastery experiences and the important interconnections between mastery experiences and physiological arousal are also highlighted. The interconnections between all four sources of self-efficacy, and the importance of relationality is discussed, along with the central role of affect and relevance for the student participants.

Across Participant Analysis

Four sources of self-efficacy information evident in all participants

Quotations from the ten participants illustrate a cascading continuum of beliefs and reflections regarding mathematics:

“I don’t mind math, there are some aspects of it which I like” Sue

“It is a real struggle for me in the beginning, but in the end, I’m ok… I’m not one of those people who just get it” Abigail

“I usually catch on pretty quickly…it’s kinda boring…if it was really hard, then I wouldn’t want to do it” Alice

“I’m definitely not bad in math but it is not my favourite subject” Heather

“I don’t like it… but I’m not, like, dreading it” Jen

“If I don’t have anything else to do, I will do the math” Lily

“I didn’t like it, but I knew I was good at it” Andrew

“I struggled with it my whole entire life… since grade 1,”
it’s sort of been my enemy”  
Sara

“I hate math… I often wait for the hour to go by and pretend I’m doing something”  
Henry

“I absolutely hate math” he’d rather avoid it “even if it involved cutting off my pinky!”  
Scott

Although these comments summarize a wide range of experiences with mathematics, across the data all four sources of self-efficacy information were evident in each student’s experience. During data analysis evidence of each source of self-efficacy was found within all interviews.

**Dominant Role of Mastery Experiences**

“Mastery is typically posited to be the strongest component of self-efficacy belief development” (Hodges & Murphy, 2009). The present research concurs with this conclusion. Many other mathematics self-efficacy studies, across a variety of settings and ages, report similar findings (Lent, Brown, Gover & Nijjer, 1996; Lopez & Lent, 1992; Lopez et al., 1997; Luzzo et al., 1999; Zeldin, Britner & Pajares, 2007).

Furthermore, as with Hodges and Murphy’s 1701 middle school students, in this very small sample, generally speaking, the students with “the lowest performance had the most negative beliefs and self-efficacy beliefs” (p. 719). Andrew’s conflicting messages, his low performance juxtaposed with statements of confidence, prevent a broader conclusion. His behaviour may be reflective of his young age. Hodges and Murphy found younger students tended to overestimate their abilities and a report on other research (Demetriou & Panaoura, 2006 in Hodges & Murphy, 2009) found a more precise self-image develops as students become older.
A quote from Heather’s interview captures the typical tone of the participants who tie their sense of their mathematical experience to their ability to successfully perform in mathematics: “I don’t find math hard at all, once someone teaches it to me, I get it and I can do it.” Being able to “do it” was the key for all the students. Bandura (1997) and other researchers (Lopez, Lent, Brown & Gore, 1997) emphasize the perceptions of mastery are central to self-efficacy, not just one’s objective results. Abigail’s story illustrates this point as she presents herself as a confident student with a good understanding of herself, yet does not achieve high results. She has a good grasp of her personal goals and how her organizational skills hamper her efforts. She speaks confidently of her ability to get through math, while acknowledging that her performance is not that of an A or B student, “I usually am a C+ student and I’m ok with that.” Sue’s story echoes the emphasis on mathematics performance with her comment “I can just do it.” For Lily there is less consistent success: “there’s some things…I’m good at.”

At the other end of the spectrum, a lack of mastery is a central feature in Sara’s, Scott’s and Henry’s lack of self-efficacy: Scott explains that “other people…just get it when I don’t” and Henry notes “I never really understood it.” Objective results does remain the principal means by which students judge their mastery which in turn impacts their confidence. From Jen’s story she refers to her marks and notes “before last year, I felt [math] was my strongest subject…but then last year that went down, so I guess, math is not my thing anymore.”

**Dominant Role of Physiological Arousal**

Across-participant comparisons highlight the importance of physiological arousal. Fatigue, boredom, stress, dread, and other aspects of the students’ affective domain were
identified as significant contributors to the students’ sense of self-efficacy. This finding is noted for both genders in contrast to Lent, Brown, Gover and Nijjer’s (1996) study and Steven, Wang, Olivárez, and Hamman’s (2007) finding that found “affective variables to be more important for the girls” (p. 354). Self-efficacy literature has traditionally reported affective/physiological contributions to be the least important source of self-efficacy beliefs (Hodges & Murphy, 2009). The present research identifies the students’ feelings as a central influence to their sense of self-efficacy. The importance of the affective domain is reflected in the recently released Western and Northern Canadian Protocol (WNCP) Common Curriculum Framework for Grades 10-12 Mathematics (2008). This document highlights that “a positive attitude is an important aspect of the affective domain that has a profound effect on learning” (p. 3).

Other research notes the debilitating impact of mathematics anxiety (Fennema & Sherman, 1986). Sue’s strong self-efficacy is not disrupted by negative feelings. In math there is “nothing emotional” for Sue. When she does not perform well on a test, she notes “I do get upset but it pushes me and I have to try really hard on the next one.” Sue’s positive feelings are important and they support her self-efficacy. For other students, their feelings are a central feature of their experience and continually undermine their sense of self-efficacy. Heather links her sense of stress in math to her dislike of the subject, resulting in her dreading math and describing it as “one of those things you just have to get through.” Abigail notes that all the obstacles she described regarding math “are all about feelings.” For Abigail a lack of enthusiasm, not wanting to be vulnerable, and a lack of confidence undermine her mathematics experience. Sara’s feelings of relief are linked to her not taking math in her senior year. She emphasized that she has “been
so happy ever since [dropping math].” Heather spoke of boredom and having to “suffer through” homework assignments. Alice also spoke centrally of her attitude towards math, towards homework in particular: “it’s about attitude… I just don’t want to do it.” The research data illustrates that for these students, their feelings are a central component of their mathematics experience. It is not however, sufficient to focus only on students’ anxiety. As Zimmerman (2000) reminds educators discussing academics in general, the literature points to the “benefit if educators focus on fostering a positive sense of personal efficacy rather than merely diminishing scholastic anxiety” (p. 87).

Inter-connection between Mastery and Physiological Arousal

Panoura, Gagatsis, Deliyianni and Elia (2009) acknowledge “the relationship between cognition and affect has attracted increased interest on the part of mathematics educators” (p. 714). Zan, Brown, Evans, and Hannula (2006) aver “arguably the most important problem for research in mathematics is the understanding of the interrelationship between affect and cognition” (p. 117). “People who emphasize action without equally emphasizing the importance of thoughts and feelings destroy the unity of the experience. Thoughts and feelings are simply aspects of experience”(Oliver, 1998, p. 248). The stories from the students in the present research similarly demonstrate physiological arousal playing an inseparable, central role, in how the students describe their sense of competence. It creates a strong link between students’ physiological arousal and their sense of mastery. Abigail’s story made this link explicitly: “I get it and I’m happy about it, as opposed to, I don’t get it, this is not making sense, I’m dumb, I’m not looking forward to this class.”
In test settings, Alice, Lily and Scott also expressly linked their mastery perceptions to their sense of anxiety. Alice noted that her test anxiety was tied to not knowing what she was doing. Lily commented “I’m ok with tests if I know what I’m doing.” Scott had few mastery experiences to draw upon but still noted “I’m fine with test anxiety… I trust my own ability to know what I need to know.” From Sara’s story another link between mastery and physiological arousal. Sara talked about her dislike, dread, and endless stress regarding math, all tied to her lack of mastery experiences: “I would really start to panic when I would get really low grades in math.” In another instance Sara noted “I was just… [I] couldn’t do it, so I was stressed out.” In contrast, this same link is illustrated by Alice and Abigail in a positive way: from Alice, “it’s a good feeling to know what you’re doing,” and Abigail states “you feel so good [when you get something] and it’s like, Yes!” The student’s positive and negative comments illustrate the interwoven influence of mastery and physiological arousal on one’s self-efficacy.

*Inter-connection between all four sources*

Usher and Pajares (2009) worked with over 2700 middle school students to develop a 24-item scale for quantitative researchers to measure the four sources that contribute to self-efficacy beliefs. The authors caution that qualitative work must complement quantitative methodologies as “conclusions about the relative influence of the four sources on self-efficacy outcomes should never be made in the absence of a detailed description of study participants” (p. 99). Usher and Pajares note, the four sources, and vicarious experience in particular, is a difficult construct to “capture using traditional self-report, quantitative measures” (p. 99). These authors call for a qualitative
lens “to illuminate the blind spots inherent in solely quantitative approaches” (p. 100). The evidence from the present study sheds some light on the inter-connections between the four sources of self-efficacy. The intertwined nature of the sources of self-efficacy has been noted in the literature (Usher & Pajares, 2006), but may be best illuminated by qualitative methods.

Across the students’ stories, whenever evidence of vicarious or social persuasion experiences were noted, there appeared to be important affective domain influences. Encouragement or support from a parent, modeling or support by a teacher, and modeling and support from friends, each demonstrated the importance of relationality. The inter-connections between self-efficacy sources, and the important role of relationship are consistent with an Indigenous worldview where all things are connected and the physical, emotional, and spiritual aspects of the world can not be isolated from one another. The relationship the student had to the source of the vicarious experience or social persuasion appears to be a central feature of the experience. In Abagail’s story this was evident in how she stressed the importance of being able to relate to the teacher. For Alice, math club had been a positive enterprise because of the other kids involved. In both Henry’s and Heather’s stories, extra help and support was not sought in the school’s homework club, the key was having friends to go to for help. Zeldin and Pajares (2000) similarly noted that women, their participants, “were especially attentive and susceptible to the encouragement of those about whom they cared and with whom they felt a relational bond” (p. 238). In the present study, Scott, Henry, and Abigail each tied their comments about teachers and their modeling influence to how they felt about the teacher. Scott felt encouraged by calm, patient teachers, Henry needed a model that could joke and
understand him, and Abigail explicitly identified the importance of her bond with her teacher. Henry, Lily, Heather and Jen each noted the importance of having friends as part of a positive math experience. In Jen and Henry’s stories, they noted their difficulty when they did not have friends to draw upon in math class. Lastly, Sue, Alice and Jen each noted the impact relationships had on their efforts to stay motivated in math class. Sue noted the importance of having friends who all want to do well, while Alice and Jen shared their struggles of finding themselves surrounded by people who brought a negative influence to their motivation efforts. In all these cases, relationality played an important role in shaping the vicarious and social persuasion experiences.

**Gender Analysis**

The three young men who participated in the present research all experienced great difficulty with mathematics. In contrast to other studies that have found male students to demonstrate significantly higher mathematics self-efficacy (Lent et al, 1993; Zeldin, Britner & Pajares, 2007), the male students in this study exhibited the weakest self-efficacies of the participants. As found in the literature, this research found males rely heavily on performance mastery experiences in the formation of their mathematics self-efficacy (Lent, Lopez, Brown & Gore, 1996; Zeldin, Britner & Pajares, 2007).

Andrew focused on “how to do stuff,” he noted that he “just need[s] to know how to do the work.” Both Henry and Scott focused on their lack of mastery experiences. Henry repeated a number of times in his interview that he’s “never been good at math.” He acknowledges that he has “never really understood” math. Scott similarly fails to understand much of the mathematics he encounters. Scott’s comment, “I just don’t get it,” serves to highlight his lack of mastery experiences.
Other studies have found that “females experience higher levels of anxiety in mathematics-based subjects than males” (Martin & Marsh, 2008; see also Lent, Brown, Gover & Nijjer, 1996; Lent, Lopez, Brown & Gore, 1996; Smith, 2001). Martin and Marsh note that females may be more willing than their male counterparts to admit their anxiety. The female and male participants in this research both openly shared their feelings with anxiety. In this study there was not evidence of anxiety being a more dominant factor for the female students.

A number of studies have suggested vicarious and social persuasions experiences may play a more significant role for women then for men (Lopez & Lent, 1992; Lent, Lopez, Brown & Gore, 1996; Lopez, Lent, Brown & Gore, 1997; Zeldin & Pajares, 2000). Other studies have emphasized vicarious, and social persuasion experiences, but in settings where the traditionally dominant mastery experiences are absent. Pietsch, Walker, and Chapman (2003) report on research that suggests when students face novel tasks, they lack prior mastery experiences to inform their sense of competency, and they may draw more heavily upon the other sources of self-efficacy to inform their self assessments. Hodges and Murphy’s (2009) research investigated self-efficacy in an online, asynchronous learning environment. They too suggest that vicarious and social persuasion experiences may play a more important role in their research because students had not previously experienced online learning and therefore had no mastery experiences to draw upon. In the present study females did not appear to rely more heavily on vicarious and social persuasion experiences than the males. This conclusion, like Pietsch, Walker and Chapman, and Hodges and Murphy, may stem from the lack of mastery experiences found in the male participants in the present study. The recent qualitative
inquiry that does support the assertion that men draw on vicarious and social persuasion experiences in a different manner than women (Zeldin, Britiner & Pajares, 2007), studied men with successful mathematics/science/technological careers and did not include participants with very weak mathematics self-efficacy. It remains for future inquiries with balanced representation of self-efficacy beliefs across both genders, to make gender inferences regarding the relative importance of vicarious and social persuasion experiences.

Summary of Chapter V

Across a small group of ten participants evidence of Bandura’s (1997) four hypothesized sources of self-efficacy are evident. Performance mastery experiences, or their absence, for all the students, appears to be the source that exerts the dominant influence on mathematics self-efficacy development. The students’ affective domain, manifested as physiological arousal, is also of central importance. Performance mastery and physiological arousal appear to be inextricably linked within the students’ experiences. Similarly, all four sources are inter-connected with relationality playing an important role in all experiences.
Chapter VI – Conclusions

Summary of Major Findings

A striking and unexpected finding of the inquiry process is the centrality of students’ feelings. This finding illustrates the interconnectedness found within all experience, including mathematics education. Anna Neumann (1997) writes of silences and stories from post-holocaust lives. She notes “people live their stories as much as they tell them in words…they live them in the feelings that come to surround them” (p. 107-108). How these Aboriginal students felt in mathematics class is similarly central to the stories they tell of their mathematics education experiences. The narrative encounter, a socially situated, interactive encounter, between the researcher and student, enabled voices to emerge (Chase, 2005). The researcher expressed her voice by interpreting and sharing the experiences of the students. The students developed their voice in the telling of their stories.

Mastery experiences appear to play a dominant role in the formation of these students’ self-efficacy beliefs. These mastery experiences are intertwined with the students’ affective domain. Inter-connections between vicarious and social persuasion experiences and relationality are also noted.

Limitations

Quality

The qualitative nature of this inquiry characterizes the research as contributing to an emic understanding of self-efficacy beliefs, an emphasis meaningful to the actor, in contrast to the “imposed etic construct,” (Klassen, 2004a, p. 228) meaningful to the
observer, that dominates the literature. Of utmost importance have been issues of quality. To meet Brickhouse (2006) and Simon’s (2004) standard of quality, the research has sought to answer meaningful questions. The present research sheds light on seldom heard voices in an attempt to contribute to a much needed and better understanding of Aboriginal high school students’ mathematics experiences. As researcher, this inquiry benefits me the most. The students’ willingness to share their stories has made this inquiry possible and enables me to complete my graduate studies. There was also evidence of the inquiry process being helpful to the participants, including demonstrations of insight, providing instances of Lather’s (1986) catalytic validity. Abigail and Sara both expressed that they found the inquiry process helpful. At the end of each of their interviews they chose to take their completed math experience maps home, saying that they found the opportunity to reflect on their experience helpful, and they wanted to share their maps with their parents.

Another student appeared to gain insight into their view of relevance, an experience detailed in Implications for Research. Sue gained insights into higher-level mathematics courses and the nature of a graduate study research process through our discussions. Lastly, it is my sincere hope that the research may usefully inform policy and practice through Implications for Practice and Implications for Research.

The present study has attempted to present a justified and warranted argument to meet Simon’s (2004) further measures of quality. I have been mindful that the “research process is not formulaic. Rather it is a reasoned response to the purpose and context of the work” (Simon, 2004, p. 162). It is my hope that the reflexivity of the researcher throughout this study has contributed to the quality of the research.
The Nature of a Narrative Qualitative Inquiry

Whittemore, Chase and Mandle (2001) remind researchers that qualitative inquiry is contextual and subjective, not generalizable and objective. “Qualitative research seeks depth over breadth” (p. 524). The qualitative nature of this inquiry delimits the present study. To borrow a turn of phrase from Simon and Tzur (1999), the inquiry has not been an attempt by a neutral observer. It has however, been an attempt to construct a coherent account of ten Aboriginal students’ high school mathematics experience providing insight into their self-efficacy beliefs. Clandinin and Connelly (2000) remind narrative inquirers “we work within the space not only with our participants but also with ourselves” (p. 60). Since, “one of the starting points for narrative inquiry is the researcher’s own narrative of experience, the researcher’s autobiography” (p. 70), this study began by discussing the position of the researcher. The some-times conflicting experiences as researcher or teacher influenced this qualitative inquiry and the resulting narratives. When Heather, Henry and Scott spoke about relevance of mathematics material, often in a way I perceived to limit their receptiveness to learning, my experiences as a teacher influenced the socially constructed reality of our interview, and my need to offer alternative perspectives to the students. When Sara spoke of her struggles with mathematics, memories of angst and despair, I tried to focus as a researcher on a sense of “Ubuntu” (Swanson, 2009). Ubuntu is a South African cultural concept, one that “values obligation and responsibility, it is also defined by acceptance of difference” (p. 13). Ubuntu’s power lies in an ethical spiritual commitment, a focus that values humility and avoids imposing a set of values on an Other. I listened
carefully to Sara as a researcher, resisting a teacher’s instinct to ponder how it might have been, or could be, a different experience for her.

_influence of Task-based Tool_

Creating and using a task-based tool, the math experience map, brought challenges and benefits to the inquiry process. The tool may have disrupted students’ narrative flow and unintentionally influenced some aspects of their stories. During the interviews, when and how the map was introduced varied across participants and may also have affected the students’ stories. Using the map took time, potentially available for other narrative focus, away from the inquiry process.

The tool also brought many benefits to the research. It served as an entry and exit mechanism for conversations and therefore helped with rapport building. It enabled the researcher to adapt to the participants’ communication style. The map reminded the researcher of which points to return to. The maps are evidence of a history of collaboration, and one student reflected on the map as a living document noting that she “can add on stuff.” The maps helped stimulate recall in students and often became an anchor for conversations. Using a tool helped take the heat off of the interview process, by displacing the focus away from the interview onto the tool itself. In particular, the map was a useful excuse to avoid sitting across from participants, as a side-by-side arrangement helped build rapport and minimize power differences between researcher and student.

_power imbalances, authenticity, and limits to relationality_

I was mindful of O’Kane’s (2000) concerns regarding disparities in power and status between adults and children throughout the research process. This research
attempted to mitigate disparities by expressly stressing the importance of the participants’ views to the students and often commenting that I was the student, the one to learn from them. Sitting beside students, dressed casually, I adopted an informal style of speech. I invited all participants to choose their own pseudonyms; Abigail, Alice, Lily and Andrew are names chosen by the students themselves. Nevertheless, there were instances that demonstrated how difficult it can be to minimize power and status disparities. Very early in Andrew’s interview he began with “can I say something?” Similarly, Alice paused in her interview, hesitating to author more sticky-note ideas, asking “should I write it down?” In contrast during Heather’s interview when I said I did not want to sound like a math teacher today, she commented that I was “doing really well.” Despite this success, it remains important to note that power and status differences were not successfully minimized throughout the research.

Cottle (2002) cautions that “no single narrative can ever represent the final statement of the Other” (p. 533). This view highlights that the nature of the research data is ultimately limited. It may be limited by the temporal, and co-constructed character of the interview experience as already noted, but may additionally be limited by relationality shortcomings. Chase (2005) reminds the researcher to not be naïve, not to assume that participants reveal their authentic selves in interviews. In keeping with a social constructivists’ lens, voices and selves are mediated by social context (Chase). While the goal during interviews was to encourage relationality and a relaxed atmosphere to foster openness, instances of tension and a lack of relationality remained. During Sue’s interview a lack of flow and ease was apparent as we both reacted somewhat nervously to hall noise outside the interview room. Jen’s repeated fidgeting with her bangs betrayed
her moments of discomfort. At other times, I felt I achieved a supportive voice that helped move students’ voices to the forefront. Abigail’s interview concluded with her remark “actually, I enjoyed this…it’s been very helpful.” Sara similarly reflected on her interview positively, and in specific reference to her math experience map, commented “I think this will help and I’m going to show this to my parents.” Indications of successful rapport building were sometimes evident long after the interviews. Scott, Henry and Jen each encountered me in the community while they were hanging out with friends, and each made a point of catching my eye or speaking to me.

Implications for Research

Accepting Possible Limits to Relationality

Of the ten participants who made the research possible, only one student responded to the opening questions in the interview, about their family, their background, and their interests, by self-identifying as Aboriginal. The other students may have deemed a comment regarding their Aboriginality unnecessary as the consent letters for the research (see Appendix C) made it clear that only students of Aboriginal identity were being invited to participate. Having only one student comment on their Aboriginality may, however, be a reflection of a lack of relationality for the participants working with a non-Aboriginal researcher. Two other students did mention Aboriginality in some other way during the interview. All students were given the opportunity to ask me any questions they may have at the end of the interview. The two students touched on Aboriginality at this juncture. One student asked why I was focusing on Aboriginal students; another student asked if researching Aboriginal students’ perspectives had been done before. I spoke with a fellow researcher, someone of Aboriginal descent, looking
for insight into my participants as I pondered if it was significant that the students often chose not to mention their Aboriginal ancestry more centrally. The Aboriginal researcher shared with me, that from her experience, the students I was interviewing may be fairly young to feel comfortable emphasizing their ancestry, especially with someone not of Aboriginal descent. The only student who self-identified during interviews as Aboriginal in this research, was the eldest of the participants, so this perspective may shed some light on what the students chose to share with me. It remains an unknown aspect of the research, raises the question: In what ways unknown to the researcher, was the study impacted by its cross-cultural nature? It points to the need for further research into the mathematics education experiences of Aboriginal students, to be by researchers of Aboriginal ancestry. Additionally, by changing the cross-cultural nature of the present study, other researchers coming from worldviews and perspectives different from my own, may impart different interpretation of mathematics education stories.

Future research may be able to better facilitate dialogue with youth by exploring online opportunities for data collection. Hendrick (2000) recognizes children as both social and political actors in their world. “We have to be extraordinarily sensitive to their standpoint, rather than those of their parents, school teacher, social workers and others” [emphasis in original] (p. 55). Online options untapped by the present research include blogs, chat rooms, or inviting email submissions to the researcher. Some of these methods might elicit participant perspectives not found with interviews.

Research Settings

This research joins Klassen (2004a) in a call for “further study of the relative importance of the sources of self-efficacy in differing cultural contexts” (p. 228). A first
step may be to compare findings in a comparable high school sample of non-Aboriginal students, enabling some cross-cultural comparisons to be made. The present research was not able to draw cross-cultural comparisons since only Aboriginal students were interviewed. Further research may also benefit by drawing from a greater number of data sources; teachers’ and parents’ perspectives on students’ self-efficacy would add to the understanding of each participant. Further study is also warranted with Aboriginal students in less-urban and non-urban settings.

*Researcher Growth*

From a recent lecture on the life of Gregory Bateson and subsequent communication with his daughter Norma Bateson, I am struck by her words “you think you are thinking your own thoughts, but you are thinking your culture’s thoughts” (N. Bateson, personal communication, January 12, 2010). As a researcher and teacher I reflect on Bateson’s thoughts and acknowledge that my ideas and perspectives are deeply influenced by the ideas I have explored as part of my University of Victoria Master of Arts program and my immersion in the teaching profession. As a researcher and teacher, I hope that my research has helped develop my ability to listen, to really hear, “to listen with three ears: two on the sides of our head and one that is in our heart” (Archibald, 2008, p. 8). In spite of my research and personal understanding of connectedness inherent in Indigenous worldviews, my research journey has revealed to me how influenced I am by Western worldviews and traditional academic paradigms. The importance of interconnectedness and relationship within mathematics self-efficacy should not have struck me as an unexpected outcome of the research. As I move forward working in cross-cultural settings, I hope to improve; I hope to be able, more quickly, to identify and
move away from a Western worldview that tends to examine pieces of a puzzle in an isolated fashion, often missing a connected perspective of the whole. My journey can serve to illustrate to other researchers and teachers how difficult cross-cultural understandings can be to enact. I do believe by really listening to Aboriginal students there are valuable perspectives to enlighten researchers and teachers to enable them to better understand student experiences.

Another important facet of my growth as a researcher also resonates with an Indigenous paradigm - reciprocity. Oliver (1998) and Lincoln (1995) identify an aspect of reciprocity, a part of the giving back to participants, as helping them develop their own voices. One of the participants’ parting words were “thanks for this, it was good to see my stuff.” As I reflect across all the interviews, it was the act of giving back, of finding ways to provide value to the students, that was central to my researcher journey. It also clarified my interest and motivation as a teacher. Building relationships and making a difference for students is what has brought me to teaching.

One further aspect of researcher growth is important to note. Throughout the research process I have regularly been employed as a teacher-on-call at a number of secondary schools in Victoria and often at the research-site school. The research process has afforded me the opportunity to build relationships with a number of Aboriginal students. These relationships have made a clear and significant difference to my teacher-on-call endeavours. I have noticed time and time again that relationship and a sense of connection with the students has helped make possible meaningful academic engagements with the students.
Implications for Practice

“The power of narrative for educators does not lie in generalizations (which are not attempted) or truth (which is not sought): rather, the power of narrative stems from readers interpreting the stories based on their own needs or the needs of their students. The lifeliness, the verisimilitude, of narrative allows for multiple interpretations, and multiple interpretations render multiple educational possibilities.” (Oliver, 1998, p. 249) Oliver’s words highlight how different educators will bring their own interpretations and students’ needs to their reading of the research. Oberg, Blades and Thom (2007) similarly invite readers to engage with a text and “to notice their response[s] to them,” [emphasis in original] readers must ask “what assumptions and values” produce their responses (p. 135). In this way the research aims to open conversations, “to enable people to see and then question what their biases and prejudices are” (Oberg, Blades & Thom, p. 136). The academic and education community does not often listen to youth, it does not “really listen” (McFeetors & Mason, 2005, p. 16). The voice of students from what McFeetors and Mason call the non-academic mathematics courses is seldom found in academic literature. Four of the students who made this research possible draw their mathematics experiences either from Applications of Mathematics classes, Essentials of Mathematics classes, or are struggling to complete course material in the Principles of Mathematics classes. These voices are rarely heard in the literature and make an important contribution to mathematics education literature. Social constructivism has been an overarching framework throughout the research. The implications for practice must similarly be constructed as “meaning is not inherent in an act or experience, but is constructed through social discourse” (Josselson, 1995, p. 32).
The research did not include non-Aboriginal students so has not drawn comparisons between Aboriginal and non-Aboriginal students. The research can however, speak to the importance of relationship, and all students may benefit from an awareness of this finding. The cross-cultural nature of the research journey can also inform all audiences. Reflexivity is essential in all endeavours, and is harder to enact than it first appears. Our cultural assumptions and traditions deeply influence how we interact with the world and can often unwittingly continue to shape our views even when we attempt to avoid these paths. We must acknowledge how difficult it can be to understand and perceive our own cultural assumptions. As Steinhauer (2002) reminds researchers, “we must never think of ourselves in isolation” (p. 77), and so it is for the world of mathematics. The research has highlighted the importance of relationality: it is an important finding for a variety of audiences: researchers, teacher educators, teachers, and parents. Relationship and connectedness appear to be central to the students’ receptiveness to learning experiences. Connectedness is also a central feature of an Indigenous worldview and may be an aspect of a mathematics education paradigm that benefits all students, those of Aboriginal descent and of non-Aboriginal descent alike.

*Implications for Teachers*

As for researchers, and teacher educators, mathematics teachers can be informed by the cross-cultural nature of this inquiry process. Cultural assumptions and experiences shape the way we view and interact with the world and mathematics classes are not isolated from this reality. Teachers can benefit by recognizing that they interact with students in culturally-laden ways, that cross-cultural border crossings and interpretations may be at work in their classrooms.
As noted above, a heightened understanding of relationship and connectedness is important. Additionally, mathematics educators may benefit from a heightened awareness of the interconnected nature of the four sources of mathematics self-efficacy that has been identified in the research. A strong need exists for teachers to ensure a broad pedagogical approach, one that focuses beyond the performance, of their students. There is much at stake for mathematics students; for many students, if they fail at mathematics, they fail at school. Educators need to maintain a sensitive understanding of the importance of students’ affective domain. How students feel is inextricably linked to their performance, and is impacted by the tone and content of the vicarious and social persuasion experiences they encounter.

It is recommended that teachers vary how they post student performances. Class marks, posted by student number for anonymity, should not be posted in order of performance. Teachers may wish to explore alternative ways to celebrate the top performers in a classroom. One hundred percent, or ‘A’ club, names could be celebrated with classroom postings, to celebrate successes while avoiding emphasizing the ranking of the poorest performers in the class.

The prevalence of problems following student absences indicates a need for department wide post-absence policy development. Teachers are already aware that student absences create problems, but the students’ stories indicate a need to look for new ways to support students following both short and extended absences.

Teachers may find it beneficial in some circumstances to avoid delivery of entire units as a single booklet. Three of the participants struggled with aspects of unit booklets, in contrast to one student who expressed support for booklets. One student was
overwhelmed seeing the volume of a unit at one time. It may be that some of the less confident students are susceptible to being overwhelmed with an entire unit’s work laid out at once. Another student lost interest in their homework as homework feedback had only been received at the end of the unit. It may be beneficial to explicitly renew with the students the benefits of the booklets, and the flexibility of their use.

Over the last number of years, teachers and students alike have been introduced to, and embraced, changes in classroom assessment strategies. In my experience teaching, teachers and students understand and articulate the value of assessment for learning. (Assessment for learning differs from assessment of learning typically done with a unit’s completion to check for mastery of concepts, by providing students and teachers with performance feedback during learning. Assessment for learning helps guide teachers and students through the learning process.) A similar and explicit instructional strategy is recommended with regards to homework and relevance of mathematics content. A number of the students complained about mathematics homework. One student demonstrated a typical view of homework, commenting that in the younger grades it was worth more of their mark and was therefore worth doing. This immature view demonstrates a lack of understanding with the emphasis on marks for younger grades’ homework as an attempt to build study skill habits. Students may benefit from continuing efforts by teachers to make explicit the value of homework. Homework as an opportunity for independent practice, leads many students to discover the limits of their understanding and mastery prior to a testing situation.

Students may similarly benefit from renewed and ongoing effort by teachers to explicitly speak to student concerns regarding relevancy of mathematical material. One
student in this study spoke about students being hampered by a need for relevance. She articulated students who “only want to know the basics…they don’t want to go into it…it makes them not do well, because they say there is no point, they won’t use it again. The attitude makes them not do well.” While some students may benefit from an increased effort on behalf of teachers to identify how mathematics material is relevant, other students may be helped when teachers explicitly discuss the value of doing mathematics when specific relevance is not apparent. As an example, during one interview with a student passionate about art, I was able to find an explanation of homework and relevancy that resonated with the student. I asked them to reflect on their art concepts and compositions of five years earlier. Could they see growth, development, and a maturity of approach in themselves as they considered where they had come to across five years? Indeed they could. I pointed out that the same growth and maturity of approach, an ability to tackle increasingly complex concepts, was happening for them in mathematics. While they may not wish to develop their mathematical maturity beyond a high school setting, by tackling increasingly difficult concepts and problems, they were developing a maturity of thinking, a mathematical creativity, that would stand them in good stead regardless of the field or interests that they pursue in life. The student still remarked later in the interview that math was “one of those things you just have to get through,” but they did say in response to my art maturity/math maturity analogy that “it’s the best explanation I’ve ever had.”

These suggestions for mathematics educators are not new ideas. An apt analogy of the journey for mathematics educators may be the viewing of gestalt drawings, an analogy used by Frank (2000) in his description of a storyteller’s role. Gestalt drawings
have a foreground and background figure to be discerned. It is difficult to teach someone how to see the image they do not at first detect, but once seen, one can move back and forth between the two images. Teachers are focused on students’ performances yet are also aware of the importance of relationships and students’ feelings. Similarly, teachers have experienced the benefits of explicitly outlining the value of homework, and described the relevancy of the mathematics work at hand. Recommending a renewed focus on these items may enable teachers to readily keep multiple perspectives and needs in mind, much like viewing the two images of a gestalt drawing, enabling educators to move amongst viewpoints and perspectives to meet the variety of needs demonstrated by their students.

*Implications for Parents*

Parents need to know that math matters. It is an important subject as it impacts students’ future choices and plans. Many parents are not aware that mathematics course choices and outcomes often impact a son or daughter interested in the trades, business, or a health career, not just those students who are aiming at science related careers. The research has reported evidence that four sources of information impact a students’ sense of competence in mathematics: performance mastery, vicarious or modeling experiences, verbal or social persuasions, and physiological arousal. Each source was reported in each student who participated. Since verbal persuasions influence students’ experiences, it is important for parents not to create a legacy of negative mathematics experiences. Parents must not inadvertently discourage their student by saying something like “I could never do math either!”
Another important finding of the research is that while being able to do math is of central importance to a student’s sense of competence, the connectedness and relationality is also centrally important. Parents may lack mathematical ability themselves, particularly as their child progresses through high school, but nonetheless, the importance of relationship points to the benefit of parents staying in touch with a student’s mathematics journey. Keeping in touch with the student, their teacher, and the school, in order to support a connected experience for the student.

**Summary of Implications for Practice**

The Implications for Practice are summarized in Table 2 – Summary of Implications for Practice.

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**Table 2 – Summary of Implications for Practice.**

<table>
<thead>
<tr>
<th>Teacher Educators</th>
<th>Performance mastery is central to students’ sense of competence but relationships and connectedness are also of central importance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>Broad pedagogical approach indicated: Students’ feelings, relationships, and sense of connectedness important.</td>
</tr>
<tr>
<td></td>
<td>Performance results should not be posted by students’ rank.</td>
</tr>
<tr>
<td></td>
<td>Renewed focus needed to improve student support following short and extended absences.</td>
</tr>
<tr>
<td></td>
<td>Less confident students may be overwhelmed if delivered entire units of work at one time.</td>
</tr>
</tbody>
</table>
Revisit explicitly highlighting to students the value of homework.

Renew efforts to demonstrate where possible how students’ mathematics is relevant to life journeys.

Share with students the perspective that values tackling increasingly difficult mathematics in situations where relevancy of material is not readily apparent, as it develops a creativity and maturity of thought processes.

Parents

Math matters and influences futures regardless of their choices (trades, business, or science futures).

How we encourage students matters: Avoid telling students you couldn’t do math either. Alternatively, be encouraging and find ways to support your student.

All relationships matter: stay in touch with students, their teachers, and their school. Through relationships you can advocate and support for your student without having mathematics ability yourself.

Conclusion

Oliver (1998) quotes Joseph Conrad’s writing of 1898, noting it is “the writer’s task, by the power of the written word to make you hear, to make you feel – it is before all, to make you see” (p. 251). These words highlight the nature of knowledge and understanding and its intertwined character with feelings. These words resonate with the connectedness of an Indigenous worldview. So it is with the formation of mathematics
self-efficacy; enactive experiences are inextricably intertwined with one’s affective domain, how one feels throughout one’s experiences is central to one’s perceptions of one’s competence. The research has been a modest effort to uncover a nuanced understanding of Aboriginal students’ high school mathematics experience. This understanding gleaned from ten urban Aboriginal students focuses teachers and researchers on the importance of relationality. This emphasis on connectedness and relationship can serve all students well.

A qualitative inquiry with relational narrative methodology has aimed to make a valuable contribution to mathematics education research. Generalizability of this study is limited. Yore (2002) stresses “generalizability is ultimately the responsibility of the reader and the user, but researchers can do much to facilitate this process,” (p. 5) hence limitations have been detailed accordingly. The research has reinforced the existing emphasis in the literature on the importance of performance mastery experiences in the formation of students’ mathematics self-efficacy. The research has also illuminated the central importance of students’ feelings; attention to student’s affective domain is of critical importance to a successful journey through mathematics.
References


Retrieved October 18, 2008 from

http://www.ccd.rpi.edu/Eglash/nasgem/jmc/Challenges%20and%20


British Columbia: Ministry of Education.


British Columbia: Ministry of Education.


British Columbia: Ministry of Education.


Appendix A: Human Research Ethics Board Approval

Human Research Ethics Board
Modification of an Approved Protocol

Principal Investigator: Larry Yore
Faculty:"

Co-investigator(s):
- Dr. Anne Marshall, Co-Principle Investigator
- Francis Guenette, Research Coordinator, UVic
- Tanya Ward, Research Assistant, UVic

Supervisor: Katie Fisher, Research Assistant, UVic
Dr. Leslie Francis-Pelton, Thesis Supervisor to Katie Fisher, UVic

Department/School: EDCI

Project Title: Pacific Centre for Scientific & Technological Literacy: Real science opportunities for students
Sub Study: Aboriginal Students' High School Math Experiences: Stories of

Protocol No: 08-05-127f
Date: 08-Jun-09

For modifications to an Approved Protocol, your protocol approval period remains the same as your original certificate of approval.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.

This Certificate of Approval is valid for the above term provided there is no change in the protocol. Extensions and/or amendments may be approved with the submission of a "Request for Annual Renewal or Modification" form.

Dr. Richard Keeler
Associate Vice-President, Research

08-06-127f Yore, Larry
Dear [insert school Principal],

I am writing in my capacity as a graduate student from the University of Victoria in the department of Education. Your school is being invited to participate in research being conducted by me, Kate Fisher, entitled **Aboriginal Students’ High School Math Experiences: Stories of Opportunities and Obstacles**.

I am conducting this research study as part of the requirements for a Master of Arts degree in math education. It is being conducted under the supervision of Dr. Leslee Francis-Pelton.

The purpose of this research project is to learn about the mathematic experiences of Aboriginal students across grades 9 through 12 and to investigate their overall career aspirations. Research of this type is important because few Aboriginal students take higher-level math, or go on to enroll in post-secondary programs that require math. As a result, Aboriginal students are under-represented in careers that use math. This research will explore through individual interviews, the opportunities and obstacles Aboriginal students experience in math and how these experiences contribute to their self-perceptions in math. In group format the research will explore the career aspirations of these youth using a possible-selves mapping technique.

If your school community voluntarily participates in this research, participation will include recruiting self-identified Aboriginal students across grades 9 – 12. A recruitment and participant consent letter, and a parent/guardian consent form will be provided to each potential participant. Students who are interested in participating in the research will return their consent form and parent/guardian consent form to the Aboriginal Academic Support Teacher. I will then collect these forms.

Participation will include two interview sessions. The first interview will be approximately one hour to explore the obstacles and opportunities the students have experienced in mathematics. The second interview will be a group session, held over a lunch hour, with a group of participants to explore a broader picture of goals and fears for...
the future. Participants will be provided with transcripts of their individual interviews and asked if the transcription accurately reflects their experience or if they have anything further to add.

The Aboriginal Academic Support Teacher will be asked to arrange the date, time and location of individual interview sessions. It would be ideal to arrange the interviews during school time, using spare blocks where possible, or asking for staff support for students to miss a block of mathematics. Students who need to cancel or reschedule an interview may inform the Aboriginal Academic Support Teacher, or me directly. Interviews should be held at a quiet area in the school such as an office or empty classroom. Students who choose to participate in the research will be offered a $15.00 honorarium to demonstrate my appreciation of their time and commitment. The Aboriginal Academic Support Teacher will also be asked to help arrange group sessions. I will provide a pizza with fruit juice and bottled water lunch for these group sessions. At the end of the research a group meeting of participants and their families will be scheduled in order to share results of the research.

There are no known or anticipated risks to the students by participating in this research. I will however, contacted the school’s counselling department to make them aware of the research, and will also remind students of this resource in the event they wish to discuss issues that arise during discussions. A potential benefit of the research is contributing to the development of personal agency. Students are engaging in a reflective process which may foster personal growth. A further potential benefit is that students will be contributing to informing future math practices.

Student participation in this research study must be completely voluntary. Whether or not a student participates will have no bearing on their grade or standing in school. A student may withdraw from the study at any time without any negative consequences and they will not be asked to provide any explanation. Should students wish to withdraw from the research, their honorarium is theirs to keep.

All student identities will be anonymous in the research. No real names will be used in any published results of the research. Confidentiality of participants’ data will be protected by storing printed transcriptions of the interviews, filed by participant number codes, in a locked filing cabinet located at a research office at the University of Victoria. All digital audio recordings of the interviews will be saved on my personal computer which is password protected, and once transcribed will be destroyed.

It is anticipated that the results of this research will be shared with others in the following ways:

1. The results of the research will be shared with all participants and families in a group meeting.
2. The results of the research will be presented at my thesis defence.
3. The results of the research will be shared with the school’s math staff.
4. Results may be reported in academic presentations or articles.
Data from the research will be disposed of once I have made a final presentation of my research to my supervisory committee at the University of Victoria. If you have any further questions regarding this research, please feel free to contact me or my supervisor:

Researcher: Kate Fisher  kfisher@uvic.ca  cell  250-217-1360
Supervisor: Leslee Francis-Pelton  lfrancis@uvic.ca  office  250-721-7794

You may also verify ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Assistant at 250-472-4545 or by e-mail at ethics@uvic.ca.

Sincerely,

Kate Fisher – Researcher
Aboriginal Academic Support Teacher

Aboriginal Students’ High School Math Experiences: Stories of Opportunities and Obstacles

Dear [insert Aboriginal Academic Support Teacher],

I am writing in my capacity as 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 Aboriginal Students’ High School Math Experiences: Stories of Opportunities and Obstacles.

I am conducting this research as part of the requirements for a Mast of Arts degree. It is being conducted under the supervision of Dr. Leslee Francis-Pelton. My supervisor may be contacted at (250)721-7794 or by e-mail at lfrancis@uvic.ca.

The purpose of this research project is to learn about the mathematic experiences of Aboriginal students across grades 9 through 12 and to investigate their overall career aspirations. Research of this type is important because few Aboriginal students take higher-level math, or go on to enrol in post-secondary programs that require math. As a result, Aboriginal students are under-represented in careers that use math. This research will explore the opportunities and obstacles Aboriginal students experience in math and how these experiences contribute to their self-perceptions in math. Using group sessions the research will also explore the career aspirations of youth using a possible-selves mapping technique.

If you agree to voluntarily participate in this research study, your participation will include recruiting potential participants across grades 9 – 12. A copy of the recruitment letter, a parent/guardian consent form, and a participant consent form will need to be provided to each potential participant. Please review the material with each potential participant. Students who are interested in participating in the study will return their consent form and parent/guardian consent form to you. I will collect these forms from you.

Participants will participate in two interview sessions. The first interview will be approximately one hour to explore the obstacles and opportunities the students has experienced in mathematics. The second interview will be a group session to explore a broader picture of goals and fears for the future. These group sessions will also be approximately one hour. Participants will be provided with transcripts of their individual
interviews and asked if the transcription accurately reflects their experience or if they have anything further to add.

As a school contact, you are requested to arrange the date, time and location of individual interviews. It would be ideal to arrange interviews during participant’s school schedule, using spare blocks where possible, or asking for staff support for students to miss a block of mathematics. Students who need to cancel or reschedule an interview may inform you, or me directly (kfisher@uvic.ca or 250-217-1360). Students who choose to participate in the research will be offered a $15.00 honorarium to demonstrate my appreciation of their time and commitment. You are also requested to arrange group sessions, which would be best done over lunch hours at school. Towards the end of the research, you are requested to help schedule a group meeting of participants and families interested in hearing the results of the research.

There are no known or anticipated risks to the students by participating in this research. I will however, contact the school’s counselling department to make them aware of the research, and will also remind students of this resource, in the event that discussions raise issues they wish to discuss further with a counsellor. A potential benefit of the research is contributing to the development of personal agency. Students are engaging in a reflective process which may foster personal growth. A further potential benefit is that students will be contributing to informing future math practices.

Student participation in this research study must be completely voluntary. Whether or not a student participates will have no bearing on their grade or standing in school. A student may withdraw from the study at any time without any negative consequences and they will not be asked to provide any explanation. Participants may tell you, or me directly, if they wish to withdraw. If a participant withdraws from the research, their data will not be included in the research and their data will be destroyed. Should students wish to withdraw from the research, their honorarium is theirs to keep.

Your identity and all student identities will be anonymous in the research. No real names will be used in any published results of the research. Confidentiality of participants’ data will be protected by storing printed transcriptions of the interviews, filed by participant number codes, in a locked filing cabinet located at a research office at the University of Victoria. All digital audio recordings of the interviews will be saved on my personal computer which is password protected, and once transcribed will be destroyed.

It is anticipated that the results of this research will be shared with others in the following ways:

1. The results of the research will be shared with all participants and their families in a group meeting.
2. The results of the research will be presented at my thesis defence.
3. The results of the research will be shared with the school’s math staff.
4. Results may be reported in academic presentations or articles.

Data from the research will be disposed of once I have made a final presentation of my research to my supervisory committee at the University of Victoria.
If you have any further questions regarding this research, please feel free to contact me or my supervisor:

**Researcher:** Kate Fisher  
**Email:** kfisher@uvic.ca  
**Cell:** 250-217-1360

**Supervisor:** Leslee Francis-Pelton  
**Email:** lfrancis@uvic.ca  
**Office:** 250-721-7794

You may also verify ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Assistant 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 research, that you have had the opportunity to have your questions answered by the researcher and that you are interested in participating in this research.

____________________________  ________________  _____________
Name  Signature  Date

Sincerely,

Kate Fisher – Researcher

*A copy of this consent will be left with you, and a copy will be taken by the researcher.*
Appendix C: Consent Letters

Aboriginal Students’ High School Math Experiences:
Stories of Opportunities and Obstacles

Dear Student,

My name is Kate Fisher and I am a graduate student from the University of Victoria in
the department of Education. You are being invited to participate in research that is
being conducted by me entitled Aboriginal Students’ High School Math Experiences:
Stories of Opportunities and Obstacles.

I am conducting this research study as part of the requirements for a Master of Arts
degree in Education. It is being conducted under the supervision of Dr. Leslee Francis-
Pelton. My supervisor may be reached at (250)721-7794 or by e-mail at
lfrancis@uvic.ca.

The purpose of this research project is to learn about the mathematic experiences of
Aboriginal students across grades 9 through 12 and to investigate their overall career
aspirations. Research of this type is important because few Aboriginal students take
higher-level math, or go on to enroll in post-secondary programs that require math. As a
result, Aboriginal students are under-represented in careers that use math. This research
will explore through individual interviews, the opportunities and obstacles Aboriginal
students experience in math and how these experiences contribute to their self-perceptions in math. In group format the research will explore the career aspirations of
youth using a possible-selves mapping technique.

You are being asked to participate in this research because you are an Aboriginal student
taking mathematics. You were recruited for this research by your school’s Aboriginal
Academic Support Teacher.

If you agree to participate in this research, you will be partake in two interview sessions,
each approximately one hour in length. I will ask you for permission to audio record
your individual interview. The interview will explore the obstacles and opportunities you
have experienced in mathematics. You will be provided with transcripts of your interview
and asked if the transcription accurately reflects your experience or if you have anything
further to add. The second interview will be a group session to explore a bigger picture of
goals and fears for the future. I will ask you for permission to video record the group
session. The individual interviews will be scheduled at times convenient for you, such as
during a space block, after school, or during a mathematics class where you feel
comfortable missing a block of math. Students who choose to participate in the research
will be offered a $15.00 honorarium to demonstrate my appreciation of your time and commitment to the research. It is important for you to know that it is unethical to provide undue compensation or inducements to research participants and, if you agree to be a participant in this study, this form of compensation to you must not be coercive. If you would not otherwise choose to participate if the compensation was not offered, then you should decline. Should you withdraw from the study at any time, the honorarium is your to keep. Group interviews will be scheduled at lunch times and I will provide pizza and fruit juice and water for these sessions. The Aboriginal Academic Support Teacher at school will arrange the date, time and location of your interview. If you need to cancel or reschedule an interview, you may inform the Aboriginal Academic Support Teacher or me directly at kfisher@uvic.ca or my cell phone 250-217-1360.

Near the end of the research there will be a group meeting for all participants and their families interested in the results of the research. This meeting will be held at school during the evening to accommodate parent and guardian work schedules. I will ask all participants for permission to audio record this meeting. The meeting will take approximately 60 to 120 minutes.

You will be identified by first name only at the group meeting. All participants who attend a 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. I will however, contacted the school’s counseling department to make them aware of the research, and will remind you of this resource, in the event that any discussions raise issues you wish to discuss further with a counselor. A potential benefit of the research is contributing to the development of personal agency. You are engaging in a reflective process which may foster personal growth. More significantly, your contributions will help inform future math practice.

Student participation in this research study must be completely voluntary. Whether or not you participate will have no bearing on your grade or standing in school. You may withdraw from the research at any time without any negative consequences and you will not be asked to provide any explanation. Participants may tell the Aboriginal Academic Support Teacher or me directly, if they wish to withdraw. If you withdraw from the research, your data will not be included in the research and your data will be destroyed.

All student identities will be anonymous in the research. No real names will be used in any published results of the research. Confidentiality of participants’ data will be protected by storing printed transcriptions of the interviews, filed by participant number codes, in a locked filing cabinet located at a research office at the University of Victoria. All digital audio recordings of the interviews will be saved on my personal computer which is password protected, and once transcribed, will be destroyed.
It is anticipated that the results of this research will be shared with others in the following ways:

1. The results of the research will be shared with all participants and their families in a group meeting.
2. The results of the research will be presented at my thesis defense.
3. The results of the research will be shared with the school’s math staff.
4. Results may be reported in academic presentations or articles.

Data from the research will be disposed of once I have made a final presentation of my research to my supervisory committee at the University of Victoria. All typed transcriptions of interviews will be shredded in a paper shredder, and audio recordings will be deleted from my computer. If you have any further questions regarding this research, please feel free to contact me or my supervisor:

Researcher:  Kate Fisher  
             kfisher@uvic.ca  cell  250-217-1360

Supervisor  Leslee Francis-Pelton  
             lfrancis@uvic.ca  office  250-721-7794

You may also verify ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Assistant at (250) 472-4545 or by e-mail at ethics@uvic.ca.

Your signature below indicates that you understand the above conditions of your participation in this research, that you have had the opportunity to have your questions answered by the researcher and that you are interested in participating in this research.

Name of participant  Signature  Date

Your signature below indicates that you give permission for the personal interview to be audio recorded.

Name of participant  Signature  Date

Your signature below indicates that you give permission for the group session to be video recorded.

Name of participant  Signature  Date

Please return this consent form to the Aboriginal Academic Support Teacher at your school, and keep a copy for your own records.

Sincerely,

Kate Fisher – Researcher

_A copy of this consent will be left with you, and the signed copy will be held by the researcher._
Aboriginal Students’ High School Math Experiences: 
Stories of Opportunities and Obstacles

Dear Parent or Guardian,

My name is Kate Fisher and I am a graduate student from the University of Victoria in the department of Education. You are being invited to participate in research that is being conducted by me entitled Aboriginal Students’ High School Math Experiences: Stories of Opportunities and Obstacles.

I am conducting this research study as part of the requirements for a Master of Arts degree in Education. It is being conducted under the supervision of Dr. Leslee Francis-Pelton. My supervisor may be reached at (250)721-7794 or by e-mail at lfrancis@uvic.ca.

The purpose of this research project is to learn about the mathematic experiences of Aboriginal students across grades 9 through 12 and to investigate their overall career aspirations. Research of this type is important because few Aboriginal students take higher-level math, or go on to enroll in post-secondary programs that require math. As a result, Aboriginal students are under-represented in careers that use math. This research will explore through individual interviews, the opportunities and obstacles Aboriginal students experience in math and how these experiences contribute to their self-perceptions in math. In group format the research will explore the career aspirations of youth using a possible-selves mapping technique.

Your student is being asked to participate in this research because they have self-identifies as an Aboriginal student taking mathematics. Your student was recruited for this research by the Aboriginal Academic Support Teacher at your students’ school.

If you agree that your student can participate in this research, they will be partake in two interview sessions, each approximately one hour in length. I will ask for permission to audio record their individual interview. The interview will explore the obstacles and opportunities they have experienced in mathematics. Participants will also be provided with transcripts of their individual interviews and asked if the transcription accurately reflects their experience or if they have anything further to add. The second interview will be a group session to explore a bigger picture of goals and fears for the future. I will ask for permission to video record the group session. The individual interviews will be scheduled at times convenient for the student, such as during a space block, after school, or during a mathematics class where they feel comfortable missing a block of math.
Students who choose to participate in the research will be offered a $15.00 honorarium to demonstrate my appreciation of your time and commitment to the research. It is important for you to know that it is unethical to provide undue compensation or inducements to research participants and, if they agree to be a participant, this form of compensation must not be coercive. If a student would not otherwise choose to participate if the compensation was not offered, then they should decline. Should a student withdraw from the study at any time, the honorarium is theirs to keep. Group interviews will be scheduled at lunch times and I will provide pizza and fruit juice and water for these sessions. The Aboriginal Academic Support Teacher will arrange the date, time and location of interviews. If a student needs to cancel or reschedule an interview, they may inform the Aboriginal Academic Support Teacher or me directly at kfisher@uvic.ca or my cell phone 250-217-1360.

Near the end of the research there will be a group meeting for all participants and their families interested in the results of the research. This meeting will be held at school during the evening to accommodate parent and guardian work schedules. I will ask all participants for permission to audio record this meeting. The meeting will take approximately 60 to 120 minutes.

Students will be identified by first name only at the group meeting. All participants who attend a 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 student anonymity and confidentiality.

There are no known or anticipated risks to the student by participating in this research. I will however, contact the school’s counseling department to make them aware of the research, and will remind students of this resource, in the event that any discussions raise issues they wish to discuss further with a counselor. A potential benefit of the research is contributing to the development of personal agency. Students are engaging in a reflective process which may foster personal growth. More significantly, student contributions will help inform future math practice.

Student participation in this research study must be completely voluntary. Whether or not students participate will have no bearing on their grade or standing in school. Students may withdraw from the research at any time without any negative consequences and will not be asked to provide any explanation. Participants may tell the Aboriginal Academic Support Teacher, or me directly, if they wish to withdraw. If students withdraw from the research, their data will not be included in the research and their data will be destroyed.

All student identities will be anonymous in the research. No real names will be used in any published results of the research. Confidentiality of participants’ data will be protected by storing printed transcriptions of the interviews, filed by participant number codes, in a locked filing cabinet located at a research office at the University of Victoria. All digital audio recordings of the interviews will be saved on my personal computer which is password protected, and once transcribed, will be destroyed.
It is anticipated that the results of this research will be shared with others in the following ways:

1. The results of the research will be shared with all participants and their families in a group meeting.
2. The results of the research will be presented at my thesis defense.
3. The results of the research will be shared with the school’s math staff.
4. Results may be reported in academic presentations or articles.

Data from the research will be disposed of once I have made a final presentation of my research to my supervisory committee at the University of Victoria. All typed transcriptions of interviews will be shredded in a paper shredder, and audio recordings will be deleted from my computer.

If you have any further questions regarding this research, please feel free to contact me or my supervisor:

Researcher: Kate Fisher kfisher@uvic.ca cell 250-217-1360
Supervisor Leslee Francis-Pelton lfrancis@uvic.ca office 250-721-7794

You may also verify ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Assistant at (250) 472-4545 or by e-mail at ethics@uvic.ca.

Your signature below indicates that you understand the above conditions of your student’s participation in this research, that you have had the opportunity to have your questions answered by the researcher.

_________________________  _________________________  ______________
Name of participant  Signature of Parent/Guardian  Date

Please return this consent form to the Aboriginal Academic Support Teacher at school, and keep a copy for your own records.

Sincerely,

Kate Fisher – Researcher

A copy of this consent will be left with you, and the signed copy will be held by the researcher.
Appendix D: Math Experience Map

Figure 2 - A reduction of 11x17" Math Experience Map
Interview Protocol
Introduction
I would like to explore your ideas, past experiences and thoughts for your future around math today. I’d like to start with a bit of background. Can you tell me a bit about yourself, your age, family, interests, in other words, your life outside of math class? I’d like to invite you to tell me a story that paints a picture for me about you and math. Can you share with me your experiences in math so I have an idea of what you are like in math?

I have made A Math Experience Map for us to use to guide us through what we talk about today.

Brainstorm supports in your math experiences
I would like to start by asking you to think about your experiences in math over the last number of years. I would like you to write down on these notes, a few keywords regarding past experiences that come to mind, things that helped or supported you in math. We are going to put your notes on this area of the Math Experience Map I light-heartedly call the land of opportunities and supports. When you have had a few minutes to think about those experiences, I would like you to share some of those stories with me. …….(…….signifies wait time, give the students quiet time)

Respond to what a student has written
Can you tell me a bit about ….. and what that was like for you.

If student can’t think of positive experiences- prompting questions:
Would you describe yourself as someone confident in math?
Have there been people in your life who have encouraged you in math?
(If only negatives are offered: Does a particular story or incident come to mind when you might have felt differently?)

Brainstorm barriers in math experiences
I would like you now to think about experiences that have hampered you, or been barriers to success in math, and have you write down a few keywords on this other colour of notes. We are going to put these notes on the land of obstacles and barriers. Again, when you have had a few minutes to think about those experiences, I would like you to share some of these stories with me.

Respond to what a student has written
Can you tell me about this experience and how if felt for you.

If student hasn’t come up with any negative experience
Have you had experiences where you felt discouraged in math?
Do you associate math with dread or anxiety? How do you feel in math class?
Can you recall instances when you felt your sense of confidence being undermined?
Rank and Group Experiences
Let’s look at the stories about your math experiences that have come up.

Do any themes emerge when you look at these experiences?
   Could you group the experiences and give them a name or a title?...Starting
   with the positive experiences that have supported you in math.
   Which ones seem the most important? ......
   The least? ......

Let’s do the same thing with the barriers you have experienced in math.
Which experiences seem to have had the biggest impact?.......
The least?........

Reflecting on past experiences to guide future path
Reflecting on your experiences in math, can we identify positive things you
   can do, or things you can ask for, that would help support you and help you
   experience greater success in math?
 ..................

Can we also look at the barriers to math success and come up with ideas to
limit them recurring in the future?
 ..................

Overall impressions and feedback
Looking at the Math Experience Map we have created, what is your overall
impression?
 ......
Is there anything you would like to add or change?

Do you feel it has been a helpful experience going through this reflective
process?
Appendix E – Completed Math Experience Maps

Barriers (B)
B1: other subjects and homework
B2: sometimes there's just not enough time to study

Supports (S)
S1: mom and dad support me
S2: All my friends want to do well which encourages me
S3: I always personally want to do my best

Figure 3 - Sue's math experience map
Barriers (B)
B1: Opening up
B2: Vulnerable
B3: Lack of enthusiasm
B4: Lack of confidence

Supports (S)
S1: Be confident
S2: Organize!!!!
S3: Go in for help
S4: Homework / Peer tutors
S5: Support

Figure 4 - Abigail’s math experience map
Barriers (B)
B1: Challenge of missed information
B2: Memory work
B3: Not understanding the methods
B4: Not getting my homework done
Outside of class

Supports (S)
S1: Taking notes in class
S2: Working with my friend
S3: My attitude

Figure 5 - Alice's math experience map
Barriers (B)
B1: Quiz’s and test worth
   More %
B2: More instruction time
B3: Homework

Supports (S)
S1: Study skills / organize
S2: Stress free learning
S3: Private school
S4: Friends

*Figure 6 - Heather's math experience map*
Barriers (B)
B1: Teachers
B2: Memory-focused learning
B3: People I’m around in class
B4: Putting off homework

Supports (S)
S1: Step by step instruction
S2: Organized binder / separate
S3: Do work immediately
S4: Friends in class

Figure 7 - Jen's math experience map
Barriers (B)
B1: Lack of instruction
B2: Friends distracting
  - talking when we should be working
B3: Sitting in one spot too long
B4: Going from A to B with no Transitions – lack of connection
B5: Lack of communication / isolation

Supports (S)
S1: Ideas to apply the math skills with / how it can help understand how things work (baking/pizza for fractions)
S2: [needing clear] Due dates
S3: Repetition / games / songs
S4: Friends / helps with what you miss [re: absences]

Figure 8 - Lily's math experience map
Barriers (B)
B1: Reducing decimals to fraction
B2: Distractions
B3: Procrastinator
B4: BEDMAS [order of operations skills]

Supports (S)
S1: Visualize
S2: Keeping to exactly what you need to know
S3: With a times table you can use your hand to find the answer
S4: Someone there for you

*Figure 9 - Andrew’s math experience map*
Barriers (B)
B1: The pace was often too fast. We tried to get too much done in a single week
B2: Class size too big – teachers could not help all the people with their hands up in time for end of class

Supports (S)
S1: More help available, more teacher’s assistants in class
S2: After school one on one sessions with teachers
S3: Weekly mark updates to see how my grades were doing and how I could improve (retests etc)

Figure 10 - Sara's math experience map
Barriers (B)
B1: Style of teacher
B2: Trying to pass
B3: Supplies [being out of them]

Supports (S)
S1: Having a partner in math
S2: Feedback – knowing your mark
S3: Pace – going over it slowly

Figure 11 - Henry's math experience map
Barriers (B)
B1: Lack of relevance
B2: Quantity to do
B3: Comparisons

Supports (S)
S1: Teacher’s patience / sets calm tone

Figure 12 - Scott's math experience map