TRANSFORMING MATHEMATICS EDUCATION FOR MI'KMAW STUDENTS THROUGH *MAWIKINUTIMATIMK*

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ABSTRACT

This research project explores how curricula and pedagogy can be transformed to support Mi'kmaw students as they negotiate their position between Aboriginal and school-based concepts of mathematics. The work was conducted over a nine-month period in two Mi'kmaw schools that are part of a unique jurisdictional agreement with the Government of Canada giving Mi'kmaw communities control over their education system. . In after-school sessions with teachers, support staff, and elders, modeled after a traditional community practice known as *mawikinutimatimk* (coming together to learn together), participants identified four key areas of potential tension for Mi'kmaw students learning mathematics. These areas of tension provide insight into instances of conflicting worldviews, as well as possible pedagogical strategies to support Mi'kmaw learners in a context in which disengagement with mathematics and science is a concern for many teachers.

The first key idea identifies the need to learn from Mi'kmaw language. This involves both learning the language and learning about the way the language works. Most notably, a change in discourse patterns to reflect Mi'kmaw verb-based grammar structures, referred to as "verbification," is exemplified as a strategy that holds promise for supporting Mi'kmaw students learning mathematics. The importance of attending to value differences between Mi'kmaw concepts of mathematics and school-based mathematics is another key area addressed as is the importance of attending to ways of learning and knowing. The final area of tension highlights the significance of making ethnomathematical connections for students. Some challenges and successes are highlighted and pedagogical implications of each area of tension are shared.

DEDICATION

To the children of Mi'kma'ki, especially

to those who, as my students, taught me

how to be a better teacher.

Wela'lioq.

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The year was 1995. I was a young teacher in a Mi'kmaw community school who was committed to learning the Mi'kmaw language. I decided that it would make sense to learn how to count in Mi'kmaq given that I was teaching mathematics. I went to some of my Mi'kmaq speaking colleagues and told them that I wanted to learn to count in Mi'kmaq. "Great," they replied, "what are you counting?" "What am I counting? What do you mean what am I counting? I'm just counting: one, two, three..." "Yes, but what are you counting?" I was confused. They laughed and explained to me that in Mi'kmaq *what* one counts determines *how* one counts.

The counting words a Mi'kmaw speaker uses are different depending on the situation. Consider a child jumping rope; as she jumps she would count *newt, tapu, si'st*, [one, two, three] and so on which would represent a present tense type of counting that accompanies the action. To discuss the total number of objects the words would change, and the construction of the word would depend on whether the objects were animate or inanimate[1]. For example, two birds would be referred to as *tapusijik jipjijk,* which would tell the listener that there are a total of two of these animate objects called birds. To talk about two inanimate objects such as two pieces of firewood one would say *tapukl puksukl*. The distinction between animate and inanimate has significant implications for the teaching of number.

Over the years, as I have continued to learn about numbers in Mi'kmaq, I have noted many other important distinctions. The word used to describe *Grade 2* is different from the word for *two years old* and these are both different from the word for *having*

[1] Animate and inanimate in the Mi'kmaq understanding of these terms is not necessarily the same as in English. A door, for example, is considered an animate object in Mi'kmaq.

two legs. Each of these concepts and many others have the twoness embedded into the word, rather than using *two* as an adjective. It is common in mathematics education to claim that context matters but this expression took on a new layer of meaning for me as I began my teaching (and learning) career.

This dissertation is a reflective step along my journey to more deeply understanding the factors and issues that must be addressed to support Mi'kmaw students in the learning of mathematics. Learning to count was just the beginning.

Formulating a Question

This research project addresses the following key research question: *How can curricula and pedagogy be transformed to support Mi'kmaw students as they negotiate their position between Aboriginal and school-based concepts of mathematics?*

This question is mine, but it is in many ways a compilation of the questions asked by myself and my colleagues during my teaching career. As such, I felt the journey to discovery also needed to draw on this spirit of collective knowledge and hence I invited the staff of two Mi'kmaw schools to journey along with me in afterschool discussions which I will describe in chapters 3 and 4. While this dissertation is ultimately an account of my own reflections and discoveries, it is also interwoven with the stories of participants through inclusion of their own words from transcripts, through my descriptions of their words from field notes, and through descriptions of things I observed during the project.

While the research question helped to guide the discussions, it quickly became apparent that it was necessary to explore the space between Aboriginal and school-based concepts of mathematics. In chapters 4 through 8, I describe this journey of discovery and

focus on the key areas of tension that must be attended to if mathematics education is to be substantively transformed for Mi'kmaw students.

Before moving on, I set the context for the research in the rest of this chapter by describing in more detail my own journey of discovery that happened during my teaching career. I connect my own understandings, questions, and musings to those of others who are equally concerned about the engagement of Aboriginal students in mathematics and discuss why this work is important. I will also offer some key reasons why this is an opportune time to be doing this work.

My Personal Journey to This Research

I began my teaching career in a Mi'kmaw school in Nova Scotia in 1995. When I was hired to teach mathematics for students from Grades 7 through 12, I committed myself to ensuring that what went on in my classroom was something significantly different than what was happening in most provincially run schools. I was a first year teacher who had been inspired by Aboriginal mentors during my university studies to believe that Mi'kmaq-controlled education would address the needs of Mi'kmaw learners in a direct way through curriculum and pedagogy grounded in Mi'kmaw values, culture, and traditions. I was quickly confronted with a reality that did not live up to this vision.

I felt immediate and constant pressure to make my classroom the very model of the provincial system. I was told by the director of education, a Caucasian man from outside of the community, that we needed to be "as good as, if not better than," the provincial schools using the same texts, the same curriculum documents, and the very same mathematics program. The school was not pursuing the vision of Mi'kmaw education I had hoped to find; instead, it was being run by non-Mi'kmaw administrators

who believed that the goal should be to imitate the mainstream system. As hard as I tried, I could never understand why we were trying to replicate a system that had consistently failed our students, yet thinking that somehow this time it would work. I made a conscious decision at that time to resist the pressure to conform to provincially imposed regulations and, instead, to demonstrate that culturally responsive teaching would better address the needs of my students and would improve their mathematical achievement overall.

During my Masters studies (Lunney, 2001) I focused on the conflict between the imposition of mainstream educational values on Aboriginal schools and the expressed desire by Aboriginal communities to substantively embed their own values and culture in their educational system. I was inspired to conduct my own research attempting to determine what a truly Mi'kmaw definition of education would be. Through in-depth conversational interviews with two community members, I developed themes that helped to establish a framework for education that would guide further discussion and investigation. While the focus of this work was not particularly related to mathematics education, several key ideas emerged that strongly influenced my quest to transform my mathematics classroom.

Both participants in the Masters' study spoke openly about the importance of community culture, language, and traditions being incorporated in a meaningful way in the curricular and pedagogical practices of the school, rather than just as add-ons to the Eurocentric system. One participant claimed that "In a Mi'kmaw school, you should have Mi'kmaq in every classroom not just the Mi'kmaw classroom. It shouldn't be a Mi'kmaw course at all. It should be all Mi'kmaq" (Lunney, 2001, p. 116). He felt that this was not

simply an issue of improved educational standards for Mi'kmaw students; he instead saw it as essential for cultural survival stating, "To save my culture; that is my concern." (Lunney, 2001, p. 112) So what then was my role in his quest? How could I, a white woman from a working class background, transform my mathematics classroom so that Mi'kmaw language, culture, and values were the foundation of the learning that takes place?

During the 10 years that followed the start of my teaching career I can proudly say that our staff, working as a team in collaboration with the community, put in place many changes that moved our school closer to the vision of Mi'kmaw education that I had originally expected to find. In 1997, our school, along with several other Mi'kmaw schools in Nova Scotia signed, an agreement with the Government of Canada that transferred jurisdiction over education to the communities; I will outline this agreement in more detail later in this chapter. However, with the arrival of this agreement came a new attitude and enthusiasm about Mi'kmaw education (Orr & Cameron, 2004). The collective of nine (later becoming 10) communities began working more closely together to ensure greater cultural relevance in educational practices.

More Mi'kmaw teachers were hired to teach in all subject areas, not just Mi'kmaw language and social studies as had been so often the case previously. Retention rates and graduation rates improved, and more Mi'kmaw language and culture were incorporated into the culture of these schools. Our own school graduated 65 students between 1997 and 2005, while making a more significant effort to include language and culture in our everyday practices, and within recent years, Mi'kmaw people have been promoted to positions of administration.

In the later years of my time at the school, I acted as the regional math leader for all Mi'kmaw schools in Nova Scotia, thus sitting on the provincial math leaders committee and conducting in-service professional development work with teachers in these schools. This process prompted me to question even more what we were doing with mathematics education in these schools. I was engaged in professional development work around the provincial outcomes but knew in my heart that we needed to do something different than what was currently prescribed in the curriculum documents.

Working with other teachers of mathematics and science in Mi'kmaw schools, we often engaged in discussions of how we might better address the needs of our learners through the inclusion of culturally based mathematical knowledge. We shared success stories and offered support to each other. We made suggestions of research that needed to be conducted and worked together to promote mathematics and science in the schools.

These are some of the small steps we have taken in the struggle to decolonize the mathematics curriculum, yet there is an overwhelming sense that more needs to be done. All of this has brought me to a place in my own development where I find myself thinking deeply about my own classroom experiences and reflecting on what implications these emerging understandings might have for this research initiative.

Musings of a Curious Teacher

Despite my new identity as researcher, I still see myself very much as the curious teacher who is interested in improving mathematics education for her Mi'kmaw students. I may no longer be a teacher in "my" school but my bond to these students remains strong and I want to improve education standards in my own former school as well as the other Mi'kmaw community schools. A great deal of my interest in this research topic has

emerged from my own questions that arose as I progressed throughout my career. It is important to draw on some of these musings at this time to establish a baseline for where my thinking was as I began this doctoral research project.

As I said in the opening story, when I first began teaching I was committed to learning the language of the community. I thought this would be a respectful thing to do and I saw this as a way to come to know and connect with the community members on a deeper level. As I learned the language, I gained insights into the way in which language could influence the teaching of mathematics. I have shown that, with number words, one must know the context in order to know which word is to be used. School-based mathematics treats counting as a fundamental concept that children learn early in their educational development. Counting is not so simple in Mi'kmaq; in fact, rote counting done without context makes very little sense.

Concepts of shape and space are similarly contextualized within the Mi'kmaw language. Much like numbers, I learned early on that many shapes that school-based mathematics refers to as basic shapes are in fact not so basic in the Mi'kmaw language. In Mi'kmaq the shape of the object is embedded in the name of the object, for example, *kiniskwikuom* means "a dwelling that comes to a point" such as an A-frame house or a *wi'kuom* (wigwam).

This contextualization of language is not indicative of a lack of abstract reasoning, but rather demonstrates a difference in worldview and what is valued within the culture. "The Mi'kmaw language grammatically encodes details concerning how speakers experience the world and how a speaker and the person spoken to connect with and evidence this experience" (Inglis, 2004, p. 400). What may be perceived as a

resistance to abstract words could also be seen as a favouring of contextualized words with the relatively intentional purpose of responding to and connecting with one's environment rather than shaping it.

This connectedness of language has often made me think about how shape and space concepts are typically presented in schools with the abstract shapes (i.e., circle, square, triangle, etc.) being presented for students often apart from any context. I frequently wonder what is lost for Mi'kmaw children in these classrooms where the new message is that context does not matter and that a triangle is always a triangle.

Some words have been created to accommodate these basic shapes in school-based mathematics but the words are often highly contentious and meet with considerable debate amongst elders, as in an ongoing conversation around the proper word for circle. During an in-service day for teachers from Mi'kmaw Kina'matnewey (MK) schools focusing on a mathematics event called *Show Me Your Math* (explained in more detail later in this chapter) a conversation arose relating to the proper word for "circle". There were a few words offered for consideration that day and many other variations have been offered to me as I have recounted this conversation to others.

A commonly used word for circle in Mi'kmaw immersion classes is *empĩsqa'wik*[2] or *memqĩsqa'wik*[3], although another participant at the workshop suggested that he used *musisqa'wik* for circle. In consulting other speakers, they have agreed that this latter term could also be used to describe a circle. The discussion of circles on that day led teachers to agree that this would be a wonderful topic for students to explore as part of our *Show Me Your Math* event.

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[2] The use of the symbol ĩ has been chosen to use in this document for a schwa (a crossed i) as the correct symbol is unavailable in Word 2003.

[3] Word lists from Eskasoni immersion teachers obtained from Helen Sylliboy.

As I reflected on this and many other discussions about Mi'kmaw words, I was reminded of the importance of examining Mi'kmaw words to understand mathematical reasoning; I was also reminded how complex this might be given the variety that is built into this language. It has been said that speaking an Aboriginal language is like quoting the elders who walked the land thousands of years ago and who used the language to describe and remember what they saw (Basso, 1996). I cannot help but wonder if there are so many different words to describe a circle because there are so many different contexts for talking about a circle in Mi'kmaw language. The circle is a very important symbol within Mi'kmaw culture. Again I wondered what is being lost in mathematics classrooms for Mi'kmaw students who are shown a circle devoid of any context and told that everything that looks like this is a circle. In chapter 5, I describe a similar conversation about the word for "triangle" that emerged during the research.

The discussions around words led me to think about the role of the Mi'kmaw language in mathematics learning. Many questions arose over the years especially as I reflected on my own practice. For example, when I look back on how I used language in my classroom, I continue to reflect on verbs and their use. I realize that in my teaching, I found ways to use verbs in situations in which I would have used nouns before. This helped me represent the motion and action involved in the mathematics. I realized that the more I spoke in verbs, the greater the success of my students.

An example of this would be a unit on linear equations I did with my grade 8 students one year. This was their first real introduction to linear equations. I had developed a series of centres that involved different representations of linear equations. Some activities required students to read from a table to solve a problem or create a

graph; others involved word problems to solve using tables or graphs; and still others involved graphs that needed to be interpreted in order to solve a problem or create a story problem. Through these explorations the students had begun to develop a clear understanding of how linear equations worked and how they could be used to model various situations.

Most notable is the conversation that surrounded our discussions of the equations. We talked about going over and up a certain amount each time, discussing how the graph was changing rather than discussing "the value" of "the slope." We talked about where the graph started off and how that connected to the equation, rather than discussing "the y-intercept." Once students had a clear understanding of the mathematical concepts, I could then talk to them about how these ideas, like most ideas in mathematics, have names, like slope and intercept.

Pimm and Wagner (2003) claimed that a feature of written mathematical discourse is nominalisation—"actions and processes being turned into nouns" (p. 163). In my classroom as we shifted the discourse to focus more on using verbs, I wondered if this "verbification" of mathematics helped my students understand the mathematics. This question is one idea I want to explore in this research and will discuss in depth in Chapter 5.

Why is Mathematics Education Important for Aboriginal Students?

My own musings highlight some of the reasons why this research is so important to me in the context of my own classroom experiences, but my interest extends beyond my high school teaching. I see a pressing need to address the disengagement from mathematics for all students, but in particular, for Aboriginal students.

Why are so few Aboriginal students pursuing higher level studies in mathematics and science? How can mathematics and science education be transformed to counter this disengagement? These questions haunt me and the answers are evasive. This has been my daily struggle – a struggle lived out in collaboration with many of my colleagues - and although I have experienced some successes and have been recognized for these achievements, I know there is more to be done. Despite my best efforts to support Mi'kmaw students in my mathematics classrooms, and to encourage many to pursue post-secondary studies in mathematics and sciences, they did not choose this path, and many others continued to struggle with the higher levels of school mathematics.

The National Council of Teachers of Mathematics (NCTM, 2000) had stated that "the need to understand and be able to use mathematics in everyday life and in the workplace has never been greater and will continue to increase" (p. 4). In today's changing world which is so heavily dependent on mathematical knowledge especially in areas of science and technology, it is essential that all students have an opportunity to "learn significant mathematics with depth and understanding" (p. 5). The importance of mathematics education is highly accepted throughout the world yet, as Bishop (1991) stated, "mathematics is in the unenviable position of being simultaneously one of the most important school subjects for today's children to study and one of the least well understood"(p. xi).

The learning of mathematics is important for all children and this is especially true in Canada's First Nation communities as they begin to re-establish their self-government and self-determination. They are confronted with the need to develop sustainable economies and manage natural resources while negotiating treaty rights and

land claims within the context of a growing population and insufficient infrastructure. Aboriginal leaders are looking to the younger generations to acquire the knowledge and skills to address these challenges. Such capacity-building requires that young community members have education in related fields, especially in mathematics and science, but currently few Aboriginal students are choosing to pursue studies in these essential skill areas. This disengagement often begins as early as elementary school.

While it is difficult to gather accurate statistics on the numbers of Aboriginal students pursuing educational paths involving mathematics and science, serious concern exists among interested parties across Canada regarding the low participation rate of Aboriginal students in these subject areas. The Minister's National Working Group on Education (as cited in Indian and Northern Affairs Canada, 2002) has suggested that a key area to be addressed in Aboriginal education in Canada is the development of culturally relevant curricula and resources in areas of mathematics and science where there is currently an identified weakness. Although not specific to Canada, this argument is supported by a relatively recent NCTM publication in which the authors have stated that Aboriginal people in North America have the lowest participation rates of all cultural groups in advanced levels of mathematics (Secada, Hankes & Fast, 2002).

The 2005 Canadian Mathematics Society's National Forum on Mathematics Education held a working group session in Toronto, Ontario, specifically designed to explore the issues surrounding mathematics education and the Aboriginal community. In addition to this, in 2005, many concerned educators and researchers met in Sydney, Nova Scotia at the Canadian Aboriginal Science and Technology Conference to hold a special educational forum to discuss how more Aboriginal students might be encouraged to

pursue higher studies in mathematics and the sciences. Many of the participants decided the time has come to address these concerns on a national level. This group had planned to work together to form a national association to address these issues through research and professional development. Although this has yet to come to fruition, communication continues amongst researchers and educators in Canada who are interested in transforming mathematics education for Aboriginal students. Many came together at the 2009 Canadian Mathematics Education Forum in Vancouver to discuss ways to relate indigenous knowledges and mathematics education with the goal of engaging more Aboriginal students in mathematics.

What are the Reasons for the Disengagement of Aboriginal Students with Mathematics?

A primary reason for Aboriginal youth's disengagement from mathematics and science is the discrepancy between their Aboriginal, culturally informed mathematics and school-based mathematics that is informed by a Western cultural perspective. Cajete (1994) stated that a Western cultural perspective science program acts in opposition to the values of traditional culture for Aboriginal students. He has claimed that this affects their performance in mathematics and science simply because it is not connected to their daily lives. A number of researchers support the argument that this occurrence of conflicting worldviews has led many Aboriginal students to either ignore the possibility of studying science or mathematics, or to struggle within these disciplines (see Aikenhead, 2002; Ezeife, 2003; Secada et al., 2002). Thus, if we are to meet the needs of Aboriginal learners, we must move towards a decolonized approach to education that allows for the inclusion of indigenous world views (Aikenhead, 2002; Battiste, 1998; Battiste, 2000; Orr, Paul, & Paul, 2002; Tompkins, 2002;). Aikenhead has advocated for

a cross-cultural approach to science education that incorporates different world views. He stated that, "Central to a cross-cultural approach to science teaching is the tenet that aboriginal children are advantaged by their own cultural identity and language, not disadvantaged in some deficit sense. Aboriginal students have the potential of seeing the world from at least two very different points of view" (p. 3). I think this optimism must be qualified in the face of reality: the potential referred to by Aikenhead can be an advantage for students, only if their multi-cultural position is legitimized by their educational institutions.

Much of the research referred to here has pertained specifically to science education because the body of research relating specifically to the success of Aboriginal students in mathematics is very limited. Also, in much of the literature reviewed, authors often have described mathematics and science collectively. Furthermore, given that mathematical understanding is essential for success in science and technology, a decolonized, cross-cultural approach could apply equally to mathematics education. It follows that by incorporating indigenous worldviews into the teaching and learning of mathematics, we can establish new pathways for Aboriginal students to develop understanding in mathematics.

This issue is not unique to Aboriginal students in Canada; a body of international research exists that supports the call for mathematics education to be more reflective of the culture of students. Globally, critical theorists also argue that cultural worldviews must be reflected in classroom practice to motivate students and build their capacity in mathematics (see Valero & Skovsmose, 2002).

The quest for greater cultural relevance in the teaching of mathematics has resulted in many projects that have attempted to document the cultural mathematical knowledge within indigenous communities of North America (Barta et al., 2001; Lipka, 2002b; Lipka et al., 2001; Poirier, 2005); however, such ethnomathematics scholarship is more extensive in Brazil and Africa (Powell & Frankenstein, 1997). While such scholarship often describes indigenous understandings, it only occasionally provides substantive help toward designing innovative and sustainable curricula. Furthermore, it often fails to guide teachers' pedagogical practice in response to the impacts of colonizing curricula. The *Math in a Cultural Context* series (University of Alaska Fairbanks, n.d.) stands out as an exceptional project, having provided both learning resources and teacher supports.

Some applied research has treated indigenous knowledge of mathematics as add-ons to non-Aboriginal curricula, as in basket and beadwork patterning (see Secada et al., 2002). Doolittle (2006) has argued that this can lead to an oversimplification of complex ideas which he referred to as the "cone on the range"—the complexity of a tipi is reduced to an example of a cone. Such trivialization does not honour the knowledge or learning needs of Aboriginal students nor does it promote substantive change in teaching practice.

Encouraged by the Success of Show Me Your Math!

Substantive change will happen when indigenous knowledge and community worldviews are given a position of privilege alongside traditional school-based views of mathematics. Decolonization is not about valuing one way of knowing over another, but rather about valuing multiple worldviews equally. *Show Me Your Math* is an event that

provides a space for such valuing, inviting Mi'kmaw students and their teachers to explore and value the mathematics within their own community context.

A component of a large scale project on ethnomathematics, *Show Me Your Math* emerged as a result of a conversation I had with my doctoral supervisor, David Wagner. We had been discussing our deeply enriching conversations we had with elders related to mathematics (see Lunney & Wagner, 2006a; Lunney & Wagner, 2006b; Wagner & Lunney, 2006) and were curious as to how we could create opportunities for students to engage in similar conversations. I suggested a contest through the Atlantic Canada First Nation Help Desk. Other contests, such as the elders' storytelling contest and the national Earth Day contest, had proven to be successful in engaging students from the various First Nation communities, and I felt this might be a way to engage a large audience and encourage students to act as ethnomathematicians.

We approached the Mi'kmaw schools and Atlantic Canada First Nation Help Desk with the idea and they were excited about the opportunity. We met with teacher representatives from each school to provide them with some background on ethnomathematics as a field of study and engaged in conversations with them about what kinds of projects students might do for the contest, how we might determine categories and prizes, and how we might display the work. Using Bishop's (1991) list of mathematical activities (counting, measuring, locating, designing, explaining, and playing) we were able to generate a wealth of potential topics for investigation. The teachers in attendance exhibited great enthusiasm for this project and wanted to have more than just a web-based contest. They wanted to have a Math Fair.

Students in many of the Mi'kmaw schools worked on projects throughout the winter term and on May 11, 2007, delegations of student representatives attended the first annual Math Fair. The amount of projects and the variety of topics were inspiring. Some students explored the mathematics in traditional crafts such as basket making, designing regalia, and doing beadwork. Others explored the mathematics involved in making a drum, playing *waltes* (a traditional bowl and dice game), baking four cents cake, and building a canoe. In one project, students used paper folding techniques and two cuts to create an eight point star, while another presented the connection between the Fibonacci numbers and the dream catcher.

What I found to be incredibly encouraging was the way in which teachers and students embraced this opportunity to explore the mathematics that is part of Mi'kmaw cultural ways of knowing and being. Many teachers opted to do whole class projects, inviting community elders into their classrooms to support students in these projects by teaching skills such as drum-making or basket-making. Other teachers included this activity as a class assignment encouraging all students to do a project. The response from teachers and students was extremely positive. The students were excited to talk about the mathematics they had learned while doing their projects, and they were proud to show the mathematical knowledge that is embedded in their culture.

The success of the event lends support to the work described in this research project. *Show Me Your Math* allowed students to engage in a project that privileged community knowledge and placed it on comparatively equal footing with the dominant school-based mathematics. The goal with my research project is to make this type of decolonizing work a daily event in mathematics classrooms for Mi'kmaw children.

The Possibilities and the Challenges of the Mi'kmaw Kina'matnewey Agreement

Events like the one described above are becoming more commonplace within Mi'kmaw schools and are demonstrative of the increased desire within these schools to transform education for the benefit of Mi'kmaw students. Much of this capacity has emerged as a result of the Mi'kmaw Kina'matnewey Agreement which presents both possibilities and challenges, which I detail next.

This research is grounded in a collective of nine Mi'kmaw communities in Nova Scotia responsible for their own education under the Mi'kmaw Kina'matnewey (MK) Agreement with the Government of Canada (recently renewed for 2005–2010). The *Mi'kmaw Education Agreement* was signed in 1997 and came into effect in 1998 (Department of Justice Canada, 1998). It was a first-of-its-kind agreement designed to transfer jurisdiction to the member communities providing them with the right to make laws regarding the delivery of primary, elementary, and secondary educational programs and services, and the administration of post-secondary support. Community laws were deemed to have precedence over provincial and federal laws. The agreement also established a "body corporate" now known as *Mi'kmaw Kina'matnewey* (MK) that was given an objective of supporting the delivery of education programs and services in member communities.

This agreement is being closely scrutinized during the implementation process to determine its potential as a model for future agreements (Indian and Northern Affairs Canada, 2005). While the communities under this agreement have experienced some significant improvements and successes (see Orr & Cameron, 2004) they also continue to

struggle with some of the challenges of assuming greater control over their educational systems.

One of the key challenges of this agreement is that the federal government requires that these MK schools provide provincially-transferable curricula. The MK agreement (1998) clearly stipulated that:

> The participating communities shall provide primary, elementary, and secondary programs and services comparable to those provided by other education systems in Canada, so as to permit the transfer of students between education systems without penalty, to the same extent as the transfer of students is effected between education systems in Canada. (section 5.4)

Yet this imposed curriculum often acts in direct opposition to Mi'kmaw values and is in contrast to the goals of Aboriginal communities who wish to have culturally-based curricula rather than applying mere add-ons of language and culture to fundamentally Eurocentric-based curricula. Battiste (1998) has noted that this is simply another example of the cognitive imperialism that has been used to discredit Aboriginal knowledge bases and privilege Eurocentric knowledge. She argued that:

> Indigenous knowledge, embraced in Aboriginal languages, is thus being supplanted in First Nations schools with Eurocentric knowledge supported by federal policies that mandate provincial curriculum. Instead of education that draws from the ecological context of the people, their social and cultural frames of reference, embodying their philosophical foundations of spiritual interconnected realities, and building on the enriched experiences and gifts of their people and their current needs for economic development and change,

> education has been framed as a secular experience with fragmented knowledge imported from other societies and cultures. (p.21)

Bear Nicholas (2001) echoed this point, claiming that many band-operated schools:

> … have been forced to accept the imposition of federal and provincial pressures mandating provincial curriculum, provincial teacher certification, and the use of English as the medium of instruction [forcing them] to emulate non-Native schools, rather than tailoring their own programs to suit their particular communities and cultures. (p. 9)

This discussion is indicative of the tensions that result when Aboriginal schools are forced to adhere to curricular standards that are not reflective of their community culture.

There is a constant struggle to find ways to counter the discourse of the mainstream ideologies while at the same time struggling to find an alternative. The MK has a stated goal of embedding Mi'kmaw language, culture, and traditions in all curriculum areas. It is difficult for Mi'kmaw and other Aboriginal schools to achieve their stated goals of developing curriculum guidelines based on their own Aboriginal languages, cultures, and values when they are legally required to offer provincial curriculum. My desire to find ways to support these schools as they negotiate this challenge is one of the things that led me to this research project.

Tensions are inherent in this kind of work. It is expected that someone reading about this or similar work would feel these tensions and recognize that they are not easily resolved. Negotiating the space between competing worldviews and curricular goals is inherently complex. The participants in this research project live with these tensions daily. Thus, their stories—some of which I retell here—are fraught with tension. Some of

the stories at times express themselves in apparently contradictory claims, which represent perspectives that are valued but in conflict with each other. This is the nature of the climate within which this research takes place.

In subsequent chapters I examine some of the literature related to this field, explain the methodology used for this project, and describe in detail the journey of collective discoveries. While I had many partners along this journey, much of this work is really about my own process of discovery—my own learning as a teacher of mathematics. Although I share some of the ideas and suggestions provided by participants, ultimately, I only have access to my own discoveries.

CHAPTER TWO: DEVELOPING CULTURALLY RESPONSIVE MATHEMATICS EDUCATION FOR MI'KMAW STUDENTS: A REVIEW OF THE LITERATURE

The purpose of this chapter is to examine some of the important research, policies, and programs relating to the development of culturally responsive mathematics curricula and pedagogy for Mi'kmaw students. This chapter is divided into six major sections. In the first section, I briefly describe the history of Aboriginal education in Canada from pre-contact times through to the present with a particular focus on the Mi'kmaw people. In the second section, I examine current research regarding a renewed vision for Aboriginal education in Canada that attempts to counteract the effects of colonization. In the third section, I explore the current body of research that examines culturally responsive mathematics education on a global level. In the fourth section, I describe an expanded view of equity as it pertains to mathematics. In the fifth section, I examine in detail some of the Aboriginal mathematics research and programs that have been developed in North America. The final section highlights two important pieces related to the importance of learning from Language to support Aboriginal students in mathematics. Connections to my own work will be made throughout the chapter.

The Historical Context of Aboriginal Education in Canada

Prior to the arrival of European colonizers, the Indigenous peoples of North America had systems and structures for the education of their younger generations. Education in this sense was a way to pass on knowledge from one generation to the next, which often took the form of oral storytelling. Education also involved helping younger members of the community develop their individual skills so they could contribute to the community, ensuring survival of the people. While working in the Mi'kmaw community,

I heard many stories of such traditional forms of education and in conducting research I have discovered that other North American indigenous cultures held similar values regarding education.

The Pueblo people occupy the south-western region of North America, a location quite distant from the Mi'kmaq of the northeast, yet the value of education is seen from a similar perspective. Cajete (2000) has explained that for the Pueblo people, education was said to be about finding your face and your heart, and developing a strong foundation upon which to express both. Finding your face implies connecting with who you are, where you come from, and discovering your unique sense of self. Finding your heart refers to finding your vocation, i.e., something you could do with passion that would also allow you to contribute to the life and survival of the community.

Following contact with European colonizers, Aboriginal people were subjected to European models of institutionalized education. This system of education was designed to "civilize and Christianize" the Aboriginal peoples of Canada, in an attempt to eliminate all traces of Aboriginal languages and culture (cf. Bear Nicholas, 2001). Many Aboriginal children were removed from their families and their communities and sent to residential schools where they endured harsh conditions and were often beaten for speaking their own language. The horrors experienced in these schools have been well-documented (Chrisjohn & Young, 1997). In addition to the documented stories, in recent years many remaining victims have begun to share their stories of abuse with community members and with the younger generation. I have been privileged to listen to some of these stories, but they are not mine to recount. In Mi'kmaki (the area inhabited by Mi'kmaq) many children were sent to Shubenacadie Residential School where they

experienced great horrors and were punished for speaking their own language (see Knockwood, 1995). The negative impact of the residential school system is evident in the loss of language for many survivors; the loss of intergenerational transmission of stories, culture, and identity; the breakdown of the strong family units; and the ongoing horrors that many survivors still experience today. As Battiste (2000) has stated, "these schools broke relationships among the people with themselves, with their own guardian spirits, their parents and communities, as well as with the land and environment" (p. 4).

Following a 1969 white paper produced by the Government of Canada proposing the elimination of status for Aboriginal people and the transfer of jurisdiction for education to the provinces, the National Indian Brotherhood (now the Assembly of First Nations, AFN) responded with a paper entitled *Indian Control of Indian Education* (ICIE) (National Indian Brotherhood, 1972), which outlined a new vision for indigenous education. They argued that the federal government should transfer control of education back to the communities and allow Aboriginal people to begin the process of reclaiming language, culture, and traditions while providing their children with a high quality education that would allow them to live in both native and non-native worlds.

The Assembly of First Nations released a follow-up report to the 1972 ICIE claiming that very few of the recommendations had actually been implemented and things were progressing far too slowly. The AFN (1988) argued that local control of education was intimately tied to self-government. While many of the recommendations of ICIE were never implemented by the government, this document proved to be profoundly influential and many of its recommendations are still being fought for today by

Aboriginal communities across the country as evidenced in the 2002 report by the Minister's National Working Group on Education (INAC, 2002).

Following the Royal Commission on Aboriginal Peoples (RCAP), the Government of Canada released the "Gathering Strength" document which called for a renewed relationship with First Nations people that acknowledged past wrongs, and advocated respect and honour for Aboriginal language and culture (INAC, 1996). At this time the Mi'kmaq Education Agreement or Mi'kmaw Kina'matnewey (MK) Agreement emerged.

The MK Agreement was praised as a first-of-its-kind educational self-government agreement. Originally signed in 1997 for a 5-year period, this agreement enacted legislation which transferred jurisdiction for education to the participating communities, enabling them to make laws regarding the delivery of primary, elementary, and secondary programs for students living on-reserve. This gave communities the right to choose to educate students in their own community or to enter into tuition agreements with provincial facilities for delivery of these services. The agreement also gave communities jurisdiction with respect to the administration of post secondary student support which enabled communities to determine what types of post secondary programs would be funded. The agreement also established a "body corporate" now known as Mi'kmaw Kina'matnewey (MK) that was given an objective of supporting the delivery of education programs and services in member communities.

MK answers to a board of directors made up of the chiefs of the participating communities and offers school board type services as well as acting as the negotiating body for the MK communities (the communities that fall under the MK agreement). The

original MK agreement expired in 2002 but was extended to 2005 to allow ongoing negotiations to continue. It was renewed in 2005 until March 31, 2010.

Since the time of the MK agreement, the federal government has produced two new documents which also address Aboriginal education. One of these documents was created in 2002 by the Minister's National Working Group on Education—a group of Aboriginal educators from across the country—who set forth their recommendations in *Our Children – Keepers of the Sacred Knowledge* (INAC, 2002). The authors of this report echoed many of the sentiments of ICIE and the AFN's 1998 document, calling for transfer of jurisdiction to communities. They also made a particular mention of the need for the development of culturally responsive curriculum in the areas of mathematics and science.

More recently still is INAC's *Education Action Plan* which was created in response to observations and recommendations in the *Auditor General of Canada's Report* in 2004 outlining a plan to transfer greater responsibility for education to Aboriginal communities in Canada (INAC, 2005). Both of these more recent documents referred to the *Mi'kmaq Education Agreement* as a success story. The latter of the two made the point that this agreement is under close scrutiny to determine its potential impact for future agreements with other Aboriginal communities stating that "Since the Mi'kmaq Agreement has become a model for other 'education self-government agreements' in the country, what is learned in the implementation of this agreement can offer valuable lessons for the future" (INAC, 2005, p. 18).

The AFN responded in 2005 with an education action plan of its own which stated that the themes contained in ICIE are still relevant today and again renewed their call for

transfer of jurisdiction to communities with assurance of the proper resources and funding to ensure its sustainability. Its recommendations are reminiscent of the requests in ICIE and they continue to envision "an holistic approach to education" (AFN, 2005, p. 6) that is defined by communities and integrates "the cultural, traditional, spiritual, physical, emotional and social well being of the learner" (AFN, 2005, p. 6). It also argues that "First Nations education must be grounded in First Nations languages and cultural values" (AFN, 2005, p. 1). Although it has taken close to 40 years, it seems as though a political time is emerging in which the vision of ICIE may come to fruition.

A New Vision of Aboriginal Education

Aboriginal and non-Aboriginal researchers have, since ICIE, attempted to define a new vision for Aboriginal education. While the government of Canada has attempted to define what it means to be an Aboriginal Canadian in the *Indian Act* (Department of Justice Canada, 1985), it must be acknowledged that there are many and varied cultural groups that fall under this definition as well as many others that do not (non-status Aboriginals, for example). There is not *one* indigenous culture. Therefore, it is impossible to assume that a vision of indigenous education in one area of the country would be the same in another, and it is difficult to describe what culturally responsive education might look like in each different area. That being said, there are certain shared experiences among the various First Nations that facilitate greater transferability of ideas from one indigenous culture to another and that enable discussions to generate shared themes.

A dominant theme that emerges from much of the literature is that Aboriginal education should seek "to heal and transcend the effects of colonization" (Cajete, 2000, p. 181). It has been argued that Aboriginal education cannot ignore the reality of

colonization but rather must address the issue directly (see Hampton, 1995). In effect, Aboriginal education needs to be a decolonized form of education.

Decolonization can be seen as a process of "deconstruction and reconstruction" (Battiste, 2004, p. 10) that "engages with imperialism and colonialism at multiple levels" (Smith, 1999, p. 20). This demands the critical examination of the hegemonic structures of mainstream education that continue to perpetuate the values of colonialism (Battiste, 2004; Bear Nicholas, 2001).

Too often, the response to the call for culturally responsive education has been given the lip service response of the "add-on" model in which courses in Native Studies, books by Aboriginal authors, or cultural artefacts have been added to existing models of colonialist education. This is seen as insufficient and trivializing by many Aboriginal scholars (Battiste, 2004; Bear Nicholas, 2001) and non-Aboriginal scholars interested in Aboriginal education, including myself. It is insufficient to simply add Aboriginal content without turning a critical eye to the mainstream curriculum. The addition of *other* content continues to treat indigenous knowledge as exotic by acknowledging it "as *a* knowledge, not *the* knowledge" (Battiste, 1998, p. 21). This enables the mainstream curriculum to keep its privileged status over these *other* forms of knowledge. What is called for by most Aboriginal scholars is a postcolonial approach to Aboriginal education that uses indigenous philosophies as its base.

The word *postcolonial* refers to a different worldview, "not a time after colonialism, but rather ... an aspiration, a hope, not yet achieved [that] constructs a strategy that responds to the experience of colonization and imperialism" (Battiste, 2004, p. 1). It is "not only about the criticism and deconstruction of colonization and

domination, but also about the reconstruction and transformation, operating as forms of liberation from colonial imposition" (Battiste, 2004, p. 1).

To achieve this postcolonial vision of education, researchers such as Battiste (2002) and Bear Nicholas (2001) have argued that educators must begin to acknowledge the "hidden curriculum" that is embedded in the Eurocentric structure of school-based education. This curriculum transmits the ideologies and values of the mainstream society such as individualism and capitalism. This structure is antithetical to the values and beliefs of Indigenous peoples and as such any grafting on or adaptation of this structure will not achieve the goals of a postcolonial vision of education.

This is an exciting time in Aboriginal education. A number of collected works have been published in the effort to flesh out this new vision for Aboriginal education (see Battiste, 2000; Binda & Calliou, 2001; Brant Castellano, Davis & Lahache, 2000). The voices contained within these texts share a common objective of deconstructing the current structure of Eurocentric education that has long been imposed on Aboriginal people of this country, and reconstructing a new decolonized approach to education that is based on Aboriginal philosophies and epistemologies.

Most writing with respect to decolonizing Aboriginal education remains mainly theoretical with few examples of the implementation of a decolonized vision of education. This is understandable, however, as many Aboriginal schools, despite having local control, are still often legally mandated to offer provincial curriculum (Battiste, 2002; Bear Nicholas, 2001). It has also been difficult to prevail against the effects of colonialism given that most educators and researchers must first deconstruct the realities of their own mainstream education (Battiste, 2002; Bear Nicholas, 2001).

Some promising research has emerged recently which begins to demonstrate models of decolonization. Orr, Paul, and Paul (2002) wrote of Mi'kmaw teachers who are attempting to decolonize their classrooms through the incorporation of cultural practical knowledge, using the stories and struggles of the community to help students to construct knowledge in a way that is meaningful to them. This research emerged from communities that fall under the Mi'kmaw Kina'matnewey Agreement described previously, and is just one example of the reported successes these communities are having (see also Orr & Cameron, 2004). This includes the communities in which my research has taken place.

The Akwasasne Science and Mathematics Pilot Project is another emerging example of successful decolonization of Aboriginal education (LaFrance, 2000; Restoule, 2000). This project is discussed in more detail later in this chapter. Similarly, there are promising examples of decolonization from Alaska (Lipka & Adams, 2004) and other parts of the United States. Literature reviews have revealed how culturally-based education is showing promising results for Aboriginal students (Battiste, 2002; Demmert & Towner, 2003; Lipka, 2002a).

My own research shares the vision of decolonizing education for Mi'kmaw students. In some earlier research, I worked with community members to develop a vision of Mi'kmaw education based on community values and worldview (Lunney, 2001). The vision emphasised the importance of helping students to develop their own identity as Mi'kmaw people, learning the language and values in the context of the extended family. It also emphasised a need for education designed to help students to develop their own gifts and talents and to realize how they might use these to contribute to the community. Connecting to the community, understanding the community's history

and vitality, and having pride in being a member of this community was also seen as a goal of education. Finally it was suggested that education must provide students with the ability to lead their community into the future, being able to walk in two worlds with the skills to work toward transformation (Lunney, 2001). This community vision of education is in line with the ideas about Aboriginal education that have been described above.

My current work builds on this vision, exploring transformation and decolonization in the area of mathematics education. In coming chapters I present a model that emerged as a guide to a decolonized approach to mathematics education for Mi'kmaw schools. It is through such research that the theoretical visions of Aboriginal education begin to become reality and potentially available as models for similar implementation elsewhere.

The Global Call for Culturally Responsive Mathematics Education

The call for the decolonization of education is not unique to Aboriginal communities in North America; this theme has emerged in educational research around the world. Mathematics education in particular, which has long enjoyed the mythical appearance of being value neutral, has recently come under close scrutiny.

Ethnomathematical research has been described as "one of the most significant areas of research in the last two decades" that "has fundamentally changed many of our ideas and constructs" (Bishop, 2000, p. 2). It has not, however, been without its critics, many of whom share similar goals and values with ethnomathematicians (e.g., Vithal & Skovsmose, 1997). In this section I explore the development of ethnomathematics and the various definitions and descriptions that have been attributed to it. I also examine some of

the criticism of ethnomathematics and explore some of the ongoing debates over the use of the term. Finally, I explore how my current research fits within this body of work, and explain my own decisions regarding the use of the word *ethnomathematics*.

Gerdes (1997) has credited D'Ambrosio as the father of ethnomathematical research although, as he carefully points out, there were numerous forerunners to ethnomathematical research that explored mathematics as a way of thinking that develops particular to a culture. He has suggested that the turbulent socio-political times from the 1960s to the 1980s resulted in the questioning of the role of mathematics research and teaching and the subsequent societal and cultural implications. D'Ambrosio's ethnomathematical program was first presented as a plenary address to the fourth International Congress of Mathematics Education in 1984 in Adelaide, Australia (Gerdes, 1997). This is seen as the defining moment in ethnomathematics research.

D'Ambrosio's ethnomathematical program was proposed as a "methodology to track and analyze the processes of generation, transmission, diffusion, and institutionalization of (mathematical) knowledge" in diverse cultural systems (as cited in Gerdes, 1997, p. 335). Ethnomathematics was regarded as something different from academic mathematics and was defined as "the mathematics practiced among identifiable cultural groups, such as national-tribal societies, labour groups, children of a certain age bracket, professional classes, and so on" (D'Ambrosio, 1985, p. 47).

Ethnomathematical work requires a definition of mathematics that goes beyond the idea of mathematics as "the things mathematicians do" or "the things done in the mathematics classroom". Bishop (1991) has presented ideas of what he considers to be universal mathematical activities that develop in all cultures, according to the values and

needs in those cultures. He has argued that mathematical ideas develop from six key human activities: counting, measuring, locating, designing, explaining, and playing.

For D'Ambrosio's (2006), a definition of ethnomathematics contains the notion that mathematics involves the instruments created to respond to a need to explain or understand. This author claimed that:

> Throughout history and throughout their existence, individuals and peoples have created and developed instruments for reflection and observation, material and intellectual instruments [which I call **tics**] to explain, understand, come to know, and learn to know and do [which I call **mathema**] in response to the needs for survival and transcendence in different natural, social, and cultural environments [which I call **ethno**]. Thus from this derives the name Ethnomathematics. (p. 42)

These two notions of mathematics—Bishop's list and D'Ambrosio's response to a need—have played foundational roles in much of the ethnomathematical work that is addressed in this section.

Some researchers have attempted to classify activities that can be seen as ethnomathematical activities. Vithal and Skovsmose (1997), for example, have suggested that there are four strands of ethnomathematical research: that which explores the history of mathematics, particularly in non-Western cultures; a second and overlapping strand that explores the mathematics of indigenous cultures and in particular, those traditional mathematical ways of knowing that have survived colonisation; a third strand that focuses on the mathematics of various groups such as carpenters or market women; and the fourth and, as they see it, unifying strand, which explores the relationship between ethnomathematics and education. Eglash (1997) described similar categories that he

associates with the anthropology and sociology of mathematics but he suggests that ethnomathematics is particularly focused on researching the mathematics embedded in traditional indigenous societies.

Ethnomathematics was supported greatly by researchers who had been exploring anthropological and socio-cultural aspects of mathematics such as mathematics in indigenous cultures, informal mathematics, hidden or frozen mathematics and so on, all of whom take a broad view of mathematics and do not see its development as unilinear (Gerdes, 1997). They have suggested instead that many mathematical knowledge systems have developed in cultures all around the world. Some of this knowledge has been absorbed into formal or mainstream mathematics, but much of it has not.

One unifying idea of ethnomathematics is that it is political in nature and serves to challenge the hegemonic thinking of school-based mathematics. The idea that ethnomathematics is the mathematics practiced among cultural groups continues to be used by D'Ambrosio today (see D'Ambrosio, 2006), although he has claimed that "in addition to this anthropological character, ethnomathematics has an undeniable political focus. Ethnomathematics is imbedded in ethics, focused on the recovery of the cultural dignity of the human being" (D'Ambrosio, 2006, p. 1). Powell and Frankenstein (1997) also have considered ethnomathematics to be a political endeavour, suggesting that it is an approach to challenging Eurocentrism in mathematics education. A similar political focus can be found in the work of Knijnik (2002) who has suggested that:

> Ethnomathematics problematises the "great narrative" which modernity considers to be academic mathematics. ... By legitimizing as mathematics more than just the intellectual property of the Academe, and by considering the forms of other,

> non-hegemonic ways of knowing and producing mathematics, ethnomathematics relativises the 'universality' of (academic) mathematics and, moreover, questions its very nature. (p.13)

Eglash (1997) has argued from an epistemological standpoint that ethnomathematics explores the possibility of indigenous intentionality. Citing studies such as Gerdes' (1991) explorations of African *sona* and Ascher's (1990) work with Cayuga dish games, Eglash has claimed that there is evidence of mathematical intention. Put more clearly, it is not simply accidental that there is such strong evidence of geometric and probabilistic thinking. These cultures did not simply stumble upon something that would only be explained to them later by the great European mathematicians. Such explorations of intentionality can be seen as yet another step in the decolonization of the mathematics classroom.

Adam et al. (2003) also have argued that ethnomathematics has benefited indigenous mathematicians by giving them an avenue to critically explore the role of mathematics in colonization and find new ways to "engage with the discipline constructively" (p.329). They have suggested that "decolonisation involves reclaiming, protecting, and valuing the unique ways of indigenous knowing and doing" (p. 328). They have stated their belief that great benefit can come to the world from alternative indigenous knowledge systems. Bishop (1990) also argued that mathematics has been used as a weapon of cultural imperialism and he too has pointed to ethnomathematical work as a way for marginalized people to uncover the hidden or frozen mathematics within their own cultural contexts.

In response to critics that ethnomathematics constituted a form of revisionism D'Ambrosio (1997) argued a similar point, claiming that ethnomathematics provides "alternative epistemological grounds" to examine "the nature of mathematical knowledge" (p. 14). He stated that to date, much of the ethnomathematical work has been directed at uncovering cultural mathematical practices that resemble mainstream mathematics and that such trivialization continues to ignore the "mathematical developments in other cultures [that] follow different tracks of intellectual inquiry, hold different concepts of truth, different sets of values, different visions of the self, of the Other, of mankind, of nature and the planet, of the cosmos" (D'Ambrosio, 1997, p. 15). D'Ambrosio has proposed that there is a need to look to these alternative epistemologies to find solutions to the world's most pressing problems and has argued against complacency in accepting the world as just being the way it is because it is the way it is.

D'Ambrosio (2006) stated that "the great motivator for the research program known as Ethnomathematics is to seek to understand mathematical knowing/doing throughout the history of humanity, in the contexts of different interest groups, communities, people, and nations" (p. 8). He has suggested that "conciliating the need to teach the dominant mathematics and, at the same time, give recognition to the ethnomathematics of their traditions, is the great challenge for education for indigenous peoples" (p. 15). He has argued that "the most promising strategy for education in societies that are in transition from subordination to autonomy is to restore dignity to their individuals, recognizing and respecting their roots" (p. 30). The ultimate goal of all education, but in particular mathematics education, according to D'Ambrosio, should be about achieving peace. Thus, a goal of ethnomathematical work is to challenge the

hegemony of current privileged mathematical knowledge systems and allow for a transformed system that gives dignity and respect to all cultural systems of mathematical knowledge.

In addition to challenging the status quo, one of the proposed justifications of ethnomathematics has been that by making mathematics education more culturally relevant, it would eliminate the effects of cultural clash that was a proposed cause of failure for many students who did not see their cultural views represented in the "Western" mathematics curricula (Gerdes, 1997). Bishop (2000) has said that "For many children around the world the educative experience in schools is not culturally consonant with their home experience. Their situation is one of cultural dissonance and the educational process is one of acculturation, rather than enculturation" (p. 5). He has argued that ethnomathematical research provides mathematics teachers with a way to explore the values embedded in mathematics and an opportunity to examine the cultural roots of mathematics so as to enable children to make mathematics more meaningful for themselves. Again, this is an effort to enhance the dignity of students by helping them to see the value in their own systems of knowledge.

Adam et al. (2003) have claimed the benefits of an approach to ethnomathematics that "is an integration of the mathematical concepts and practices originating in the learners' culture with those of conventional, formal academic mathematics" (p. 332). Culture is used, in this sense, as a starting point so that students can better understand and appreciate conventional mathematics. Specifically, Adam et al. have argued that "a curriculum of this type allows learners to become aware of how people mathematise and use this awareness to learn about a more encompassing mathematics" (p. 332).

As stated previously, there have been many critiques of ethnomathematics, including the ongoing debate on ethnomathematics played out on the pages of *Educational Studies in Mathematics* (Adam et al. 2003; Rowlands & Carson, 2002; Rowlands & Carson, 2004). Although despite their differences, the researchers agree on some benefits of ethnomathematics. Rowlands and Carson (2004) have suggested that ethnomathematics does open a space for "discourse that engages all learners in a mathematical conversation, and ensures that children from indigenous and traditional cultures will be in a position to bring important resources and ideas to that conversation" (p. 336). They also agreed that "ethnomathematics engages the teacher in a side of the mathematical conversation that opens up a route of access to the child's own unique modes of thought, both personal and cultural" (p. 336). They claimed to be pleased to see that the debate is focused on what is best for the student.

Overall, there seems to be general agreement that an ethnomathematical approach to education would use the students' cultural backgrounds as starting points for understanding ways of knowing and understanding the world that can be considered mathematical. This approach allows for alternative forms of knowledge that may help to broaden our source of solutions to the world's problems. It will also bring about a greater sense of dignity for indigenous societies that have for so long had their voices silenced. This is considered to be a significant step in the decolonisation of mathematics education.

Ethnomathematics holds promise for transforming mathematics for Mi'kmaw students as it shares the goals of research that Aboriginal scholars have been calling for; but it is important to examine the critiques as well. As Vithal and Skovsmose (1997) have so aptly phrased, ethnomathematics "is not innocent" (p. 152).

One criticism of ethnomathematics is that the word itself carries with it a negative connotation. In the South African context, the language and values of ethnomathematics are seen as being dangerously close to the language and policies of Apartheid. (Vithal & Skovsmose, 1997). Vithal and Skovsmose have claimed that the ideology of providing culturally responsive education was used to mask the fact that what was really provided was an inferior quality education for those affected by apartheid. Thus any discussion of ethnomathematics in South Africa is met with heated political debate. The use of the prefix *ethno*, in their opinion, is just too politically tied to race and thus racist policies.

This fear that ethnomathematics risks further marginalizing to those who it is intended to help is also echoed by Rowlands and Carson (2002, 2004). They argued that overemphasis on using only the local culture and knowledge will deny indigenous students access to formal mathematics which "is in and of itself one of the great achievements of the human mind, a potentially empowering intellectual discipline, and one of the practical keys to material wealth and well-being" (p. 331). While I question whether material wealth should be a goal of education—as I suspect many of the ethnomathematicians referred to previously would—I believe that this risk of further devaluing indigenous mathematical knowledge is quite real. There is a danger of trivializing local knowledge and making it seem inferior to *real* mathematics if the inclusion is done in such a way as to make it seem exotic or insignificant.

Ethnomathematics does risk further trivializing the mathematical activities of various cultures by making them appear somehow more trivial. I have my own concerns about how the inclusion of basket, blanket, and beadwork patterns are used as an add-on to explain mathematics to Aboriginal students. Eglash (1997) has argued that one way to

avoid this is to turn the ethnomathematical lens on Western cultural artefacts as well, suggesting the need to explore the "appearance of the golden rectangle in the Greek Parthenon or the use of the Eiffel Tower as an example of fractal geometry" (p. 92). This notion is reminiscent of a plenary address given by Mohawk mathematician Ed Doolittle at a recent meeting of the Canadian Mathematics Education Study Group (2006) in which he suggested that if ethnomathematics can be applied to baskets, blankets, and beadwork, it could also equally apply to the pattern in Grandma's dishes.

Doolittle's (2006) suggestions are more reminiscent of ethnomathematical work; he suggested we turn the mathematical lens on common or everyday Western objects, whereas Eglash (1997) has focused more on objects that already have considerable status and are perceived as marvels of engineering. I would expect to find mathematics in studying the Eiffel Tower because mathematics would have been used in the design and construction of this structure, but what about the everyday objects? If I turn the mathematical lens on the basket made by an elder in the Mi'kmaw community should I not also turn this lens on the crochet work my grandmother did on my pillow case?

As Lipka (2002a) stated, "The connection of local knowledge to schooling is not an easy process, however. The challenge is to adapt local culture and knowledge to Western schooling without trivializing and stereotyping" (p. 3). Although it is challenging, this does not mean that this ethnomathematical approach should be avoided completely, for when it is done properly the benefits are great (Lipka, 2002a). What must be done then is to proceed with awareness and critical reflexivity so as to ensure that the goals of decolonization are achieved and the dignity of the various cultural groups is respected.

Another criticism brought forward by Vithal and Skovsmose (1997) is that ethnomathematics focuses too much on connecting to the background of the student. They argued that background is not the only factor that affects student achievement. They also claimed that there can be some benefit from connecting with backgrounds but what is equally important is to consider the students' foregrounds.

Foreground is a perceived set of opportunities that the student believes emerge as possibilities for the future based on his or her social context (Skovsmose, 1994). Foreground affects disposition or intention to learn and impacts the choice to take ownership of learning. Vithal and Skovsmose (1997) have claimed that ethnomathematics must take foreground into consideration as another cultural aspect that influences mathematics learning, claiming "the students' perception of a subject is partly determined by their perceptions of their opportunities in society" (p. 148).

A somewhat related criticism is that ethnomathematics can focus too much on historical indigenous or traditional cultures and not the modern ways in those cultures. There is a tendency in North America to perceive indigenous cultures as people of the past (Rowlands & Carson, 2004). But cultures typically adapt and change with time and want to be seen as such. Unfortunately, if ethnomathematical approaches focus too much on the historical aspects of indigenous cultures and not on modern issues in those cultures, there is again the risk of making them seem inferior and less advanced. So a real challenge is to understand both the historical and the modern day contexts of the students and what role each plays in their mathematical achievement.

In my own context I know that bringing into the classroom only historical cultural artefacts of the Mi'kmaw community would not be enough to make students want to

learn mathematics. I am well aware that the culture of my students is today more about listening to hip-hop music and chatting on the Internet than it is about making baskets or learning to navigate the woods. Yet the history of the community has contributed in very real ways to the current socio-political state, and as such, a connection to the history can provide insight into modern day issues. Therefore, I see the value of including both historical and modern culture when searching for mathematical connections. As Orr, Paul, and Paul (2002) have described, the inclusion of all cultural practical knowledge, historical and current, is useful in the process of decolonizing education.

If the ethnomathematical approach is supposed to allow students to see that mathematical thinking is as much a part of their own culture as it is of anyone else's culture, then this implies a connection to both historical knowledge and modern day concerns. Exploring historical mathematical activity helps students to see the mathematical knowledge of their ancestors. Using that knowledge to explore current day issues is an avenue to providing new insights and potential resolutions to problems that have not been found using formal mathematical knowledge structures.

The notion of foreground described by Vithal and Skovsmose (2002) is also an important aspect of ethnomathematical work. Culture is not a thing of the past that is static and unchanged; it is also a thing of today and of the future; therefore the cultural context within which students are currently living must be explored. For example, exploring the use of statistics in government negotiations or the way mathematics can be used to explore the problem of an increasing community population with a limited land mass as a result of encroachment. This is a way of bringing cultural practical knowledge into the classroom to help students to see the role mathematics can play in their own

cultural contexts. It also helps students to see the potential value of mathematics for their future and the future of their communities. Thus, the criticism that ethnomathematics focuses too much on background may be an indication of an incorrect assumption about ethnomathematics. If ethnomathematics is about exploring connections between mathematics and culture, then present day culture is easily included.

Another criticism brought forth by Vithal and Skovsmose (1997) is that ethnomathematics does not question the power relations that maintain the hegemony of the status quo, favouring instead a critical mathematics education approach. This may well have been a legitimate criticism at the time, but more recent ethnomathematical work has begun to take a critical look at mathematics education and has paid particular attention to questions of power relations (cf. D'Ambrosio, 2006: Knijnik, 2002) as was seen previously in the discussion of the political nature of ethnomathematics.

It has been suggested that ethnomathematics tends to take too much of an oppositional stance (Barton, 1999; Rowlands & Carson, 2002; Rowlands & Carson, 2004; Vithal & Skovsmose, 1997). There is a sense that ethnomathematics demonizes formal mathematics and sets up a dichotomy between formal mathematics with ethnomathematics, seemingly forcing one to choose one or the other. While I disagree that such a dichotomy needs to exist, I argue that such an oppositional stance is warranted as it can open a dialogue that exposes some taken-for-granted assumptions.

This oppositional stance seems to have been a primary concern for Rowlands and Carson (2002, 2004); they expressed fears that formal mathematics would be cast out as colonialist and inherently oppressive. They argued that much of formal mathematics, regardless of its origin, has become privileged because of its pragmatic value. They

suggested, instead, a broadening of the definition of an educated person as one who understands multiple theories of knowledge, thus warranting the inclusion of the knowledge systems of traditional and indigenous cultures as well. They strongly objected to formal mathematics being labelled as "western" because by so doing, it tells children of colour that it does not belong to them (Rowlands & Carson, 2004).

The current state of mathematics education already indicates to children of all cultures of the world that this knowledge does not belong to them and removing the "western" label will not change that. I can concur with critics that it is not prudent to simply cast away formal mathematics, for much of it has been widely accepted because it has been seen as useful. However, it is also necessary to point out that its pragmatic value has been seen from a certain ideological perspective and that many ethnomathematicians may question this perspective.

D'Ambrosio (2006) has argued that ethnomathematics should not replace "good academic mathematics" (p. 31) but he also argued that the ultimate goal of education should be peace. He has suggested that second degree trinomials are beautiful mathematical instruments but they are also the instruments that allow artillerists the:

> ... capacity to shoot a deadly bomb from a cannon to reach a population of people, of human beings, flesh and bones, emotions and desires, and kill them, destroy their homes and temples, destroy trees and animals nearby, pollute any lake or river in the surroundings. (p. 66)

He was not suggesting the elimination of the second degree trinomial from the curriculum but rather the need to include frank and critical discussions about the uses of these instruments, both their beautiful and their devastating uses.

This characterisation of ethnomathematics moves it more toward a theoretical stance that demands critical reflexivity of mathematicians and mathematics educators. Barton (1999) has echoed this sentiment, suggesting that "it is important for us as ethnomathematicians not to demonise conventional mathematics—mathematicians should be our debating partners and protagonists, not alienated by our words into dismissal or silence" (p. 34). He argued that there should not be a dichotomy—an either/or stance—but that ethnomathematicians are still mathematicians who are "contributing to mathematics in a different way, finding a way to retain cultural integrity while maintaining a belief that such contributions will come to change how mathematics is viewed in the long term" (p. 35). Barton has suggested that there is evidence that demonstrates that "ethnomathematics is beginning to have an impact on conventional, traditional, 'Eurocentred' mathematics" (p. 35) and argued that "it is the open and creative use of the theoretical tool of ethnomathematics which will continue that process" (p. 35).

The preceding discussion shows how ethnomathematics has changed and adapted in light of the critiques, most of which came from within the ethnomathematical community itself. Ethnomathematics is emerging as a theoretical perspective very similar to critical mathematics education as described by Vithal and Skovsmose (1997).

Yet some hesitation lingers within the field of mathematics and mathematics education regarding the use of the term *ethnomathematics* itself. Vithal and Skovsmose (1997) suggested that "'Ethnomathematics' emerged as a term representing an oppositional stance. It has achieved that purpose. It has established an understanding of mathematics and mathematics education as culturally and socially negotiated. But the

concept 'ethnomathematics' is itself problematic" (p. 152). I myself have experienced opposition from scholars I respect when I have used the term ethnomathematics in scholarly conversations. Has the concept become so problematic that it is no longer useful?

I feel as though I am somewhat forced to answer my own question at this point and make a decision as to whether or not I will choose to call my own work ethnomathematical. The decision is quite difficult. I remember the first time I heard the word *ethnomathematics*; my immediate reaction was that the word felt somewhat offensive, conjuring up a connection to racist discourse. I feared that this approach risked trivializing indigenous knowledge and further marginalizing those who it was intended to help. I worried that this would mean more of the baskets, beadwork, and blankets solution in addressing the disengagement of Aboriginal children from mathematics. Despite all my reading and my obvious agreement with the perspectives of the ethnomathematicians whose work is outlined above, I still cannot shake this feeling.

My work fits well within this collected body of ethnomathematical work. The critical perspective taken by many of these authors is very similar to the perspective of the advocates of change in Aboriginal education outlined in the previous section. Educators must begin to privilege indigenous knowledge and support the notion that the rest of the world has much to learn from indigenous knowledge systems. The principles of ethnomathematics are essential to my research; . I am sometimes hesitant to use the term, as are many of my colleagues who are concerned with Aboriginal mathematics education (see Doolittle, 2006), and as a consequence, I often choose to describe my

work as developing culturally-based mathematics curricula and pedagogy which I consider to be critical mathematics education.

I feel that using this phrase avoids the negative feelings that arise from the use of the prefix *ethno*; although I respect and admire the work of the ethnomathematicians who have helped to open the doors to a critical perspective on mathematics education. Ethnomathematical work on a global level strengthens and supports the work in reforming Aboriginal education in North America and in particular, as it pertains to reforms in mathematics education for Aboriginal children.

This is not to say that I shall never use the word *ethnomathematics*, but rather to assert my belief that the work I describe here should not be hampered by the debate over whether it is or is not ethnomathematics. My goal is to focus on decolonizing mathematics education for Mi'kmaw students. While theoretical debates have merit about how such work shall be named, for this research project I must move past this debate to the business of transforming classroom practice and enabling transformation.

A Focus on Equity

In recent literature the call for equity in mathematics education appears to be growing and embraced by a wider audience. In 2009 the NCTM designated equity as a strategic focus for the year, sending out a call for research related to this important theme (National Council of Teachers of Mathematics, 2009). NCSM (2009), an affiliate organization that focuses on leadership in mathematics education, has also supported leadership in mathematics education with equity as their number one leadership principle. When both organizations held their annual conferences in Washington, DC in April, 2009, equity was a predominant theme in many of the talks and workshop presentations.

Typically the question of equity in mathematics education has been a discussion around what equity means. Although equity may be interpreted differently in different contexts, it typically is focused on addressing disparity among various groups. It is often focused on improving access to quality mathematics and improving the achievement of students who have historically been marginalized by mathematics. This research embraces a broader view of equity as presented by Gutiérrez (2007).

Gutiérrez (2007) has argued that equity should be defined along four dimensions: access, achievement, identity, and power. Access pertains to the availability of resources that enable students to participate in the learning, including "quality mathematics teachers, adequate technology and supplies in the classroom, a classroom environment that invites participation, reasonable class sizes, and supports for learning outside of class hours" (p. 2). She described achievement as test scores and participation in higher level mathematics courses, pursuing mathematics-based careers, and post-secondary programs. She argued that a great deal of research related to equity in mathematics has focused on these two aspects which she envisions as making up the dominant axis in her model for equity.

However, Gutiérrez (2007) has also claimed that the critical axis made up by notions of identity and power are equally important. She argued that many students have been marginalized by mathematics because they are asked to deny their identity in order to participate in the dominant view of mathematics. For Gutiérrez, "students should be able to become better persons in their own eyes, not just in the eyes of others" (p. 3). She pointed to the work of ethnomathematicians and those who promote culturally relevant mathematics as a source of identity within mathematics education. She described identity

through a window/mirror metaphor, claiming that "students need to have opportunities to see themselves in the curriculum (mirror) as well as have a view onto a broader world (window)" (p .3).

As in the argument related to ethnomathematics above, Gutiérrez (2007) has argued that attention to identity does not have a goal of replacing "traditional" mathematics with a pre-defined "culturally relevant mathematics," but rather to strike a balance between the number of windows and mirrors provided to any given student in his/her math career" (p. 3). However, she also argued that:

> ... even if students have access to quality mathematics, achieve a high standard of academic outcomes as defined by the status quo, and have opportunities to "be themselves and better themselves" while doing mathematics, it is not enough to call it equity if mathematics as a field and/or our relationships on this planet do not change. As such, a final piece of equity involves *Power*. The Power dimension takes up issues of social transformation at many levels. (p. 3)

The power dimension involves not only questioning who has power in the classroom in terms of who participates, who talks, and so on, but also as it pertains to using mathematics to question power relationships in the world and seeing mathematics as a human endeavour.

Gutiérrez (2007) has claimed that "all four dimensions are necessary if we are to have true equity" (p. 4) but has suggested that any given lesson may place a heavier focus on one axis or the other with balanced attention to the two axes being the goal. For Gutiérrez, "It is not enough to learn how to play the game; students must also be able to change the game. But, changing the game requires being able to play it well enough to be

taken seriously" (p. 4). This statement reminded me of the claims made by one of the participants in my masters' research (Lunney, 2001). Joe[4], a participant in the research, believed that Mi'kmaw children needed to know the mainstream knowledge in order to be able to secure a better future for their communities. He equated the need to learn mainstream knowledge to knowing the enemy and argued that Mi'kmaw people needed to know what they (meaning the federal government) know, along with the community knowledge. For Joe, this knowledge would make young Mi'kmaw people better prepared to enter into future negotiations (Lunney, 2001). This is the notion of knowing the game well enough to change it.

Gutiérrez (2007) cited several examples of noteworthy contexts that have attended to the four dimensions of equity with remarkable success for students and argues that more attention needs to be paid to such successful schools in such successful contexts. She claimed that the current focus on the achievement gap in the United States is short sighted in that it focuses on the problems but fails to offer solutions. By abstracting data from contexts, what is often overlooked is the complexity that interweaves numerous factors to create an environment that enables all children to succeed. This research attempts to highlight the various threads of this tapestry as it pertains to success in mathematics for Mi'kmaw students.

Examining Aboriginal Mathematics Research and Programs

Much of the preceding discussion has examined the theoretical basis and potential impact of an ethnomathematical and/or critical focus on mathematics education. In this section I focus specifically on work that is being done in Aboriginal communities primarily in North America, although I will also highlight some aspects of related work

[4] A pseudonym

being done in indigenous communities in other parts of the world. I feel that these initiatives connect more closely to my own work in that the contexts are somewhat similar. I first give an overview of the efforts to develop more culturally based mathematics programs in Aboriginal communities. I then focus in more detail on some specific initiatives that I feel have provided promising connections to my own work.

The argument for the inclusion of indigenous knowledge and worldview in mathematics education stems from the calls to transform Aboriginal education to make it more culturally based and therefore more likely to support Aboriginal students' learning. In agreement with the arguments of many ethnomathematicians, it is fairly well accepted among researchers in Aboriginal mathematics education that the culture of the mathematics classroom is frequently in conflict with the home and community culture of the students (Cajete, 1994; Lipka, 1994; Nelson-Barber & Estrin, 1995; Nicol et al., 2006; Yamamura et al., 2003). One of the key reasons for the cultural conflict is a distinct difference in worldview. Nelson-Barber and Estrin argued that a Eurocentric worldview embedded in mathematics curricula emphasises analysis out of context which they claimed is contrary to the indigenous worldview that emphasises "interrelationships, flux, observation, and evaluation in context" (p. 176).

An example of this difference in worldview comes from Pinxten (1997) who, in his explorations of geometric concepts in Navajo communities, pointed out what he saw as important distinctions between the Eurocentric worldview and the Navajo worldview. He suggested that the mainstream view of geometry is built on hierarchies, where part/whole distinctions are of central importance and the world is treated as a static entity. He claimed that the Navajo view of geometry does not contain hierarchies but rather has

three basic notions (movement, volumeness/planeness, and dimensions) that are all topological in character and tend to co-determine themselves. As well, the emphasis is not on part/whole distinctions but rather on processes, events, and fluxes and a view of the world as in a state of continuous change, thus, dynamic not static.

Much of the literature supports the argument that this occurrence of conflicting worldviews has led many Aboriginal students to either ignore the possibility of studying science or mathematics, or to struggle within these disciplines (Aikenhead, 2002; Ezeife, 2003; Secada et al., 2002). The vast cultural divide between home culture and school culture has been seen as one of the primary reasons for lack of school success and disengagement from higher level mathematics and science courses (Nicol et al., 2006; Restoule, 2000; Yamamura et al., 2003). This necessitates the transformation of the culture of mathematics classrooms so that they are more inclusive of Aboriginal worldviews.

Lipka (1994, 2002a) has recommended a process of cultural negotiation in which the choice is not either/or but both/and, resulting in the valuing of both the mainstream and the indigenous perspective.

> Cultural negotiation is a process that makes schools' hidden values and processes visible to community and school while making the community's knowledge, values, and processes visible to schooling. Schooling then becomes explicit and open to choices—choices that can only be responded to at the local community level as they concern issues of culture, language, and identity. Through an exploration of their own cultural strengths and their particular goals and visions

> for their children, community and school can construct a curriculum of the possible–creatively devising content and pedagogy. (Lipka, 1994, p.27)

As with the development of ethnomathematics, the call for transformation of mathematics for Aboriginal children has at times been viewed as a dichotomy. But the majority of the literature supports a model similar to Lipka's (1994) idea of cultural negotiation in which students are taught multiple perspectives, including their own cultural perspective and the mainstream perspective (Nelson-Barber & Estrin, 1995; Pinxten, 1997; Yamamura et al., 2003).

Aikenhead (2002) has argued that it is essential to acknowledge students' Aboriginal knowledge and language as assets not deficits. This is reminiscent of Rowlands and Carson's (2004) notion that an educated person is one who has multiple theories of knowledge, and it also supports D'Ambrosio's (2006) claim that the inclusion of new knowledge systems can be beneficial to all students.

As with all ethnomathematical work, one of the key challenges of incorporating indigenous knowledge in the mathematics curriculum is to not trivialize or further marginalize that knowledge (Doolittle, 2006; Lipka, 2002; Nelson-Barber & Estrin, 1995). Much of the work that has been done with respect to Aboriginal mathematics has been in the form of uncovering the mathematics embedded in cultures (cf. Ascher, 2002; Barta et al., 2001; Closs, 1986). Some of this work has used notions of mathematics similar to Bishop's (1991) descriptions of universal mathematical activities (counting, measuring, locating, designing, explaining, and playing) to uncover the mathematics embedded in the cultural knowledge systems. Some similar work is currently being done

in the Mi'kmaw communities where my own research takes place (see Lunney & Wagner, 2006a; Lunney & Wagner, 2006b; Wagner & Lunney, 2006).

This research project uses similar techniques to those that have been used by Lipka (1994) and his colleagues (Lipka et. al, 1998) in working with Aboriginal communities in Alaska to transform mathematics curriculum. Such research deepens the understanding of the embedded mathematical knowledge that is part of the culture; however, to transform curriculum in an authentic way, this knowledge must be incorporated in a substantive way. This knowledge must be a basis for curriculum development and not simply adapted to fit the already existing structure of the formal mathematics curriculum. In forthcoming parts of this section some projects that have attempted to do this are highlighted, drawing from the indigenous knowledge base of the communities to develop mathematics programs.

While the add-on initiatives of baskets, beadwork, and blankets still seem to be evident (cf. Secada et al., 2002) some initiatives are producing substantive change. Lipka (2002a) has suggested that there are some exemplary programs happening in Hawaii, Arizona, and in regions of the Navajo Nation in the United States. He claims that these programs share qualities of being community controlled, using the indigenous culture and language, and demonstrating significant and measurable gains in academic achievement. Several examples of truly substantive programs are happening in Canada as well, some of which are discussed here.

Yamamura et al. (2003) have described a program initiative of the Nunavut government that is attempting to develop a framework for mathematics based on Inuit Quajimajatuqangit (IQ) philosophy. This "represents all aspects of the Inuit that makes

them a unique people, including culture, language, values, beliefs, relationships, governance, etc." (p. 2). They have included elders, parents, and community members in this curriculum development initiative.

The program involves taking the learning outside the classroom with "on the land" trips where students are engaged in activities such as building an *iglu*, which they connect with aspects of geometry, or ice fishing, in which they discuss statistical analysis and probability as they pertain to issues of conservation. Yamamura et al. (2003) suggested that the outings on the land allow students to be in an environment where they feel more comfortable and familiar. They stated that the students "are more receptive and the student-teacher-elder-parental relationships become closely aligned" (p. 2). The claim is that students often gain more confidence in this setting because they can contribute their own knowledge of the environment or activity. Even when in the classroom, the cultural focus remains, supported with the inclusion of elders who share stories and help students connect their mathematics learning with aspects of traditional life.

Yamamura et al. (2003) cautioned that there are challenges to this approach including a shortage of trained Inuit speakers for teaching in the high school. This is a significant problem but efforts are being made to train more teachers. They also said that "the new approach will also require support and resources for applying teaching to outdoor activities and for developing strategies for a more holistic approach to mathematics" (p. 3). This project was seen as a step in Nunavut's efforts to make the education system more supportive of an Inuit perspective on learning.

The Akwasasne Science and Mathematics Pilot Project (LaFrance, 2000; Restoule, 2000), which is based on Mohawk perspectives of mathematics and science, is

another program that shows great promise. The Mohawk Thanksgiving address was used as a basis for the curriculum because it draws emphasis to the interconnectedness of all creation. Mohawk elders and community members have worked with teachers and education staff to develop the curriculum for grades seven to nine. Units were developed based on four overarching goals: to learn to use symbols; to have a strong sense of local place; to learn how to live in two worlds; and, to learn how to live with contradictions (Henderson, 1996). Mohawk knowledge plays a central role in the curriculum rather than being an add-on or an after thought (Restoule, 2000).

Efforts to enhance mathematics and science education for Aboriginal students are also being made by the Native Access to Engineering Program (NAEP) based at Concordia University in Montreal. They are producing resource materials for schools that are focused on Aboriginal mathematics, science and technology. They also maintain a website that has numerous activities, profiles of Aboriginal scientists, and a wealth of resources. NAEP maintains an electronic mailing list for a network of teachers to disseminate information to support culturally based mathematics, science and technology teaching. Additionally, it hosts the bi-annual Dream Catching conference that is designed to promote the incorporation of Aboriginal perspectives into the teaching of mathematics, science, and technology in all levels of education.

Recently, a research initiative has begun in British Columbia that has a goal to explore how to better meet the needs of Aboriginal students in learning mathematics (Nicol et al., 2006). This is a response to what they see as a low participation rate of Aboriginal students in mathematics courses that lead to post-secondary studies. It is a partnership with the Haida Gwaii Nation and School District, Nisga'a Nation and School

District, Vancouver School Board, and the University of British Columbia. They are working with the communities to explore:

> ... ways of teaching that are culturally responsive practices that honour student thinking and emotions, respect and build upon community values and views, and prepare students to be successful with mathematics in a range of contexts that open possibilities for future study or careers. (Nicol et al., 2006, p.1)

They see culturally responsive pedagogy as connecting students' thinking and habits of mind and emotions with community knowledge, culture, and values, and with mathematics. The first phase of their project involves meeting with teachers, elders and community members to discuss ways to enhance opportunities for students and to better understand the experience of these students. It is also an opportunity to "Encourage, enhance, recognize and validate the use of mathematics in traditional and contemporary practices" (p.1) through conversations with elders. In the second phase of the research they will work with teachers in conjunction with the elders and community members to develop, implement, and evaluate units that are culturally responsive.

There seems to be an increasing interest in the issues of mathematics education for Aboriginal students. In May of 2005 the Canadian Mathematics Society hosted a working group with a special focus on Mathematics Education in the Aboriginal Community as part of their national forum on mathematics education. This group met to discuss some of the challenges and issues in supporting improving mathematics education for Aboriginal children in Canada and discussed a number of emerging programs from across the country that seem to be having success in addition to those described above (Poirier & Neel, 2005).

In September 2006, a group of concerned mathematics and science educators from across Canada and parts of the United States came together during the Canadian Aboriginal Science and Technology Society (CASTS) Conference to again discuss the issues surrounding the disengagement of Aboriginal youth from higher levels of study in mathematics and science. This group has formed a network of educators who plan to continue to work together to share ideas and support one other in new initiatives. It is hoped that through such discussions that the momentum will continue to build and more work will be done to address these issues.

Perhaps the strategy with the most promise is an Alaskan initiative that has been ongoing for over 20 years (Lipka, 1994: Lipka & Adams, 2004; Lipka et al., 1998, 2001) that has brought together Yup'ik teachers, elders and university faculty as a research group to develop culturally based mathematics. The project originally began with the Ciulistet group which was a voluntary group of elders and teachers, many of whom traveled significant distances for meetings, which Lipka has claimed was a testament to their desire to improve education for Yup'ik children. Although this group is no longer involved in the research, the work of transforming mathematics education in these Yup'ik communities has continued.

The university researchers have worked collaboratively with community members, relying heavily on the elders, to deepen their understanding of Yup'ik mathematical and scientific knowledge. The group chose the research focus and, the knowledge they gathered allowed them to develop units that could be implemented in school. The process of translating this indigenous knowledge into formal curriculum was difficult and required extensive support from the elders. The group developed units and

took them to the elders who then debated the details and gave feedback. The group then recreated the units and brought them back to the elders. The process began again until a satisfactory product was produced. Lipka (1994) stated that:

> The premise behind developing a Yup'ik mathematics is threefold: (1) to show students that mathematics is socially constructed; (2) to engage students in a process of constructing a system of mathematics based on their cultural knowledge; and (3) to connect students' knowledge of "their mathematics" through comparisons and bridges to other Aboriginal and Western systems. (p. 25)

This threefold approach is central to Lipka's "both/and" notion of transforming curriculum.

One of the many units developed is about building a fish rack, used to teach about geometric concepts of area and perimeter. Quasi-experimental assessments of the implementation of this unit have shown that the use of this "culturally based, inquiry-oriented math curriculum, can improve performance differences in mathematics for rural Alaska (Yup'ik Eskimo) students" (Lipka, 2004, p. 28). I wonder whether it is the units alone that have contributed to the success for these students or if it is the combination of these units along with the new understandings the teachers and elders have developed in working together has brought about this transformation.

Barnhardt et al. (2000) have taken similar notice of the improvements in mathematics education for Aboriginal students in Alaska, claiming that "building an education system with a strong foundation in the local culture appears to produce positive effects in all indicators of school success, including dropout rates, college attendance,

parent involvement, grade-point averages and standardized achievement test scores" (p. 4). Much can be learned from the experience and longevity of the research coming from Alaska.

Although the substantive work still exists only in these limited pockets, the success of these initiatives reinforces the argument that such community-based transformative work should be done in other regions. This research project is a first step in developing a culturally-based curriculum.

Some Words about Language

Another promising approach to deepening understanding of mathematics from an indigenous cultural perspective has been demonstrated by Denny (1981) who used a "learning from language" approach. Because direct translation of mathematics curriculum from English to Inuktitut proved to be very difficult—as is the case with most Aboriginal languages in North America which tend to be verb-based rather than noun-based—he chose to work with a group of elders to explore mathematical words in the Inuktitut language. They used these concepts to develop the curriculum and associated mathematics activities.

Barton (2008) also pointed to the value in understanding the connection between mathematics and language and claimed that this connection is critical for supporting indigenous students. He has claimed that:

> A proper understanding of the link between language and mathematics may be the key to finally throwing off the shadow of imperialism and colonialisation that continues to haunt education for indigenous groups in a modern world of international languages and global curricula. (p. 9)

This insight emerged as a result of his work with Maori communities in New Zealand. He described some of the challenges he faced when attempting to work with Maori elders to translate mathematics terms into Maori, and also noted that translating the nouns of mathematics into a verb-based Maori language was incredibly complex and challenging.

Barton (2008), like other ethnomathematicians, has expanded his idea of mathematics, preferring to think of it as "a system for dealing with quantitative, relational, or spatial aspects of human experience" (p. 10) or a QRS-system. He saw this as a broader view of mathematics and referred to the more formal mathematics taught in school as "near-universal, conventional mathematics" (p. 10) or a NUC-system. He argued that:

> If mathematics arises from language, then we must consider mathematics in the same way we consider language. Different concepts are expressed in different languages, and some concepts are extremely difficult, some say impossible to translate between languages. The implication is that different quantitative, relational, and spatial concepts may also not be easily transformed into each other. (p. 69)

Given that different languages afford speakers different ways of talking about a given concept, it follows that mathematical understandings are also constructed in different ways consistent with the language being used. As Barton (2008) argued:

> The evidence from language points to the conclusion that mathematics arises after, not before, human activity. The development of mathematical language is consistent with the idea that mathematical concepts, objects, and relationships

arise through language, and within particular socio-cultural environments, in response to human thinking about quantity, relationships, and space. (p. 88)

Thus mathematical reasoning and understanding is tied intricately with language and different language constructions generate different ways of thinking about mathematics.

The struggles that Barton faced in translating mathematical terms, often nouns or dense noun clauses, into the verb-based Maori language are similar to the struggles for Mi'kmaw communities who also speak a verb-based language. This provides the foundation for chapter 5, in which I highlight the significance of language for Mi'kmaw students.

Concluding Thoughts about Relevant Scholarship

Much of the reviewed work has proven to be informative, raising useful questions about the nature of this type of work and providing insights into some of the potential challenges. It has also provided avenues of investigation worthy of further consideration as they pertain to the development of methodology.

The research in Aboriginal education, mathematics education, and ethnomathematics supports this research to decolonize mathematics education through focusing on Mi'kmaw cultural knowledge as a bridge to other forms of mathematical knowledge.

This research will no doubt continue to be informed by the described areas of research, which are rapidly growing, and will become a contributing voice to these fields as well. In the next chapter I describe the methodology and method of this research project. I introduce some new literature in future sections in response to things that emerged from my findings. For example, in chapter 7 it becomes important to cite some

literature that critiques the over-generalized use of native learning styles research that was common place in the past 25 to 30 years.

CHAPTER 3: METHODOLOGY

A significant tension for me in this project arose from the need to choose a research methodology that would be respectful of the community context yet still accepted within the academy. As someone who is interested in decolonizing education for Mi'kmaw students, who believes in the inherent right of self-determination for Mi'kmaw people, and who works toward transformation of educational practices, I had concerns about how I would respectfully research the concerns I have presented. Research in the Mi'kmaw community has often brought with it many detriments and very few benefits.

For many Aboriginal people, as Smith (1999) states, research has been intimately connected with colonization and imperialism:

> From the vantage point of the colonized, ... the term 'research' is inextricably linked to European imperialism and colonialism. The word itself, 'research', is probably one of the dirtiest words in the indigenous world's vocabulary. When mentioned in many indigenous contexts, it stirs up silence, it conjures up bad memories, it raises a smile that is knowing and distrustful. (p. 1)

Richard is a friend, colleague, and a member of the Mi'kmaw Nation and he knows these feelings as cited by Smith. He often asked me during this process how my "research" was going, regularly using his fingers to indicate the quotation marks around the word, speaking in a tone that dripped with cynicism and distrust. He was not distrustful of me; in fact, he was one of my most supportive allies in this work. Rather, he was distrustful of the institution that calls the work I do "research." He told me that he did not intend to belittle my work but wanted simply to remind me that he does not want to be studied. He

was willing to talk *with* me and share ideas, to work together to find solutions to problems but he is very distrustful of the kinds of research that he has seen being done *to* and *on* his community and his people. His words point to the damaging effects of positivistic research that has been conducted in many indigenous communities. This research has often caused more harm than good and thus, any attempts to conduct research in Aboriginal communities are often met with resistance and scepticism, and perhaps rightfully so.

The academy expects one to choose a "research camp" with a methodology that has a well-studied history within the research community and gives the work a philosophical framework which helps to guide the researcher through "tried and true" research methods. This is problematic because these camps have been formed and justified from an epistemological base that is fundamentally rooted in Eurocentric thought. Furthermore, perhaps because these procedures are intended to be used in any context, they lean toward generalization and ignore the subtleties of the local context.

The institutional pressure to choose a paradigm has forced many indigenous researchers to attempt to bring indigenous values to traditional research paradigms so that their work will be accepted (Wilson, 2003). Yet, such pasting of indigenous perspectives onto Eurocentric paradigms has not been proven effective in the decolonization of these paradigms and has not been effective in giving voice to the indigenous community (Bishop, 2005; Denzin, 2005; Smith, 1999). These practices, despite best intentions, through their demands for validity and generalisability have essentialised the indigenous other. Indigenous research is "a highly political activity" (Smith, 1999, p. 140) because it seeks to negotiate and transform institutional practices and research frameworks in

addition to developing a research programme. This is often construed as a "threatening activity" (Smith, 1999, p. 140) causing the research community to dismiss frequently such work "as 'not rigorous,' 'not robust,' 'not real,' 'not theorized,' 'not valid,' 'not reliable'" (Smith, 1999, p. 140). Smith has claimed that this institutionalized dismissal presents real challenges for indigenous research:

> Sound conceptual understandings can falter when the research design is considered flawed. While researchers are trained to conform to the models provided for them, indigenous researchers have to meet these criteria as well as indigenous criteria which can judge research 'not useful', 'not indigenous', 'not friendly', 'not just'. Reconciling such views can be difficult. The indigenous agenda challenges indigenous researchers to work across these boundaries. It is a challenge which provides focus and direction which helps in thinking through the complexities of indigenous research. (Smith, 1999, p. 140)

What has emerged as a response to the challenge is a new paradigm of decolonizing research or indigenist research. Decolonizing and indigenist methodologies are seen as ways to "research back to power" (Smith, 2005, p. 90). The indigenist approach to research "is formed around the three principles of resistance, political integrity, and privileging indigenous voices" (Smith, 2005, p. 89). There is a "purposeful agenda for transforming the institution of research, the deep underlying structures and taken-for-granted ways of organizing, conducting, and disseminating research and knowledge" (p.88). There is an underlying "commitment to moral praxis, to issues of self-determination, empowerment, healing, love, community solidarity, respect for the earth, and respect for elders" (Denzin, 2005, p. 943). Indigenist research paradigms create

space to privilege indigenous knowledge (Denzin, 2005; Smith, 2005) and acknowledge that knowledge production must happen in a relational context (Denzin, 2005).

Indigenous research methodologies manifest themselves through a variety of methods that draw on indigenous epistemologies and existing community practices. I do not see this emerging paradigm as a new research camp where I can situate myself, but rather I see it as a way to legitimize my choice to select a methodology that arose from the context of the community. My research camp is situated in the Mi'kmaw communities in which I conduct my research from whence my methodology—*mawikinutimatimk*—has emerged.

Mawikinutimatimk

Despite my concerns about choosing a research camp, I recognize value in naming my methodology so that I can reflect on it in relation to established practices and also, in relation to my own research intentions. However, I believe that it is more important for ethical research conversations to have a name (methodology) that is meaningful in the context of the research rather than in the context of the academy. Some Maori researchers have taken this view too; they refer to their methodology as Kaupapa Maori (Maori-centred) research and it has been said that "This form of naming is about bringing to the centre and privileging indigenous values, attitudes and practices rather than disguising them within Westernized labels such as 'collaborative research'" (Smith, 1999, p. 125). It was this type of naming that I sought within the Mi'kmaw community. I hoped that in choosing a methodology from within the community it would help to mitigate some of the negative effects of traditional colonizing research.

Before and during the beginning of my doctoral studies I sought the advice of many elders in the community as I searched for a word to describe a culturally appropriate methodology. I wanted a word that would be used to describe the activity of people coming together to discuss an issue or solve a problem. During a conversation I had with the Grand Chief about my work, he suggested that I might want to use the word *mawikinutimatimk* which means "coming together to learn together." I checked with other community members who confirmed that this would be an appropriate word to describe the approach to research that I was seeking. However, each person who confirmed its appropriateness said "you should also talk to ___ about this," not always suggesting the same people, but encouraging me to consult other elders and language experts in the community—which I did.

Mawikinutimatimk literally means "coming together to learn together," yet this simple translation cannot truly capture its nuance. There are values embedded in the word that conjure a sense of equity and mutual respect that are not as embedded in the phrase "learning together." It implies that everyone comes to the table with gifts and talents to share—everyone has something that they can learn. It conjures an image of a community of learners working in circle where all members are equally important and necessary. Each participant who joins in the circle has something unique to contribute.

I have grappled with the decision to use the word in print, fearing that once it is written, others may choose to cite my work (and this word which is not mine) and co-opt this methodology for their own purposes. This would be wrong. I have no ownership over this word; it belongs to the Mi'kmaw people, to the Mi'kmaw language. I am not the source for the word and should not be given credit for it. Furthermore, I have been given

the gift of this word from the community. I have taken the time to learn about it and have asked permission to use it. I have checked repeatedly with various community elders and respected speakers of the language to ensure that I am using it properly and interpreting it correctly. My use of this word has involved a journey of learning for me; thus, it would not be appropriate to use the word in another context. Rather, what is appropriate is for others to take a similar journey within their own context to find the words, processes, ideas that can be used to guide their work within that context. Some Mi'kmaw scholars or others working with Mi'kmaw communities may choose to practise *mawikinutimatimk* too, yet even still, I think there is a process of discovery involved in determining whether or not this will serve them well for their context. There are other ways of learning in Mi'kmaw culture too.

Mawikinutimatimk is a methodology that is enacted in praxis; thus, it provides not only a theoretical framework but also a guiding process. Smith (1999) has claimed that for much indigenous research, what is most important—even more important than outcomes—is the process. "Processes are expected to be respectful, to enable people, to heal and to educate. They are expected to lead one small step further towards self-determination" (p. 128). It was my hope that *mawikinutimatimk* would guide our research groups through such a process.

Some Thoughts on what Mawikinutimatimk is not

When I describe *mawikinutimatimk* to colleagues within the academic community, these colleagues often want to put an academic label on this methodology. It has been suggested to me that *mawikinutimatimk* is participatory action research. It has also been suggested to me that it could be narrative inquiry. While *mawikinutimatimk*

may share similarities with both of these methodologies and perhaps others, it is important to see that it is also different from these methodologies.

Both narrative inquiry (Benham, 2007) and participatory action research (Kemmis & McTaggart, 2005) have been used to give voice to marginalized peoples and to promote transformation of educational practices. Glimmers of each may be evident to the reader of this research, in particular the emergence of themes from the stories of participants may seem consistent with narrative inquiry, yet I would argue that *mawikinutimatimk* possesses a certain spiritual quality that is not necessarily inherent in these other practices. With *mawikinutimatimk* there is an embedded understanding that the importance of relationships and the interconnectedness of participants must be honoured. This is a key Mi'kmaw value that can only emerge when the methodology is connected to the community context. To brand *mawikinutimatimk* with an accepted academic label would be to once again privilege mainstream knowledge over indigenous knowledge, thus denying the opportunity for a truly decolonized approach to this research.

Method

One of the things that I found most beneficial in my own teaching career was the opportunity to ask questions and seek clarity when issues arose in my classroom that seemed to come as a result of a cultural conflict. Those conversations arose informally as I gained insight into the culture and felt that my questions were welcomed by colleagues, community members, and elders. I felt privileged that I was able to engage in these kinds of conversations with community members. My experiences learning from community members led me to believe that establishing a structure that would create space for other

teachers to investigate tensions in similar ways, would enable everyone involved to enter into a discussion that could prove to be generative as we explored the issues at hand. Thus, I chose to use small group discussion sessions involving teachers, elders, and other community experts as a key part of this research initiative.

These more formal sessions were designed to create a space where teachers could begin to explore the challenges associated with teaching and learning mathematics and negotiate their own place in bridging Aboriginal and mainstream mathematics. All these teachers, despite their various cultural backgrounds, were educated in a Eurocentric system and learned mainstream concepts of mathematics. As such, I anticipated that most, if not all, of the teachers involved would find it difficult to think of mathematics in different ways. These sessions were designed to help these teachers think more deeply about their own conceptions of mathematics and to deconstruct them in a supportive environment.

The Two School Contexts

The two schools chosen to be part of this project were selected based on several factors. I had established relationships with both staffs. Both were keen to participate and geographic proximity made it possible to have more frequent meetings.

Wutank[5] school is a Pre-K to 12 school located in Cape Breton, Nova Scotia. During the time of this project the elementary was housed in one building and the junior/senior high in another. The two schools have now merged to become one school in a new building. While the project was available to everyone at Wutank, only the elementary staff chose to participate. Some of the teachers from the junior/senior high

[5] The names of the communities and all of the participants are pseudonyms.

had expressed interest in participating but scheduling issues, and perhaps the fact that sessions were held in the elementary building, seemed to prevent their participation.

This elementary school has 14 teachers, a principal, a counsellor and numerous support staff. Eight of the teachers are non-Mi'kmaq, of whom only two are fairly new to the community. The others have been at the school anywhere from 7 to 25 or more years. The remaining teachers, principal, counsellor, and all support staff are Mi'kmaq. All of the Mi'kmaw staff members live in the community with the exception of the principal. She lives in another Mi'kmaw community, although her mother grew up in Wutank. Almost all the Mi'kmaw staff members are also Mi'kmaw speakers. Some of the support staff were enrolled in a part-time Bachelor of Education program and spent time doing their field experience in this school during the time of this project. There are approximately 170 students enrolled in the elementary school. Almost all the children from the community attend the community school.

Eleven of the 23 elementary staff participated in the sessions which included eight of the teachers (six Mi'kmaw teachers and two non-Mi'kmaw teachers), the principal, and two members of the support staff. Prior to our first session I had spoken with the principal who had talked with the staff about who might participate. She had encouraged most of the teaching staff to take part, feeling it would be beneficial both for the research itself and for their own teaching. She also encouraged the support staff to participate, in particular those who enrolled in a Bachelor of Education program.

Some teachers, on the advice of the principal, chose not to attend the sessions as they were already busy with other projects. One teacher for example, was quite heavily involved with the reading recovery program and the principal felt it would be too much

for her to take on this project as well. The resource team was also quite busy with individual program planning when we began our sessions so were also told by the principal that they did not need to attend. However, two of the three resource teachers eventually became regular participants in our sessions.

Phillips Lake is a Primary to Grade 6 school with less than 60 students. In this community, some students attend the community school while others choose to attend one of several other local public elementary schools. There are five classroom teachers, a physical education teacher, a Mi'kmaq language teacher, one student support worker, a principal and a community liaison worker. All the classroom teachers, the physical education teacher, and the principal are non-Mi'kmaq and live outside of the community. The remaining three staff members live in the community. The Director of Education is a community member and her office is located in the school.

The principal and each of the five classroom teachers attended most of the sessions. Occasionally the teachers would take turns, coming in and out of sessions as they also ran an after-school program. The community liaison worker attended the first session and I had hoped that she would attend more often; however her schedule and family commitments often did not permit her to do so. Often when I would go to the school during the day I would spend time talking with her individually. I also spent some time talking with the student support worker and Mi'kmaw language teacher, individually, but they too had family commitments that prevented them from staying after school for these sessions. The majority of the classroom teachers were young and fairly new to the profession. Many of them were quite accustomed to staying late at the school to prepare for the next day.

The Sessions

Ten after-school sessions were held in Phillips Lake and 12 in Wutank. I describe in detail in chapter 4 the journey of these sessions as we worked together to investigate our common concerns. Each session was held after-school at an agreed-upon time. I had proposed a schedule of meetings for both schools but these changed to meet the needs of the school. Typically, after each session we would look at the calendar to determine a date for the next session. I would often send reminders via email to the school principals a few days in advance of the session.

Our conversations were often stimulated by inviting participants to simply notice and reflect on the tensions and challenges with mathematics for their students and share their thoughts with the group. I would often begin by summarizing our conversation from the previous sessions and then I would ask participants to talk about what they had noticed since last time or what they would like to share this time. Occasionally participants would come with a question or concern they wanted to talk. More detail on the flow and development of the conversations is given in chapter 4. Each session was recorded using a small digital voice recorder placed in the centre of the table.

In an effort to create a sense of community and to respect the time and efforts of the participants, I arrived at each session with food. This was often fruit and vegetable trays that I picked up on my way to school that day. I felt this was an appropriate gesture to provide an after-school snack for everyone and it seemed to be well-received. Often on the tapes of the sessions we can hear crunching and then comments made about how the crunching will sound on the recordings, followed by laughter.

In addition to our conversations, I also frequently spent the day at each school and was often invited to work with teachers in their classrooms co-planning and co-teaching a lesson, or modelling a lesson. This was arranged in conjunction with the participants. In Phillips Lake, the staff would often email me a schedule of when it would be Math time in each class. In Wutank, the staff occasionally made requests for some specific support at a previous session but more often, requests were made once I arrived at the school for the day. For example, one day I arrived and was asked by the principal to spend the day in the Resource room working on math support. Classroom sessions were not recorded but field notes were kept and experiences from the classroom sessions were often discussed during our after-school sessions.

Figure 1 is a chart of the timeline with a brief description of our conversations on each day. Each session is given a code to identify the community and the number of the session. These codes are used to reference the transcripts included in the upcoming chapters. After each transcript, the session code appears in brackets to indicate when and where the transcript was recorded.

Date	Session	Comments
11/10/07	W0	Information session. After school meeting – explained research
16/10/07	W1	Conversations: Context for research; valuing personal, cultural, and community connections; hands-on learning; language differences For shape; use more Mi'kmaq; one word in Mi'kmaq and they get it; learning from games (cribbage, darts); specific content (fractions, decimals, shape, measurement); progression of concepts; supporting children with special needs; need to connect with elders / knowledgeable community members.
20/11/07	W2	Conversations: supporting struggling students; understanding division as sharing, working backwards (whole to parts),using meaningful language; personal connections; build from student strengths in shape and space; numbers in context; hands-on learning; personal and community connections;

		playing games (cards); grouping as a theme throughout operations work; learning strategies (mastery of baskets); importance of time to learn; language confusions in English; progression of concepts; sharing Mi'kmaw words, and comfort and softness of language.
21/11/07	PL0	Information Session After school meeting – explained research
27/11/07	W	No session. Worked with Grade 5 class on division.
6/12/07	PL1	Classes: primary - learning to add with counters and addition mats; 4/5 (prep) general discussion. Conversations: Context for research; challenges in math learning; using language for understanding; using concrete materials; artificially imposed pressures to use symbols; fact learning & mental math; external pressures for quick recall; need for visual representations of facts; open activities & meaningful connections.
12/12/07	W	Snow day
12/01/08	PL2	Classes: Principal – goals for group; 6 – fractions. Conversations: changes since last time; language: using more verbs and changing discourse patterns, improvement seen in 4/5; using more concrete materials; debrief grade 6 lesson: language was used for understanding; learning centres for differentiation, challenges: lack of strong community-school connections and cultural practical knowledge (CPK).
22/01/08	W3	Conversations: big ideas to this point; we can learn from having a deeper understanding of Mi'kmaq; need to create videos of elders and others sharing ideas around language and ethnomathematical connections; these conversations are helpful to teachers who want to learn/ understand more.
07/02/08	PL	Death in my family; had to cancel
11/02/08	PL	Snow day – cancelled
12/02/08	W4	Classes: Resource: supports for struggling students, shared activities. Conversations: examined MCC to get ideas for Mi'kmaw cultural contexts; SMYM; challenge of human resources; games; visual spatial learning strengths; assessing while doing; learning by observing; one Mi'kmaw word; words and absence of words; speak English / think Mi'kmaq; cultural bias of assessments for Mi'kmaw thinkers; need Mi'kmaw speaking TAs.
19/02/08	W5	Classes: Resource: supports for struggling students – amazing progress. Conversations: Mi'kmaq / English grammar differences e.g. conjugating number in different contexts; is there a word for middle; build on visual spatial learning strengths and funds of knowledge; Mi'kmaw words to describe numbers; dividing it into three; need to ask more elders for help.

21/02/08	PL3	Classes: 4/5 – Finding the average with candies; P/1 – measurement activity Batteries died, no recording. Conversations: Debrief of classes; what we can learn from W's experiences; challenges of lack of CPK. On the way home in the car I began to develop a vision of the model.
18/03/08	W6	Conversations: value differences; common sense not math; estimation not exactness; enough not greed; spatial quantities in context of need; numbers for play; thinking Natively; sharing; self-image shaped by media / others.
19/03/08	PL	Cancelled. Went to school but they had gone swimming and principal was at a meeting (they forgot I was coming)
31/03/08	SMYM	Not part of formal research process but was informative to the research. Complexities of number; Number used in play; mastery learning (baskets); cultural connections and ideas similar to MCC resources.
03/04/08	PL4	Classes: P/1 – shapes in Mi'kmaq; 4/5– wampum belts patterns for SMYM; 6 – SMYM, 3 and a thumb. Conversations: MCC resources; four emerging concepts; valuing and reclaiming language; challenging in a community with few speakers; fears of racism, negative attitudes, and low expectations when students move to public school for 7-12; learning centers, shared examples and agreed to all bring ideas for next time; debrief of classes – good engagement when personally / community connected.
08/04/08	W	Worked in classes only – *Show Me Your Math* projects.
14/04/08	PL	Worked in classes only – *Show Me Your Math* projects.
23/04/08	W7	Classes: 3 prisms and pyramids lesson. Conversation: what is authentic Mi'kmaw culture and what has been adopted from other native cultures; the experience at Manitou college; debrief of lesson with attention to use of verbs and motion; playing cards especially crib; confusion in language around words like length, width, depth, height; the importance of connecting learning with culture – "what if we could plan a whole year?"
24/04/08	PL5	Staff goals creating meaningful learning centers, Smart Board support.
01/05/08	PL6	Collaboratively planned learning centers for the 4/5/6 probability unit.
07/05/08	W8	Conversations: Learning in context; speak and think Mi'kmaq; shared understandings tied to Mi'kmaw language and values; frustration with assimilationist practices; need a strong foundation in Mi'kmaw language and values – worldview; dual society; we're on the right track.
08/05/08	PL7	Classes: 4/5/6 collaborative learning center – probability. Conversations: Debrief of 4/5/6 activity; began planning family mathematics night

22/05/08	PL8	Planned activities and developed resources for family mathematics night
28/05/08	W9	Planning for next year with teachers. Conversations: frustrations about mental math facts, recall difficulties; complexities of so-called basic facts connected to complexities of Mi'kmaw number; strategies for fact learning.
29/05/08	W10	Presentation of findings to date for entire Wutank Elementary staff and Principal from Phillips Lake school (not recorded); positive response.
03/06/08	W11	Classes: 6 multiplication and division – mental math strategies and games. Conversations: model is accurate; need to go deeper next year; go write!
04/06/08	PL9	Family Math night in Phillips Lake (not recorded)

***Figure 1*: Timeline of sessions**

Some Thoughts on my Complex Role in the Group

My own role in each of these *mawikinutimatimk* sessions was somewhat complex and something I needed to carefully monitor and negotiate my activities. I came into this group in many different capacities. I had been a teacher in one of these schools, a mathematics leader and professional development provider for both of these schools, and now a researcher associated with the university. Each of these identities provided me with various privileges that brought about the risk that other members might look to me for approval or to provide answers despite my best intentions for everyone in the group to be equal. This proved to be more of a challenge in one school than the other as will be described in more detail in chapter 4. In this section I share some of the steps I took to mitigate potential challenges arising from my positioning in the groups.

As I have stated in chapter 1, this dissertation represents my journey: a journey of discovery of a curious teacher. In many ways, throughout these sessions, I continued to see myself as a teacher with many questions that arose from my years of experience and a great curiosity about how to improve my own teaching. While I raised some of my own

questions, there were times when this curious teacher in me needed to take a back seat in our sessions so that I did not dominate the conversation with my own ponderings. I was careful to allow the other participants involved to raise their own issues, share their own observations and wonderings, and ask their own questions. I was able to draw on my own experiences and share some of my own stories of teaching when it was appropriate to do so, yet I tried to be careful to limit my own stories.

I also came to this group as "the math expert" after having conducted numerous in-services over the past several years and having been a high school math teacher in one of these schools and a math leader for all of the MK schools. My knowledge of mathematics curriculum and pedagogy enabled me to provide clarity of topics and strategies that are common to school-based mathematics, yet much of my mathematical knowledge is just that—school-based.

It was important to discuss openly the limitations of the provincial mathematics curriculum and to be clear about our need to seek an alternative that privileges community knowledge. My concern was that some teachers, feeling external curriculum pressures, may look to me to provide solutions from "outside experts" who focus primarily on mainstream mathematics. This pressure to conform to the expectations of external pressure was much more evident in Phillips Lake; I describe this fully in chapter 4. While I agree that some scholars of mathematics education have worthy suggestions with respect to pedagogy, our goal in this group was to focus on the knowledge within the community that can be helpful in transforming the teaching of mathematics. Turning our attention to indigenous knowledge and trusting in it is a key challenge in decolonizing Mi'kmaw education.

I also came to the group with the privilege that comes from being a member of the dominant culture and from my association with the university. It has been my experience in having done research with some community members that they often want to give me what I am looking for. Frequently they will ask questions such as "Is this what you want?" which I feel stems from a generous desire to support my work and help me to be successful with my research (Lunney & Wagner, 2006b). While I feel honoured that my participants want to make sure they are addressing my needs, the emphasis of this research was on addressing the needs that emerged from the group discussions and the classroom situations. Open and honest discussions about the purpose of our work helped to mitigate the potential problems in this regard. It was important for the group to see that it was not about getting what I want, but rather about focusing on what we all perceived as important. In chapter 4 I describe some of the differences between the two schools in this regard.

Ultimately, establishing respectful relationships in these groups was essential in ensuring their success. In the years leading up to this research project, I had been engaged in the development of productive and sustained relationships with staff members from both schools. This pre-existing relationship, along with my continued effort to mitigate any potential inequities, was vital to honour the relational nature of such collaborative knowledge creation (Denzin, 2005), for without ongoing respectful relationships there could have been no legitimate research.

Some Ethical Considerations

Within an indigenist paradigm, ethical considerations were paramount. In developing an ethical framework for this research I had to first question my own role in

the research and whether I should be involved at all. If I was to have a place in the research, (which I felt I did and will explain why here), then I had to consider my role within the group. Furthermore, I needed to consider the complexities of informed consent within this context and seek strategies that would allow Mi'kmaw voices to emerge.

I had grappled with my place in this research as a non-Mi'kmaw person. I had openly questioned my authority to care, my authorization to represent people and ideas, and my responsibility to remain connected to the community after the research. It is understandable to me that there are people within the academy who have questioned my position in this research because they see me as an outsider in this context. Yet, within the Mi'kmaw community, my identity is much more complex. Lipka et al. (1998) refers to "fictive kin" to describe the kin-like relationships that often develop between long-term outsiders and insiders. This term struck a cord with me as it connected deeply to my own experience. I consider many of the people within the community where I worked to be like family; in many ways, this extends beyond that community to the larger Mi'kmaw community. I feel that it is only because of these relationships that I was able to do this work. As Lipka et al. (1998) said of their own work with Yup'ik communities in Alaska: "It was the importance of being 'related' that allowed a research agenda to evolve" (p. 209). My research agenda has also evolved from my experience within the community.

I shared with them my concerns about my role in this work in a conversation with two Mi'kmaw colleagues prior to beginning the research conversations. Their responses were reassuring. One colleague spoke about the time I had spent in the community, the way I had learned the language and the culture, and assured me that he knew that I had come to work *with* the community. This long-standing relationship is significant. The

other colleague jokingly asked me if I wanted to quit now. His teasing was a way of reminding me of our many long conversations about the research I might do some day that would allow us to explore some of these educational issues and questions on a deeper level. They both gave me the sense that not only did I have the privilege to do this work, moreover, I had an obligation. They had shared with me the language, the culture, the ways of knowing and being; they gave to me and now I was in a position to give back in a way that honoured the community. This is healthy reciprocity.

More recently, I was introduced at the Atlantic Aboriginal Economic Development Integrated Research Program (AAEDIRP) Education conference by a director of MK who explained to the crowd seated in the room that I had been "adopted into the tribe" after all of my years of working within MK communities. Such reminders assure me that my role in this work is important.

Although I was assured that my place in this research is valued and necessary, I was careful, as stated above, to be positioned not as the expert researcher but rather as a learner in the spirit of *mawikinutimatimk*. I had to be reflexively engaged in the research, always cognizant of the power and privilege that comes from my status as a member of the dominant culture and an academic. Battiste (1998) explained that non-Indigenous "scholars may be useful in helping Indigenous peoples articulate their concerns, but to speak for them is to deny them the self-determination so essential to human progress" (p. 25). To that end I needed to be mindful of the potential risk for my agenda to dominate the research initiative and take steps to mitigate that as I described above. By keeping true to the values of *mawikinutimatimk* I was able to ensure that everyone (including

myself) was both a learner and a contributor to the learning, and that knowledge was created in our relational space.

I was also mindful of the complexities of informed consent within this research context. The typical research process tends to be a one-way street with the researcher asking for permission to write about the researched. This is problematic for any research initiative but especially so within communities that carry the scars of colonization. Furthermore, such a "blank cheque" approach to research would run contrary to the values inherent in indigenous methodologies and is antithetical to *mawikinutimatimk.*

Smith (2005) has pointed to the appropriation and exploitation of indigenous knowledge as another problem that arose from the notion of informed consent, arguing that such codes of ethics are often about protecting the individual and not the collective. This brings into question who has the authority to represent the community and whether any true community voice exists. As Piquemal (2001) has explained, it is often the case that only some people in an Aboriginal community are authorized to speak on behalf of the community, especially when it comes to sacred knowledge. Furthermore, it could be said that if a member of the community is taken as representative of the community then consent should be sought not from the individual but from the entire community, and furthermore this could extend to all ancestors and progeny. This is clearly impossible but raised important points for reflection when thinking about the nature of informed consent.

In addition to ethics approval from the University of New Brunswick ethics board, I also obtained ethics approval from Mi'kmaw Ethics Watch, an organization that has taken steps to protect Mi'kmaw knowledge through the establishment of their own research guidelines (Mi'kmaw Ethics Watch, 2000). Such approval comes with an

expectation that the information gathered through research initiatives is shared with the participant communities. To that end, all participants and some non-participants at each school have been regularly informed about the content of any writings emerging from these conversations and a final copy of all written work will be provided to each school. Some parts of the research have been presented to teachers and community members from the non-participant Mi'kmaw communities and, eventually, all of this work will be made available to these communities through partnership with MK.

With respect to informed consent, the consent form for this research project was modelled along the lines of other research initiatives I have been involved with in the community in which the consent forms are not written "I agree" but rather "We agree" and each individual signs with me. This type of consent allowed for each participant to agree to begin the journey together but acknowledged that we must collectively decide what to do with new information as it arose. We have worked together to determine how data is to be interpreted and what our roles were within the group. Thus, consent was not given and then forgotten; the discussion became an ongoing part of our collective journey. This type of consent reminded us to be mindful of our responsibility to honour each other in a spirit of mutual respect and reciprocity.

Data Analysis

I personally transcribed each recording from each session. The transcripts were summarized and shared orally at the following session. Mi'kmaw speech was transcribed using the Smith-Francis orthography (Hewson & Francis, 1990) with English translations written beside them in parentheses. Parentheses were also used for accompanying descriptions. Some translations were done by me and checked with participants as

needed. Most translations were given on the spot with the speaker using Mi'kmaw and then summarizing in English immediately after. Thus, English translations capture the spirit of what was said in Mi'kmaw rather than providing a specific word-for-word translation. This seemed to be most reasonable since most Mi'kmaw phrases do not translate directly to English, and vice-versa. Occasionally there were Mi'kmaw words used in the conversations that I either could not hear clearly or did not understand. When these circumstances arose, I checked with members of the group to determine what had been said.

Square brackets were used to make a replacement in the transcript. This often occurred when children or community members were named by someone in the conversation. The names have been replaced to protect anonymity. Occasionally a pseudonym may be used but in other cases the transcript may simply say "an elder" instead of the elder's name.

It is worth noting here that the data was analysed collaboratively through our sessions. While I was reflecting on what we had talked about and what significance these ideas might have for transforming mathematical practices for Mi'kmaw students, I was also making notes and returning to the group to share these ideas. In each session we would collectively look at emerging models and themes and add to them, adapt them, rethink them, and so on, until everyone was in agreement that the model captured what we were saying in our conversations. I also presented the work to the entire staff in Wutank and the principal of Phillips Lake School on May 28, 2009 as a way of ensuring that all were in agreement. In chapter 4, I describe the journey of our conversations which will show how the themes emerged through ongoing reflective discussion.

CHAPTER 4: THE JOURNEY OF MAWIKINUTIMATIMK

In this chapter I describe the journey of this research process from the beginning stages of introducing and establishing a context for the work through to the emergence of the themes that shape chapters 5 through 8. Along the way I share some critical moments for the participants in the research process including the role of establishing questions and values, the challenge of grappling with curriculum pressures, the value of having expert knowledge, and the challenges that emerge when such expertise is not available. I will discuss my changing role in the two different contexts and explore some of the mentoring roles I played while doing the research. I describe the four themes that emerged and set the stage for the coming chapters. I then conclude by revisiting the notion of *mawikinutimatimk* in terms of the similarities and differences between the two contexts and discuss the ways in which these differences impacted the research.

Introducing the Research Project

In anticipation of beginning our *mawikinutimatimk* sessions, I made arrangements with the two principals to talk with their staffs to explain the research project. Both principals had been giving me feedback and planning with me throughout the proposal-writing phase, thus showing strong support for this project to take place in their respective schools. Also, they each had talked about the project with their respective directors of education who also supported this work. The pre-existing relationship I had with both community schools made this process go smoothly. Both administrators were enthusiastic about working on mathematics goals for the year and both were keen to include as many staff members as possible.

I went to Wutank on October 11, 2007 to meet with the staff during an after-school meeting. The staff had a planned meeting to talk about other issues and the principal agreed to give me some time to introduce the project to the staff. I provided them with an overview of the project, a copy of the consent letter, and a proposed timeline. I also shared some wonderings and questions that I had written about in my proposal, which are also articulated in the introduction of this dissertation. There were few questions from the staff who had already known about the project informally.

I was much more nervous about this initial presentation than I had thought I would be. These were my friends, my former colleagues, and my mentors. It was difficult to share my ideas with them and leave myself vulnerable and open to critique. However, I soon realized that these nerves were not necessary as I found many of the staff to be very supportive and excited about the journey we would take together.

Meeting with the Phillips Lake staff did not happen quite as quickly. I had tried several times to make arrangements with the principal at that school to do a similar presentation; however, because of my teaching schedule and her very busy fall schedule that included conferences and meetings, it was much later in the year before we were able to find a day that worked. On November 21, 2007 I met with the staff as part of their regular Wednesday after-school meetings. The presentation was quite similar as that in Wutank. I shared the ideas from my proposal, the consent letter, and worked with the staff to determine which day would work best for them.

For this session I was far less nervous. I had worked with this staff before conducting professional development sessions and, as a result, had good working relationships with most of them. There were a few new staff members, one of whom I

knew. Prior experience of two *mawikinutimatimk* sessions in Wutank enabled me to share how things were progressing there, which was appreciated by the staff in this school. Although they had seemed interested in this work in my informal conversations with them, I sensed that their hearing about the excitement and productivity of the other group only enhanced their enthusiasm for the project.

Establishing the "Big Picture"

During the first session in Wutank I found it was important to establish the "big picture" of the research and make meaningful connections to some of the related projects with which the staff were already familiar. It was not enough simply to talk about the project in isolation; I needed to talk about what had come before and led up to this work, and I also needed to talk about what would happen after the research. I felt it was important for those who had not been at the introductory session, and to simply bring a focus to our time together, to begin by situating myself in this work. I shared the following thoughts from my own experience:

> One of the things I always wondered about while I was teaching was this...you know, why aren't my kids learning math the way I was taught that they should learn math? And when I realized that, I realized that it was often me that had to change. And the more I learned about Mi'kmaw language and the more I actually learned the language and the more I learned about values and culture and that kind of stuff, the more I realized it wasn't the kids that had the problem. It was my curriculum that had the problem and I needed to bridge that. (W1)

I believe it was important to position myself as a learner, and someone who needed to adapt her own teaching in response to the students' needs. I know from my own

experience as a teacher, it was often intimidating for me and others to have someone come and talk to us about changing our practice.

I had hoped that by sharing my own journey of changing my practice and my desire to continue on that journey, it would set people at ease and help them to be more open to questioning their own practices. I did not suspect that this would be a significant challenge given that within this school there has been an overt acknowledgement that teaching practices need to change to accommodate the needs of the students. Emily, the principal, has strived to create this culture of decolonization.

As I began to share my beliefs and goals for this project a question arose about the connection to *Show Me Your Math*. This project (described in more detail in chapter 1) has had teachers and students in Mi'kmaw schools throughout the province seeking mathematics in everyday contexts. This was a project that many of the teachers and students were very enthusiastic about and so it provided a nice context for beginning this work.

Maureen: Is that related to the *Show Me Your Math*?

Lisa: It's all connected. It kind of emerged from that [...] How *Show Me Your Math* got started was we started talking with [some elders][6] about math, like, what is math? And they were telling us all this great stuff and we thought "Well shouldn't the kids be able to do this?" [...] In talking with the elders we used this Bishop's list stuff, like math is counting, measuring, locating, designing, playing and explaining, and when we started talking to people

[6] In the actual conversation these elders were named because all participants were familiar with them as they were all from this community, one of whom is part of this research group.

> about it, it was like "Oh, well I do this and this and this' and there were all these great ideas. You know Diane Toney[7] was telling me about how she just folds the circles twice to find the centre and makes her patterns. Then she was telling me about taking the rings and going three times across and adding a thumb to make the rings for her quill boxes—which is pi right? I was like "Oh my god it's pi!" – so it was no problem for the elders once we said those six things, for them to start giving us ideas of what mathematics is and so that's how the *Show Me Your Math* contest got going. (W1)

Establishing connections to knowledgeable community members was also an important piece of situating this work. I said that while my desire to do this research has emerged from my experiences and my questions, it has also been supported along the way by community members who have shared my interest and who have helped to answer some of my questions. Richard was present in that initial conversation that prompted *Show Me Your Math*. He is a staff member, an expert in the Mi'kmaw language, and well-respected by the staff. Each of the others had also contributed to programs at the school over the years. I give considerable credit to these elders, along with other community members, who have guided me along this journey. By recognizing the contributions of these community members to this ongoing conversation, I felt it brought about a deeper level of ownership for the staff. It was not simply emerging from my curiosity; it was a community wondering, part of a conversation that had been some 13 years in the making.

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[7] The late Dianne Toney was a well-respected quill box maker.

I spoke to the staff about the key question I wished to focus on: "How can curricula and pedagogy be transformed to support Mi'kmaw students as they negotiate their space between Aboriginal concepts of mathematics and school-based concepts of mathematics?" I also felt it was important to express to them some of my basic beliefs and assumptions that were guiding my work. I suggested that one thing that distinguishes this community school from many public schools is that the staff acknowledge that the system needs to adapt to meet the needs of the child. I expressed my belief that, far too often, Mi'kmaw children who have attended public schools have been expected to adapt to the public school system. Often times when these children have not fit with the system, they are told that there is something wrong and are sent for assessments or individualized programs. These IPPs often include lowered curriculum content expectations but do not address the pedagogical needs of the child. Such a "blame the victim" attitude has had negative effects for these children.

I also stated my belief that I see having Mi'kmaw language as an asset for students not a barrier. It is a common phenomenon in this school that those students who have a strong background in Mi'kmaq also do well in English and often receive the highest grades in school overall. I expressed my belief that students who have two languages also have strengths in code switching which is an essential skill for learning mathematics. I asserted that when we begin to see language as an asset and not a barrier it can help to shift our thinking to ways to build from language instead of working against it. This was not a "tough sell" in this room, given that all but one of the participants this day were Mi'kmaw speakers with varying degrees of fluency, but it was important to bring forward this idea to establish how we would work together.

The third idea I shared with the participants was my belief that mathematics is not value-free, but is in fact value-laden. The current provincial curriculum is built on the values of the dominant Eurocentric society and part of our goal would be to explore some of the value differences and articulate them more clearly.

I then connected the work to similar projects that are going on in other parts of the world such as the *Math in a Cultural Context* (MCC) work happening in Alaska and a newer project out of the University of British Columbia (Nicol et al., 2008). I also shared my hopes for what we might do in the future, expressing my long range goal of using this initial work to get larger scale funding that might allow us to develop our own curriculum materials to support mathematics learning in Mi'kmaw schools. These connections took some time to explain but proved to be valuable for the participants as Emily acknowledged.

Emily: Now we need to know what our first responsibility is.

Lisa: Okay.

Emily: For me and uncle and possibly Ma'li and Elaine and Pauline, (laughs, acknowledging she has named everyone except Maureen who is the only other non-Mi'kmaq in the room) we think uh…

Maureen: And Maureen?

Emily: And Maureen (laughter)

Maureen: Nothing like excluding me (jokingly)

Emily: We think um, first process and then we move on. We see the whole picture, we understand the whole picture, now it's to find out where do we begin and how do we begin this and what is our

expectation from now until the next time we meet.

Lisa: Well my hope is that we can have two pieces of conversation today. One is sharing some of our own musings about or wonderings about mathematics like what do we notice, whether we're teaching it or thinking back on learning it or maybe both and just kind of get some of that out there. So what are some of the things that you're wondering about? And the second piece would be to set some goals for future projects or future discussions. (W1)

With this opening moment we were off to a promising start in Wutank and many fruitful discussions followed.

Given this experience in introducing the project in Wutank and in establishing the connections to what has come before and what is to come after, I chose to initiate a similar discussion with the Phillips Lake staff when we had our first recorded session. Establishing this context seemed important to both staffs and helped to establish our focus. I outline the emerging ideas from the first session in Phillips Lake in a future section, but first I elaborate more about the beginning sessions in Wutank.

An Emerging Story of Questioning and Valuing

As we began our initial conversations in Wutank a spirit of questioning hegemony and valuing Mi'kmaw language, culture, and values was immediately established. Emily offered to begin our first round of conversation sharing a story about a student who was having difficulties with mathematics learning and who had been assessed by an educational psychologist. The assessment did not prove to be of much use to the staff as

it did not point to any problem in particular. Emily expressed her belief that these assessments often overlook understanding and connections with the children in the context of their own personal environments. She reinforced this by sharing a piece of a conversation between her and Maureen, the child's classroom teacher.

> Maureen had all the right answers when I was asking her earlier about what she thinks is missing. And she was saying, if you think about this particular student, she said everything right, right, right, right and she named everything that a teacher would normally do. I said "Yeah, you're missing the most important connection, that's making it connect to him, himself." I think we need to do that. And lots of times it's going back outside in their own lives, play area, in their own environment, in their own home, in their own personal life. I think that personal connection is lost, because we're stuck in a system where we don't allow that personal connection. (W1)

Maureen agreed that she saw a need to establish more personal connections to the curriculum materials for students as they are learning mathematics. Emily reinforced Maureen's comments by pointing out that for many Mi'kmaw children, personal connections are often cultural connections.

> Maureen: It's interesting that we're talking about that because a number of years ago, quite a few number of years ago, they did a study on math and connecting with children that were home schooled and they found that students when they are talking about abstract things and they were understanding these concepts better than kids who were in school because their parents were showing them

things that were in their home and outside their home and making them more personal to them and then they were able to make more connections that way.

Emily: And personal for us is a lot of culture. You can automatically say oh a tipi if you look at that, that's a cone on its own – but the difficulty of even making a cone – and if you look at the actual development of making a tipi, it's not a cone. But see, wouldn't you say automatically – a tipi? (W1)

Emily's words point to the complexity of finding cultural connections without over-simplification. In the moment, she sees the connection that a cone has similar shape to a tipi but also acknowledges the complexity of this culturally important dwelling and acknowledges that "it's not a cone." A cone is a simple shape; the tipi is far from simple. Calling a tipi a cone takes away from its' complexity; this is reminiscent of Doolittle's (2006) caution against the oversimplification of complex community artefacts.

As the conversation progressed on this day we soon turned our attentions to the use of Mi'kmaw language in the classroom. This was the first of many conversations we would have on this topic.

Emily: But even the language too. I find simple words like *aqq* (and) or *apa* (again), those simple terms too that any teacher could do.

Ma'li: *Me'* (more)

Elaine: *Me'*

Paula: *Me'*

Emily: But those simple terms, those things – my vision for a TA is just,

almost 75% for that, for language connectivity, if they could say something that's a connection you know, they "Uh, Oh! It's simple like that" you know "it's simple like that".

Maureen: Cause I've had – I was saying to Emily I've had times where I've had TAs in my room where in math, in other subjects too but especially in math, where a child will just be so, like having so much trouble with what I'm trying to explain and a TA will just say – and Jessica was saying the same thing Angela or whoever else - will say one word and the kid will go "Ohhh!" and they get the whole hour lesson that I was trying to explain, but they'll say one thing and they'll get it.

Ma'li: Malwan(?)

Emily: Our language is getting less and less in the home but often that language, that everyday language is still there, like *apa* and – those little things like "do it again" and simple terms that are getting mixed up in the *Miklish* (a common term used to refer to a mixture of Mi'kmaq and English) but they're still very powerful when you're teaching.

Lisa: Umhm

Maureen: Did you just say Miklish? (laughs). I've never hear that term before.

Elaine: Yeah like sometimes you say "How many are there in there?" Right? How many? They won't get it. You have to translate

"Ta'sikl?" (How many?) Then they'll get it. (W1)

In this passage Emily referred to the importance of having Mi'kmaw-speaking support workers in the classroom to support those students who require a dual language approach. This is especially important for classrooms in which the teachers are non-speakers. Maureen, a non-speaker, welcomes this support and acknowledges how important it is for the students in her class.

On this first day we did talk about fractions, decimals, operations, measurement, the need for more hands-on learning, and the connection between learning mathematics and playing games, but most of these things seemed to be secondary issues to the conversation about language. What also emerged in this initial meeting was a sense of valuing the language of the community and the personal and cultural connections of the students. Each thread of conversation seemed to lead back to this idea. Although it was never specifically said on this day, I got a sense that it was felt that learning from the language would provide insights into the solutions to the other concerns. This would later be clarified and spoken about in more detail as our sessions continued. Language would become a primary focus, but it was clearly emerging on this first day.

It was a positive start to our sessions. The staff seemed ready to embrace significant change that would transform mathematics education in their school. They were willing to question the traditional approach to teaching mathematics and think seriously about what a new approach might look like. This open attitude continued into future sessions.

Grappling with Curriculum Pressures

Our first formal session in Phillips Lake did not turn immediately to questioning the hegemony of provincially mandated curriculum, nor did it focus on valuing Mi'kmaw language and culture as it had in Wutank. By contrast the conversations in this school seemed to emerge more from a place of pressure to meet provincial outcomes. The school competes with at least two other provincial schools for students and this reality is not lost on the staff. Our initial conversations began with teachers asking questions that one might expect to hear in any school: questions that focused on fact recall, the appropriate use of concrete materials, and parent expectations. Excerpts shared below give telling examples of the pressures the teachers were facing.

Sarah raised some questions about fact recall and shared some pressure she felt from parents about some students' lack of quick recall in her grade 4/5 class. Sarah's primary concern here was focused on what she saw as a lack of automaticity with addition and subtraction facts for her class. She noted that this did not seem to be as much of a problem with multiplication and division.

Sarah: I think the parents are okay if they need to figure out multiplication because they maybe even have to figure it out but with the adding I get a lot of pressure that grade 4 or 5 it should be instant, instant. And I mean there's a spectrum in my classroom some kids have it but there are kids it's not—they're counting every single time they add.

Ellen: And it is seen as a valuable thing to know how to do.

Lisa: Absolutely.

Ellen: There's no doubt about it, you know when you go to the store and be able to do the mental math thing, you know.

Sarah: But you would say model it as much as possible not just do dry drills?

Lisa: I would say that if at grade 4/5/6 they don't know their facts, addition facts, -

Sarah: Yeah.

Lisa : If at grade 4/5/6 they don't know their facts addition facts drilling it into their head is not going to work because chances are the reason they don't know them is because they don't know why. Why? I mean you could just – you made that up, 4 + 6 is 10, you're just saying that, I could say 4 + 6 is 17, you know if I don't know why. So to me, I would be using ten frames because maybe they haven't seen ten frames or maybe they haven't, they didn't play with them enough.

Sarah: Yeah, cause they're not visualizing, they're better at visualizing multiplication which is like bizarre but it's because we spent almost all year on multiplication and now it's like, god, they can't add. (PL1)

This conversation about mental math strategies brought up an additional issue that Sarah chose to share with the group. She told us that during her teacher training she had been told that children should be weaned off concrete materials. She wondered if she should be worried that her students still needed concrete materials to support their

numerical reasoning in upper elementary. I shared with her my belief that concrete materials were necessary at all grade levels. Jessica echoed this idea.

Jessica: That's interesting that you were taught that way at school because I was taught the other way like no matter grade 1 or grade 12 they all need manips.

Sarah : I had some professors who said to use them but where I did my practicum there was this big push to be free from manips by the end of grade 3.

Lisa: That's why kids hate math by grade 3.

Sarah: I'm like, but they need them, they want them, it helps them get their work done. But when you hear it from the parents too it's like there's an expectation of me to [not use them].

Lisa: But with parents too its part of being proactive and telling them why we are using them, what concepts we are trying to develop.

Sarah: I guess I have to have it clear in my head first before I explain it to them so that helps the way you're explaining it. (PL1)

From our conversation that day, it became apparent to me that the staff in this school had a different focus than the staff in Wutank. The teachers in Phillips Lake were grappling with ways to meet provincial curriculum pressures and were seeking sound pedagogical advice based more on a mainstream philosophy. The notions of decolonizing education and transforming school practices to make them more reflective of community practices were not forefront in their minds. This does not mean, however, that they were not interested in learning more about these ideas—it appeared to me that they were—but

externally imposed pressures seemed to leave little room for them to explore these deeper notions.

Before we left that first session I asked each of the staff present to share one goal that they hoped to get from our conversations during the year. Below is what they shared.

Kelly: To be more attentive to going back and having a look at how I've taught things. Do I do things because they're best or because it's just how I've always done it?

Jen: Learn different ideas about how people think about math.

Sarah: I just keep coming back to that – just being better to get them to understand the concept before I try to label it, because I do think they need to know what it's called for when they get older but I think I'm rushing it. More variety in how they experience it and even more variety in how I present what it's called or the formal way like so we're not just like, okay for the next ten minutes we're going to sit down and name everything. I just am really interested in that whole connection and I want to be better at that.

Elizabeth: I will bring an elder in for next time.

Ellen: For me I have been focused on literacy and reading recovery and now I would like to focus on mathematics. (PL1)

The staff demonstrated enthusiasm and a willingness to engage in a journey of discovery. Their energy carried on throughout what proved to be a fairly productive year of conversations.

The Value of Expert Knowledge

In our ongoing conversations, I quickly realized the value of having participants who possessed some expert knowledge. In Wutank, Richard, an elder in the community, emerged as a teacher who contributed greatly to everyone's learning. His deep cultural and linguistic knowledge moved our conversations into new and previously unexplored territory. Many of us were not surprised by the vastness of his knowledge, as we had almost all had similar conversations with him in small groups or one-on-one; however, this was perhaps the first time we had come together to seek his advice in such a formal manner. His contributions to our meetings were valued greatly by the other participants and we often found ourselves seeking his knowledge as new questions arose. As our sessions progressed he became increasingly more comfortable in this role as teacher often coming prepared with new ideas and experiences to share.

Later in our conversations, we began digging more deeply into specific language concepts as we realized that this was an important recurring theme in our discussions. The importance of language was not really surprising for this group; we had talked about the significance of language right from the first day. But I do believe this was the first time that these participants, myself included, had the opportunity to come together to discuss the role of language in such a focused manner.

On May 28, 2008 we sat again in the Mi'kmaw Language Room talking about the importance of language in mathematics learning and talked about what we can learn as teachers from understanding Mi'kmaw words and how they are expressed in English. As we explored some of the emerging themes in the model we had been developing, Richard began to share with us more words that we should know. He explained about "straight":

Richard: If I'm talking about something straight I would use the word *pekaq* which means straight, not necessarily in a straight line like on a ruler but straight enough to make an eel spear.

Lisa: So it's connected to its usefulness?

Donna: There, I think you just made one of the most important points that we haven't made yet was its usefulness. Our kids see no purpose which gets back to the values again.

Lisa: Right that's connected with values which is this part – context matters! (W9)

As Donna and I continued some conversation around the importance of creating personal connections for students in mathematics learning, Richard rose and walked to the board at the front of the room drawing an eel spear and writing some words on the board. The discussion below ensued.

Lisa: So tell me about these words that you have written here.

Richard: Okay. A wedge is a triangle right?

Lisa: A wedge, yeah.

Richard: But it is long and just like that. I could call a wedge or similar *tlaqan*. *Tlaqan* is a wedge. But if we were talking about something that is of that shape, *Lnu* (our people) would say *Iknimuiy natakoqoey telik kutey tlaqan* (look for something that is in the shape of a wedge) or *tlaqanikiaq* (forming into a wedge) or *tlaqanik* (wedge-shaped). *Pekoqsit* which would be an eel spear or something *pekaq* which means straight; anything can be straight – *pekaq*. It

could be *pekoqsit* -not necessarily straight as an arrow but straight.

Lisa: Okay, so is this the same notion as estimation versus exactness? That straightness doesn't have to be exactly straight but straight enough?

Richard: Straight enough.

Lisa: Straight enough to make an eel spear? Straight enough to use?

Richard: Yeah. I can go and tell you *niputuk eliey* [inaudible] *pekoqsit* – as straight as possible not necessarily straight but straight enough to make an eel spear.

Lisa: So even the concept of straightness, or probably flatness to a certain extent would be about the utility of it all, straight enough, flat enough.

Richard: Now, if your making a fence (draws it on the board). Straight. A straight fence – *pektaqtek.*

Lisa: *Pektaqtek?*

Paula: We use this in everyday language.

Richard: Now this is straight. The fence would be *ketlaq* (you know)? It is a sense of motion from here to the other end – *pektaqtek.*

Lisa: Does it mean like it kind of goes along in a line?

Richard: Straight.

Paul: Yeah it's going…

Richard: From here to there *pektaqasiy.*

Lisa: But you hear motion, right?

Richard: Yeah.

Lisa: Like when I hear – as an English speaker when I hear straight I don't see motion.

Maureen: No I see straight, a straight line.

Lisa: You see straight. But when you say *pektaqtek* you see it going straight?

Donna: Yes.

Richard: Yes, from here to there.

Donna: Right.

Lisa: So there is motion to it. It's from here to there.

Richard: Yes.

Lisa: And is it relational to the person? Like…

Maureen: You are going from that point to that point?

Donna: No the fence is going from that point to that point – the fence is going, right?

Richard: I'm talking about my fence and I tell Christine here: "*pektaqtek aq*?" Like it's from here to there straight.

Lisa: So you are kind of a reference point though, in that context?

Donna: A reference point or is the fence moving from here to there?

Richard: Ah…?

Donna: Like, not that it's moving like I'm moving but…

Richard: Ah…The sense of motion is in the language…

Donna: Right, that's what I was trying to say, it's in the words, right, not the

fence itself?

Richard: But you know it's not straight, just straight. There is a sense of motion from here to there.

Lisa: Like as you go along it.

Richard: You don't even have to go along it.

Lisa: Yeah, I know.

Donna: I know what he means, yeah. (W9)

This passage is one of only many examples where Richard shared his deep cultural and linguistic knowledge with us. Not only did he teach us with meaningful examples but he also did so with incredible patience for the non-speakers in the group who struggled to understand the sense of motion within the language. In reflection, it may be that the presence of non-speakers had created a situation where Richard felt compelled to elaborate more when explaining the structure of words.

These moments were beneficial to my own learning and several of the staff members commented similarly about how beneficial they found Richard's contributions. On the few occasions when Richard was not present, we often would comment about missing his contributions or raise questions that we knew he would be able to answer but we could not. On such occasions we would make a point of remembering the question for the next time we met, such as the day we decided to ask him next time about the word for middle (detailed in chapter 5).

Emily's encouragement and leadership as the principal in the school was also incredibly valuable. She set the tone by opening the conversation on the first day and continued to move the work forward with her dedicated leadership. Although she was

occasionally busy with school matters and unable to attend the sessions, she encouraged the staff to participate and regularly invited me to spend time with teachers in their classrooms. Her desire to transform mathematics education in her school was ever present in our conversations and her focus on building from cultural knowledge remained strong throughout.

Emily felt strongly that there is a need to focus on Mi'kmaw ways of thinking and knowing in our teaching of mathematics. On May 7, 2008, Richard, Emily, Ma'li and I found ourselves still in the Mi'kmaw Language Room after many of the participants had left for home. On this day Emily spoke with passion about the importance of reflecting Mi'kmaw values in the teaching that was happening in the school. She pointed to her realization that the children who have a strong foundation in Mi'kmaq learning and values are usually more successful in school, because they have a deep sense of identity and they are confident Mi'kmaw learners. She described how important this sense of identity is as she talked about the new school that at the time was under construction. She explained that some Aboriginal schools have lots of Aboriginal art work and things that make the school look Aboriginal but she explained that what matters to her are things more substantive than this:

> What I am in putting in that school are people, the building can look like whatever it wants, it's what's going to be taught in that building. This reserve doesn't need to be told that they're Mi'kmaq. Every child who walked in my office one day, I asked "*wen ki'l*?" (Who are you?). They didn't say their names, they said "Mi'kmaq". (W8)

While Richard and Emily's contributions stand out, this is not to minimize the contributions of the other participants in the group. In Wutank, many of the participants are also community members and Mi'kmaw speakers. Each of them was able to bring experiences and cultural practical knowledge to the conversations. Whether it was Ma'li telling stories about her godfather's knowledge of the land, Catherine sharing stories of playing mathematical games growing up, or Paula sharing some of her language knowledge, each contribution helped us to think more deeply about mathematics in the context of Mi'kmaw cultural knowledge.

Grappling with the Lack of Expert Knowledge

In Phillips Lake, there was no language expert to share mathematical terms, and no cultural experts to share stories of mathematics in the community as at Wutank. Attempts made to include elder knowledge never came to fruition. In these conversations, I often was asked to assume this role as I could share both my own experience and the knowledge I had gained from the Wutank conversations. This became quickly apparent in the second session, as we tried to move more toward a discussion about the disconnection between school-based mathematics and Mi'kmaw cultural concepts of mathematics. Several staff members expressed their concerns about their lack of cultural practical knowledge and their desire to have me help them with this challenge.

Sarah: I feel like I don't know enough to make cultural connections or to encourage the kids to— I just don't know enough. And I would like them to be able to do that and have more like more community based stuff— like talk about problem solving. Like when I sit down on my own and I know okay I'm going to make up all these

problems because the problems I've seen are not going to get their interest but there's only so much I on my own can think of, right. I feel like I don't have a firm enough anchor in what's going on in the community like with the elders and with their culture to like understand where their gaps are. Like I can see them but I don't understand where it's coming from so I don't know how to address it. And even just like making those few changes like I said made such a big difference (whispers), but I only did those things because you told me to.

Lisa: But that's okay.

Sarah: Right but now I want you to tell me more stuff and that's why, like, I'm okay, I don't have a good anchor here. (PL2)

Kelly similarly expressed concerns about her lack of community knowledge and her perceived inability to make meaningful connections for students:

> Right, like my entire background in mathematics was in the mainstream school system and I was not part of the Mi'kmaw culture growing up so the way I am looking at this is completely from the outside. Although I know quite a bit about the culture, that's not the point, I don't know the connections so how can I show them the connections? And I don't want to show them connections that are wrong. (PL2)

She acknowledged that she could probably make connections to some of the more modern aspects of cultural life such as the video games kids play claiming: "These kids, their world is video games, etc. No problem to do this because that's my contemporary

culture too. The problem is in incorporating some of the historical culture." She also felt she needed support in this area and thought what might be helpful is to see what this could look like. She expressed her hope that I could show them how they might do this.

The participant teachers were interested and willing to learn more about the culture of the community and how they might make meaningful connections in their teaching of mathematics but they were unsure as to where to start and positioned me as the expert who would be their leader on this path of discovery. I explore more about the difference in my positioning in the two contexts later in this chapter.

The principal, Ellen, also often looked to me to share my experiences with her as she grappled with making the school truly a community school while also meeting the demands of provincial curricula. Often when I would arrive in the school for the day, I would spend some time talking with Ellen in her office. These conversations were never recorded but we often talked about the experiences I had during my time as a staff member in another MK school. She would often bring up challenges she was facing and ask how my colleagues and I might have dealt with similar challenges. We also often talked about my experiences as the representative of the MK schools on the provincial math leaders' committee and ideas about new initiatives going on within the province.

My conversations with Ellen proved to be quite fruitful and often would carry over into our after-school conversations as well. The passage below, also from this day, gives an example of this carrying over. This conversation began with me talking about the work on improper and mixed fractions Chris and I had done with the grade 6 class during the day. This story is described in detail in the next section.

As we continued to talk, our conversations focused on specific students who had done quite well in the class today even though they did not always have this level of success. One student in particular, who normally required adaptations to his program, was able to participate quite successfully in the class because of the use of concrete materials. Also, other students were developing an understanding without rules because they were encouraged to figure out the mathematics with reasoning rather than rules. Chris commented on his surprise at how engaged many students were with the activity. This prompted Ellen to recount a part of our conversation earlier in the day:

> And that was something else that we were talking about before you came in here when we were talking in the morning, like the amount of time that teachers spend trying to teach something, that—and then—well you were talking about things that can be set up in centres so that you can do it so that its differentiated so a child that can only count to 5—the cards that they pull out will only be up to five. It's the same activity but limited and so—it's a lot of work for the teacher to do up front but once you've got it done—like Lisa was saying she's got examples of centres that she works with. And then the kids get it and the ones that are going to get it no matter what are still going to get it but it helps the other children. (PL2)

This comment by Ellen was followed by my description of some of the learning centre ideas we had talked about earlier in the day. The focus on developing good differentiated tasks that students could connect with in a meaningful way, such as those that emphasised a spatial approach to learning number, became key in our after-school sessions as the year progressed. The participants were keen on developing learning centres for their students and this seemed to me to be an effective way to invite the

teachers to think about these lesson ideas in the context of what they already know about their students. Again, however, I became positioned as the leader or expert in this initiative. It was a position I accepted but with awareness that I would need to make a concerted effort to encourage the participants to reflect on and recognize what they already know about their students and the community.

Mentoring while Researching

In both schools, in addition to being the researcher I also provided support by working alongside teachers in classrooms and resource rooms, an experience which proved to have many benefits. It enabled me to build stronger relationships with the teachers as well as many of the students. It also provided me with the opportunity to see how students were responding to various pedagogical strategies and provided me with insight into children's thinking. Some of the stories of these experiences are embedded throughout this dissertation and these in-class experiences also regularly gave us fodder for conversation during our after-school sessions. I thoroughly enjoyed these classroom experiences. I recount one story here of teaching improper and mixed fractions in the grade 6 classroom in Phillips Lake.

Having been invited into the grade 6 class to help with the concept of mixed and improper fractions, I decided that I would focus on making the whole. The teacher had written the definitions of improper fractions and mixed fractions along with some examples on the board before I arrived in the room. He was instructing students to copy these into their notebooks. This is a typical approach to mathematics teaching: moving from the definition to the examples to some questions. The teacher asked me if there was something I would do differently and offered to let me take over the class.

I began with pictures. A SMART Board© was available in the classroom and I had some fraction blocks in the gallery of the SMART Board notebook on my laptop. We began by letting the yellow hexagon be one whole. All students had pattern blocks at their seats so that they could then determine the names of other blocks. We talked about why we name fractions the way we do. These students had been told about the terms "numerator" and "denominator" and could connect these terms with the "top number" and "bottom number" but did not seem to know what information these two numbers told us about the fraction. I began by asking them questions such as, "If yellow is the whole then how many reds do I need to make a yellow?" The students were able to take the red trapezoids and show that two of these blocks would make a yellow hexagon. I explained to the students that since they needed two of these to make the whole then each of them would be one-half, one of the two they need to get a whole.

We repeated this activity for the blue rhombus which is one-third of the hexagon, and the green triangle which is one-sixth of the hexagon. In each case I reminded students to think about how the fractions were named based on how many of them were needed to make the whole. The goal was to have them see that the denominator tells them how many are needed to make the whole.

I then explained how the numerator tells how many of the pieces they have. I explained that if I have 2/3 then I would have two of the three pieces I would need to make a whole and so on. Many of the students seemed to be connecting with these terms in a new way as they held the pieces in their hands and thought about making wholes. I consciously focused on using language that I believed would help to promote a deeper understanding for these students.

I was then able to ask students to think about improper fractions such as 9/2. "If I have nine halves how many wholes can I make and how much do I have left over?" I asked students to build it and show me their answer. They were quickly grouping the red trapezoids into hexagons and they were able to see the four whole hexagons and one left over trapezoid giving 4½. I asked them a number of additional questions such as "How many wholes can we make with eleven sixths and how many sixths will be left over?" and "How many wholes can I make with eight thirds and how much will be left over?" When the questions were phrased in this way, combined with the use of concrete materials, the students were quickly able to understand and identify the mixed fraction equivalent. Because the words I used focused on conceptual understanding over procedural knowledge, the students were able to reason out the answer rather than simply using the procedure that had been written on the board at the beginning of class.

They were also able to generalize their understandings to situations for which they could not use the pattern blocks. All students were able to answer the questions in a fairly brief amount of time. I asked them to tell me how they figured out each question. One student explained "You just have to think about it" and, when prompted further, they began to talk about thinking about groups, about making wholes. Thinking about the groups made it possible for these students to figure out the answer, and this new understanding came from having new ways to talk about what the numerator and denominator meant, i.e., ways that were focused on meaning.

A typical lesson on this topic might involve instrumental rules such as "Divide the top number by the bottom number to get the whole, then place the remainder over the bottom number to get the fraction." But on this day the discourse focused more on

understanding and allowed students to make sense of this concept through hands-on techniques and visual models. The teacher later expressed his surprise about how well his students had done with this activity with this small change in discourse.

The Emergence of Themes

I returned to Wutank for a third session in January (W3) and intended to follow this up with another session in Phillips Lake in early February, but as a result of inclement weather, I visited Wutank two more times (W4, W5) before returning to Phillips Lake in late February (PL3). When I returned to Phillips Lake, the group was curious to hear about the ideas we had been discussing in Wutank. Through summarizing some of the discussions from Wutank with the Phillips Lake group, I began to see some recurring ideas emerging. I recount some of these Wutank stories in this section and then describe the emerging themes.

The group for the January session in Wutank was quite small (Maureen, Elaine, Rose, and me) but we still agreed to spend some time together and talk through what had been discussed in the previous two sessions. Our attention turned to language and how we can make more meaningful connections, revisiting a conversation about the difference in grammatical structures between English and Mi'kmaw. Maureen raised the issue of her own lack of knowledge of the language, expressing that she wished she knew the Mi'kmaw words for shapes while teaching her geometry unit. This reminded me of a conversation I had with a number of teachers at a *Show Me Your Math* professional development day where we talked about the many different words for circle. Recounting this story with the participants on that day led us back to talking about the notion of motion embedded in the language.

Lisa: Like one of the words for circle was *kiktoqasik.*

Elaine: When you say *toqasik* it means it's moving around.

Lisa: But there's motion in it right?

Elaine: Yeah.

Lisa: See that's the thing—that's the thing that fascinates me about math and the language is that, it's this notion of motion. That's the part that I think—that's something that I'd like to take forward as we go forward this year like trying to figure out how we could model our language so that it's more verb-based than noun-based. It just fascinates me—the whole notion of motion.

Maureen: (laughing) You should write a paper on that—The Notion of Motion.

Lisa: I may, it's a good title.

Maureen: It's a very good title.

Lisa: Like even with the whole "coming to a point" – *kiniskwikiaq* – it's not just pointed it's moving to the point. And I just wonder if incorporating that idea of motion and movement would help kids to understand shapes better. Like if I'm talking about a cylinder I would just talk about how I keep going around.

Elaine: This way (motions the shape of a cylinder with her hands) but *kiniskwikiaq* is like (moves her hands to a point) - a *wi'kwam* is like that.

Lisa: But, I said "oh it's like a cone' but Kiju said no because

kiniskwikiaq is also like (motions hands like a roof) like a pyramid is *kiniskwikiaq* or a prism when it comes to the edge or like a tent or the roof of a house is *kiniskwikiaq* as well. So it's still that notion of coming to a point like it's sloping.

Maureen: Ah so it doesn't have to be a cone cause it's sloped.

Lisa: So it's like it's sloping up but its coming to a point.

Maureen: So that word would mean anything that comes to a point.

Lisa: Right because it is describing that nature of coming to a point. Now a cone comes to a point all around whereas a prism comes to a point on the edge. Those are the things I sit at home and think about at night. (W3)

Passages similar to this will emerge in the upcoming chapters because this topic of conversation was something that we returned to often.

On this day we also examined the *Math in a Cultural Context* (MCC) series of books as a model as we thought about what we might produce in our own context in the future. We were drawn to the *Picking Berries* kit (Lipka et al., 2004) and immediately made connections to picking blueberries in Maine, a practice that has been common historically among Mi'kmaw people in Nova Scotia. Although there are fewer people travelling each summer to Maine to pick berries, it is a significant piece of the economic and social history of the community. Elaine said to Maureen, "You could use that in graphing, like my sister got this many, my brother got this many." (W3) Maureen was not really aware of the extent of this practice and was somewhat surprised and excited as she listened to Rose and Elaine talk a little about trips to Maine and the summer school

program that used to happen for the children. As a group we concluded that looking to these MCC resources might inspire us to think of any number of ways we could build mathematics lessons from cultural practices.

During this session I recounted my experience in previous conversations I had with elders. I explained how each time I asked a question intended to generate a numerical answer, I would instead be given a spatial answer, often accompanied by a gesture. Rose commented that she noticed a similar phenomenon with her mother saying "Even measurements, they don't use like measuring cups sometimes. Like with my mom, it's not like how many cups, it's like about this much." (W3) Elaine agreed that she had seen similar things in her own experiences.

Although we began this particular day's session with a small group, the time seemed to fly by and I felt as though the day's discussion had been useful and productive. Maureen, in particular commented that she had found it very good and suggested that we should begin making videos of these types of conversations and perhaps conversations with elders.

Maureen: I just thought of a fantastic idea.

Lisa: What is it?

Maureen: You should make math videos—I'm serious, this is the future—math videos that would talk about what we are talking about right here. You know.

Lisa: We could do that.

Maureen: And then we could be playing them for people like me -

Elaine: Show and tell like *aqatayik* (a half)

Maureen: Yeah. You know like a geometry, like geometry words.

Elaine: *Pukwe'k* (a piece)

Maureen: Yeah exactly you could have like a -

Lisa: Well, I started a paper on that but instead of having me do it, we could have community elders speaking on the video. We could have some of that language of mathematics and we could use it for the kids but we could also use it for teachers.

Maureen: Umhm

Elaine: Yes!

Lisa: That's a good idea. (W3)

In this passage we see the teacher participants identifying future needs in this journey of transformation with Maureen's suggestion of providing videos of elders connecting mathematics and Mi'kmaw language for use as teacher professional development.

This was the end of our session and I agreed to come back again soon when more people would be available.

Our next session took place in early February with more participants than the previous session. We began with a summary of what we had talked about up to this point and then we again took a look at some of the MCC resource books. This brought our attention to the *Show Me Your Math* event that had been going on for 2 years, in association with many of the MK schools. Maureen suggested that these resources made her think that we should really be doing *Show Me Your Math* types of activities every day to some extent, but she also pointed out that this is challenging due to lack of resources, in particular, the human resources.

The MCC resources provided our group with some insight as to how we might begin to make meaningful connections between cultural activities and mathematics to bring about the personally meaningful connections for students. Even among this group, however, the conversations initially seemed to express a belief that these connections should be more historical in nature. I was careful to point out that this was not necessarily the case.

Lisa That's the thing with *Show Me Your Math* too, it's not necessarily historical connections. It could be a modern current connection too. I mean it's nice to think of historical connections because it's also good to learn a little social studies while you're doing your math too right. But you could also think of it as a modern connection, like what are some of the things that we do every day in the community that are mathematical?

Maureen So if we were to take a concept or concepts specific to Wutank like say the fishing derby. So you could talk about measurement of fish or weight or whatever, is that what you're talking about? (W4)

As we followed this line of conversation, we generated more ideas of things in the community that might bring about relevant and meaningful connections for students such as playing games like *waltes*, cards, and bingo. We then moved from this question of context to the approaches we use in teaching.

Lisa The other piece that we were just talking about earlier, the other piece of it is not so much the context but the approach that we use. One of the things that I noticed the more I taught, the more I

realized that I needed to change how I talked about mathematics and how I got the kids to engage with mathematics like more hands-on, doing -

Donna And that's absolutely true because every child we have had assessed is visually great and spatially great, it's everywhere else that they're falling down and so we should be able to tap into those two strengths to improve their math skills. And those are two things that are really important for math, right? (W4)

This was the first time during our conversations that we formally began to talk about the visual and spatial learning strengths that many of the children in the school exhibit, but we would return to this many more times in the future. Donna truly saw this as an important area of concern, and one that is frequently overlooked by the mainstream system.

Donna But spatial and visual learning styles don't fit into the curriculum and that is the problem; that is the whole problem. You can be gifted spatially and visually and it doesn't fit into the way that we present information. Why doesn't it fit? Why is it not valued as much as the oral or the symbolic? Why don't we value it much as the other? And we don't, we don't value it.

Maureen I think that is because the reason is when you get older the visual tapers off.

Donna Uhuh

Lisa No

Donna That's the whole thing, that's another thing. If you think about it, a person who is really gifted as an engineer needs to have a vision, needs to see the whole job, the whole spatial reality and those people are usually visual learners who have adapted.

Lisa They can convey it symbolically.

Donna They can convey it symbolically but they think in pictures.

Ma'li It's like one day I was looking at [a student] working, he was working on this little clay making a turtle. And I'm looking at [him] and I said there's no way I could make a little turtle the way it was, it had details and everything. I said [student's name] do you already see what you're going to make. No. You don't see it [student's name]? He said no I just make it. He told me he didn't see what he was going to make at the end, he was working on it during – during, that's when he sees it. Cause I told him, there's no way I could make a turtle like that. And after he was done (she mashes her hands together) he wrecked it.

Lisa (jokes)Yeah, cause it was about the process not the product. But I think there are a lot of people who are very good at math who are actually visual spatial learners …

Donna Absolutely

Lisa But have learned to translate that into the symbolic because it's useful to learn the symbols. So how do we use that strength and bridge to that because even though the curriculum doesn't value it,

we need to value it and we need to—that's kind of the piece—the question of this research is how do we help kids negotiate their space between school-based mathematics and their cultural concepts of mathematics and their worldview sort of mathematical, and how do we bridge that? So building on their strengths to access this mathematics without denying their own strengths and values.

Donna Right.

Lisa Because I think a lot of the time what public schools do is they expect kids to change, to come over to this side…

Donna Yes, absolutely (W4)

Richard picked up on some of these ideas about visual spatial learning strengths and tried to think about how this might connect to teaching something like fractions.

Richard You know when you're talking visual, I started thinking, cause I deal with fractions mostly, and I'm trying to get fractions in their heads and then -

Donna The problem is that they have to see a picture in here (points to head) everyone thinks that visual learners are people who look here (points to table) visual learners are people that can visualize in their head. So they can make a picture of the whole in their head but then they can't get it on the paper or they can't explain it orally to you but they can see it in their head and if they can point to the answer -

Richard Well I was just thinking maybe if I gave them a bag of beans or something—not jellybeans cause that'll be gone in no time—just

give them a bag of beans and just put them on the table and I tell them, okay now without moving one over here and one over there, just show me approximately half the pile. And then when we get the half pile I tell them okay, now show me a quarter or a fourth.

Donna Yeah (W4)

I then told the story of working with the Grade 6 class in Phillips Lake on fractions, commenting that *how* I expressed certain ideas had made a difference. My choice to talk in a way that focused on understanding rather than procedure had made a difference for them. Donna picked up on this right away, saying:

> Right, that's part of the problem, which is part of the problem with the language of mathematics. When you try to say—you listen to them say "we must use the proper language, we must use the proper language." Well we can't use the proper language if there's no relationship to that language. (W4)

Donna was careful to point out that she is not opposed to the students learning the words, but that we need to build to these words in a way that makes sense for the students.

Lisa That's what we were talking about earlier is this notion of languaging the concept in a way that makes sense and then giving them the word for that concept.

Donna Yes, after! After they know that concept as opposed to using the word first and then trying to teach it. (W4)

We continued for some time to talk about language and the role it plays in children's conceptual understandings. There was agreement that even children who are not speaking Mi'kmaq are still thinking Mi'kmaq. These ideas are described more in the next chapter

so I do not elaborate here. The fifth session in Wutank also had a strong focus on language and much of the detail from this session is described in the next chapter as well.

After these three sessions in Wutank, I found myself reflecting deeply on the substance of these conversations, and when I returned to Phillips Lake in late February I was able to share much of what we had talked about in Wutank. Unfortunately, this session in Phillips Lake was not recorded due to unrecognized dead batteries so I am unable to recount much of the substance of the conversation on this particular day. What is significant about this day is that on my way home in the car, some big ideas began to emerge in my mind that I felt could provide a guiding structure for the findings of this research. In reflecting on the conversations as I drove home, themes began to emerge. These themes were not all perfectly clear on the day but they would eventually become solidified as learning from language, ways of knowing, values, and cultural connections.

I had many opportunities in the following months of our work together to investigate these themes with participants and get feedback. I found that with each after school session the themes became even clearer, and participants felt these ideas truly captured the essence of our conversations. Many of the details of these conversations are illustrated in the upcoming chapters.

On May 28, 2008 I was invited to attend a professional development day in Wutank to talk about the work we had been doing throughout the year and recount our ideas to all teachers, both participants and other staff who had not participated in the research sessions. The principal from Phillips Lake School was also in attendance. As I described the themes and talked about what this might imply for teaching of mathematics, I found the staff to be very receptive. They were excited to see the model coming

together (see figure 2) and all agreed that the school should take a greater focus on these ideas and their implications for mathematics in the future.

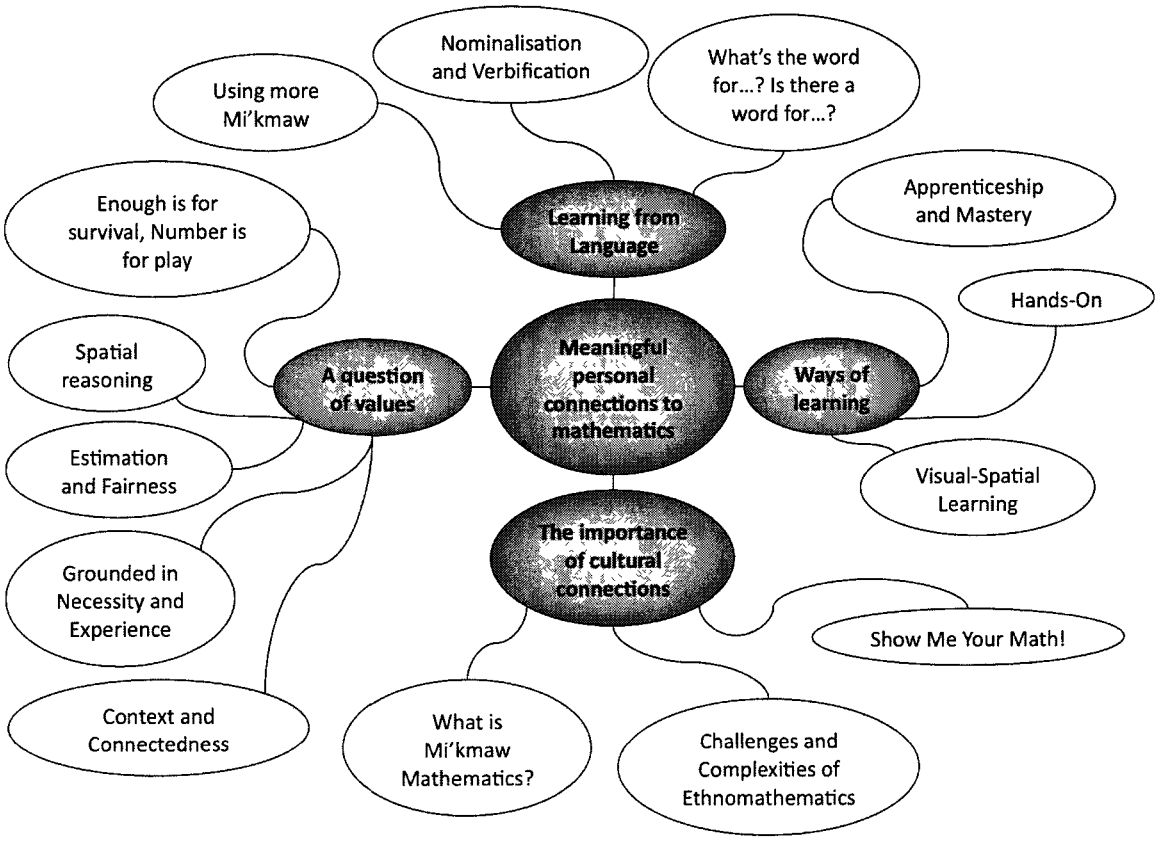

***Figure 2*: Model of themes with sub-themes**

In the following chapters I detail the themes. One idea that had taken a dominant place in our conversations was the role that Mi'kmaw language can play in helping teachers to better understand student reasoning and also provide insight into pedagogical strategies. This notion is elaborated in chapter 5. A second idea that we often returned to was a question of values, in particular, how Mi'kmaw values and the values embedded in school-based mathematics often conflict. This is elaborated more in chapter 6. In chapter 7 I address some of our conversations around the visual and spatial ways of thinking and learning and the related pedagogical implications. Chapter 8 contains an exploration of the fourth theme that mathematical reasoning is part of Mi'kmaw ways of knowing and

that there are many connections that educators can make between daily community practices and mathematics. I refer this chapter's contents back to the other chapters to demonstrate the interconnectedness of the ideas. Chapter 9 is a presentation of some emerging questions and future directions for this work.

The Importance of Mawikinutimatimk

Before moving to the description of the themes, I come back to the journey of *mawikinutimatimk.* In this chapter I have attempted to describe some of our moments of learning together to give a sense of how the research journey progressed. It is important now to discuss the value of this process to the project and also to describe how the diversity of the contexts enabled a greater richness to the study.

As stated in chapter 3, *mawikinutimatimk* enabled the group to establish a context in which everyone has something to learn and everyone has something to share. There was a great deal of sharing between these two schools about the moments from the classroom that gave insight into children's thinking and presented all participants with ideas for various pedagogical strategies that might support their students. Advice flowed often through me as the intermediary but this later evolved into some ongoing PD happening with all schools within MK, with the two principals, Emily and Ellen, taking the lead to organize these PD sessions.

Expert culture and language knowledge emerged in the Wutank context and some of this knowledge has been highlighted in this dissertation. The Phillips Lake group provided expert insight into the situation for many First Nation schools in this country. This is a relatively new school. It competes for students with neighbouring public schools, and most importantly, because it is only a K to 6 school, it is faced daily with the

pressure of having to prepare its students for the public school system that has little interest in the decolonization of education. This experience is common for about half of the MK schools in Nova Scotia and for many other Aboriginal schools across the country.

The stories of complexity that have emerged from Phillips Lake have provided this research project with insight into the challenging nature of the tensions that emerge when schools are faced with external systemic pressures to be the same, while they strive at the same time to provide culturally responsive education. Many teachers in Aboriginal schools across the country will identify with the tensions experienced by the teachers in Phillips Lake.

The participants in Wutank could also identify with these complexities. They too face external pressures from the provincial school system but perhaps are somewhat less affected than those in Phillips Lake because Wutank is a K to 12 school. Yet, they still have provincial assessments that are administered in their schools. This brings about frequent questioning concerning quality in relation to the provincial system from both within and outside the community. Students who graduate from Wutank go on to the same colleges and universities as provincial graduates, thus, there is pressure to meet provincial standards for admission.

Because the Wutank school has existed in the community longer, they were able to give some advice to Phillips Lake about how they had faced similar challenges, although they also knew that for each community the path to "success" may be quite different. Although the two staffs never had the chance to talk together during the research session, my role in the two schools facilitated greater communication between

the two groups which enabled the two schools to build a stronger bond and they are now working together more closely on projects.

The ways in which Phillips Lake chose to use our time together offers a lens into the possibilities for a small school beginning to take decolonization seriously through initiatives to include more Mi'kmaw language and culture while seeking ways to strengthen ties with the community. To this end they chose to take steps that would move along pedagogy and would move them closer to connecting with the community. The parent night held during our last session proved to be just one of the wonderful examples of this project. During one of our afterschool sessions we brainstormed some ideas of fun mathematics games and activities we could do with parents and children. The staff took the lead in preparing the activities and inviting parents, and I returned to enjoy the evening as a participant. While some of the staff commented that the number of participants was low, what was truly amazing was to see parents playing mathematics games with their children and the teachers in the school. It was a wonderful sight to see and was a positive experience for everyone involved. When I shared this story with the Wutank group they thought it was something they should do as well. I have recently learned that Phillips Lake has hired a B.Ed. student from the community to make these family math nights a regular event.

It was significant to this project to connect these two contexts because it helped me to see that each context is unique and must progress at its own pace and in its own way with the supports they have at hand. True to the spirit of *mawikinutimatimk*, each group—and probably each participant—moved thinking along. Although we did not all end up in the same place, each took from the experiences what they were ready for and

what they needed. In recent informal discussions with participants from both schools I see that they are continuing to reflect on the work we have done and are hopeful to continue our discussions in the future.

In the following chapters, it may seem that the stories from Wutank play a more dominant role than the stories from Phillips Lake. I want to make clear that this is not to discount the conversation and developments in Phillips Lake. This dissertation is ultimately about my own journey of discovery. The experiences in Phillips Lake were important to my learning because they allowed me to revisit some of my own early struggles with integrating cultural knowledge and provincial curriculum, and they allowed me to be always mindful of the complex nature of contexts where the external pressures of the provincial system are ever-present. They also led me to synthesize some of the discoveries from what could be seen as the more decolonized context of Wutank and bring them into the still more colonized context of Phillips Lake. In Wutank, I was often positioned more as a learner who sought answers to her long-standing questions. Both the existing tensions and the new insights into old questions are embedded in the sections to come.

CHAPTER 5: LOST IN TRANSLATION: UNDERSTANDING THE CONNECTION BETWEEN MI'KMAW LANGUAGE AND MATHEMATICS

> A proper understanding of the link between language and mathematics may be the key to finally throwing off the shadow of imperialism and colonialisation that continues to haunt education for indigenous groups in a modern world of international languages and global curricula. (Barton, 2008, p. 9)

"You should call your paper 'lost in translation'" Emily said as we talked about some of the emerging themes from our work, "That's what happens" (W8). On the surface, her statement points to the many difficulties in translating Mi'kmaw to English and vice versa; however, as she explained later, the true meaning of her statement was something much deeper. She talked about the difference between *Lnuitasi* (Mi'kmaw ways of thinking) and *aklasie'witasi* (Anglophone ways of thinking) and talked about the fact that even some Mi'kmaw people have become so colonized that they have now changed their ways of thinking to *aklasie'witasi.* She felt that many conflicts arise for children when their ways of thinking (*Lnuitasi*) come into conflict with teachers who have different ways of thinking (*aklasie'witasi*). There is something being lost in the translation of worldviews, of ways of thinking and styles of communication. Emily sees the conflicts arising on a daily basis as the students in her school struggle to find their way through a colonizing curriculum. Something is being lost in translation and she is searching for ways to resolve this challenge.

In this chapter, I explore the connection between Mi'kmaw language and mathematics. Barton (2008) has claimed that "mathematics and language develop together" (p. 142), that "mathematics is created in the act of communication" (p.144), and

that "each language contains its own mathematical world" (p. 144). From this argument, given the profound difference between Mi'kmaq and English, it makes sense that Mi'kmaw learners would have difficulty understanding school-based mathematics that has developed with English at it base. It is, therefore, essential to explore the mathematics embedded in the Mi'kmaw language to better understand the ways in which M''kmaw learners may be supported to understand and use mathematical reasoning.

In considering the topic of language, there were many emerging ideas that are distinct and yet complementary in many ways. Firstly, the Wutank group want to include more M'i'kmaw language in the mathematics classroom. This group in particular stressed the importance of reclaiming mathematical words and supporting Mi'kmaw-speaking teachers to develop a lexicon of words that could be used in their classes. Secondly, a great deal can be learned from studying the structure of the Mi'kmaw language even for non-speakers. In particular, this notion included a multi-layered discussion about what teachers, both speakers and non-speakers, can learn by asking questions such as "What is the word for…?" or "Is there a word for…?" Thirdly, a closely related idea focused on investigating discourse patterns and the ways in which the Mi'kmaw language is structured. Further in this chapter I elaborate on these ideas and raise some key questions emerging from this exploration.

Including More Mi'kmaw language in the Mathematics Classroom

I recall one day when I was still teaching in Wutank, I went to visit a friend after work. I was sitting in her kitchen talking with her about something that had happened at school that day. While I do not remember exactly what the topic of conversation was, I remember that at one moment I had used the word *reciprocal* and she asked me what that

word meant. I gave her a number of different explanations but she did not seem to understand me. Just then her husband came into the kitchen. Seeing my struggle and her confusion he asked what we were talking about. I told him I was trying to explain the term 'reciprocal' to her. He smiled then turned to her and said one word in Mi'kmaq, and she said "Oh!" and seemed to understand the concept. If only I had been able to do that.

This story is not uncommon. On our very first session together in Wutank similar stories were told by many participants. Elaine in particular commented on the way in which her students often do not understand what she means when she says "How many?" but noted, "say '*Tasikl* (how many – inanimate)?' and they get it." (W1) The reader will see this pattern arising again in stories in this chapter. As we gathered in our after-school sessions, this type of story would be told and retold in new contexts with new characters but the moral was always the same, when it is said in Mi'kmaq, there is greater understanding. What does this mean for the teaching of mathematics in Mi'kmaw schools? Why are many of these schools not striving to include more Mi'kmaw language?

It has been my experience that the "I said one word in Mi'kmaq and s/he understood" story often gets countered with the "but they come to school speaking English" story. There is an assumption that because students are coming to school speaking English they are also coming to school thinking English. There is also an assumption that because students are not speaking Mi'kmaq they do not understand Mi'kmaq. Both of these assumptions are not necessarily true.

Let me address the latter assumption first. Many students are coming to school speaking English, yet there is a good chance that at home they are still hearing some

Mi'kmaq, in particular when it comes to everyday words like command words. Even in predominantly English-speaking homes in Mi'kmaw communities, parents are likely to ask their children to come in, sit down, close the door, help out, listen, behave, and so on, with Mi'kmaw words.

Furthermore, there is a comfort and ease that comes when the children hear their language being spoken. Many participants recounted stories of having conversations with children; sometimes the children would simply not open up about what was bothering them when they were being spoken to in English but as soon as an adult would ask "*telatiken*?" (What's wrong?), the child would instantly open up and begin sharing his/her story. Similarly, participants recounted stories of the difference between asking students in English to work versus asking them in Mi'kmaq; the participants always found the Mi'kmaw request received a much better response. Such an example is given in the passage below:

Emily Sometimes you tell a child "Ok, *Lukwaten, apa ke' apa*" (work again, please again) – they'll do something for you again but if I say it in English "Okay let's read it again" –un uh [Shakes her head no] but "*ke' apa, ke' lukwatamuj*" they're more ahhh [let's out a sigh of relief indicating a level of comfort or ease].

Richard: They're not even thinking when you say that to them.

Emily: No. So they'll do it again with ease, rather than "let's read that again." It's that whole language.

Carol: Even if you think about these kids, *msit wen* (everyone) um, "Sit down and do your work!" Say that in Mi'kmaq "*ke' pasi aqq*

lukwatenuj" (Please sit and do your work). It's totally, um, *jiksituinul Lnuiktuk* (it's better when you hear it in Mi'kmaq) "*ke' pasi*" (please sit) 'cause there's no threat

Richard: There's no order.

Emily: But I think that language is still used in the home, I think that's the language, but it's so direct *nike* (now), there's no conversation to it, which is probably what we're missing in the home. *Aknutimaq wenaq* (people are not communicating with each other using the language), that's missing but that direct language is still used a lot in the home. You tell any child "*ke' lukwatinuj*" (please work) and they'll know exactly what you are saying. (W2)

This passage draws emphasis to the sense that English is perceived as harsh and threatening, especially within the context of school, and that when Mi'kmaq is used the children feel much more at ease and are much more likely to participate in what they are being asked to do. Additionally there is an emphasis on the fact that these are words that are still being used at home. Thus, the notion that children are speaking English and therefore should be spoken to in English is quite likely to be damaging to students who may actually benefit greatly from hearing their own language and being addressed in their own language.

In the Wutank site in particular, there was a strong desire to include more Mi'kmaw language in the mathematics classroom, and although the group acknowledged that there were some challenges to achieving this goal, they seemed committed to working toward this end. In Phillips Lake the situation with language was different. As

stated in the previous chapter, the teachers in this school were all non-speakers and not members of the community. While many of the staff seemed interested in learning the language, and Amy often tried to use simple Mi'kmaw words in her classroom, they acknowledged that they currently did not have the capacity to teach mathematics, or many other subjects using Mi'kmaq.

It is interesting to speculate about how a teacher like Amy, or any non-speaking staff member, might benefit from learning some of the simple Mi'kmaw phrases that the Wutank group talked about in the preceding passage. I know from my own experience that learning some basic words in Mi'kmaq for "come in," "sit down," "thank you," and so on, seemed to strengthen the relationship between myself and my students. Perhaps in a community like Phillips Lake that expressed a need for more language resources, helping non-speaking teachers to learn such phrases might be a reasonable first step.

Ellen expressed an interest in increasing the teaching of Mi'kmaq in Phillips Lake in years to come although she also acknowledged that there are challenges. This community has a significantly smaller percentage of Mi'kmaw speakers and thus it is difficult to find speakers to help with the language program. Despite this, I noticed that in my own interactions with the children, I often used Mi'kmaw words such as *wela'lin* (thank you) and *tepiaq* (enough – in the context of "that's enough") and the children seemed to respond positively to these. Similarly, Amy's P/1 class seemed to take great pride in using the Mi'kmaw shape words they had learned for their *Show Me Your Math* projects. Ellen told me that many parents were responding positively to the Mi'kmaw language learning that was currently happening in the school and hoped that she would

find ways to continue to improve this program. So, what will happen with language in this community remains to be seen but it does seem hopeful.

Due to the limited use of Mi'kmaq in Phillips Lake, the description in this chapter focusing on Mi'kmaw language use in the classroom draws primarily from the experiences in Wutank. I reiterate that this ought not to discount the efforts being made in Phillips Lake. Rather, it raises the question of how communities with limited language resources can be supported to reclaim their language. I revisit this and other related questions in chapter 9.

Addressing the Challenges of Teaching Mathematics in Mi'kmaw

It is one thing to say we should teach mathematics in Mi'kmaw; it is an entirely different thing to see that through to reality. There are many challenges associated with such an endeavour. Although neither of the participant schools has full instruction in Mi'kmaq, there are some other schools within MK that now provide Mi'kmaw immersion in the early grades. Some work has been done in these schools to develop mathematics words for the immersion classes, yet it is acknowledged that mathematics continues to be a challenge. These challenges will become more apparent throughout this chapter. I outline some of the challenges that arose in our research conversations in this section.

One primary concern is that even the teachers who have grown up speaking Mi'kmaq have learned mathematics in English. Although these teachers feel quite comfortable including everyday Mi'kmaw words in their daily classroom activities, many of them were not familiar with the Mi'kmaw words that would be used to describe mathematical concepts. Furthermore, as evidenced by the work of Barton (2008), Denny

(1981), and the work in this project that will be elaborated on later in this chapter, the concepts may not easily translate or may not exist in the same way in a different language, especially when the languages are so vastly different as they are here. The participants in Wutank agreed that there was a need to talk about Mi'kmaw words for the mathematics classroom.

Throughout our conversations we were able to generate lists of some Mi'kmaw words that could be used to describe concepts in school-based mathematics. One day in particular, I had brought along a list of activities that we do at each grade level in an effort to help us decide what to focus on in our sessions. When Richard looked at the paper he began to translate: "*tepkisotim*, sorting; *mawkitimul*, counting" (W2). He became, as we knew he would, a vital resource in developing our list of words. The participants found his descriptions to be very beneficial as they had not known many of these words. In learning them, they found themselves thinking about mathematics differently. These conversations proved to be fruitful for many reasons that are described later in this chapter. Participants, however, felt that we need to do much more of this type of work as they were aspiring for a truly bilingual mathematics classroom.

A second challenge that was presented by the participants is directly tied to the first challenge. If the Mi'kmaw speaking teachers are not familiar with these mathematical words then it is likely that the children are not familiar with them either. This is an important challenge to address and it may be responded to in at least two ways.

First, Emily had already communicated her belief that many children are familiar with and hear at home many Mi'kmaw words that can be built upon to help them to develop a deeper understanding of mathematical concepts. Children may not come to

school knowing the Mi'kmaw words for these concepts but they also do not come to school knowing the English words for these concepts—they are taught the English words. Why is it acceptable to use the new English words but not the new Mi'kmaw words? I would argue that students are more likely to have some conceptual understandings that will help them connect better with the new Mi'kmaw word than the new English word.

Second, Mi'kmaw communities have been undergoing efforts to reclaim and revitalize the Mi'kmaw language. If Mi'kmaw words are avoided because children do not come to school knowing them, then when will these children ever learn them? Failure to make use of these words will guarantee their loss. If they are used, they will survive.

The argument that I present in favour of using more Mikmaw language may not be received easily by teachers. Being mindful of the external pressures discussed previously, I was aware that many teachers worry about what might happen when the students go to another school where they will need to know the English words for things. Sarah expressed this concern even about that language she uses in class: "I worry if I open it up too much they're not going to get those key phrases and I don't want them to be lost in middle school" (PL1).

In Wutank, the students are fortunate enough to be able to attend school in their own community up to grade 12. In Phillips Lake, however, the students move to public school after grade 6. Whether students are enrolled in mathematics classes at university or in middle school, they will need to be familiar with the English terms for mathematical concepts. The argument to use more Mi'kmaq does not negate the need to learn English terms, but rather it is to suggest that teachers must build from what students know and are comfortable with (i.e., the Mi'kmaq) to what they do not yet know but will need to know

(i.e., the English). Thus, in suggesting that teachers use more Mi'kmaq in the mathematics classroom, I simply argue that the education system needs to help students build the concepts in their first language first and then teach them the corresponding English terms.

Speaking bilingually in this way enables the students to approach these concepts from a dual perspective. This need to reclaim language and move toward the notion of duality was expressed quite eloquently in the passage below:

> Richard: We need somebody to push us into that, back to our language somehow, some way. That's why I keep pushing people into Mi'kmaq. I will speak English in my class but now and then, if I am one on one with you, I will speak in Mi'kmaq and then if you say "Well I don't understand" then I will repeat it in a different way and then I will translate it.
>
> Emily: And that's the thing and that's why I think Wutank is on the right track. We are a dual society, we have to speak dual. *Lnuimultis, Aklesie'wimultis, apaj Lnuimultis, apa Aklesie'wimultis, nestuwitis.* (Say it in Mi'kmaq, say it in English, then again in Mi'kmaw, they will understand.) You can't have one without the other. More Mi'kmaq than without. *Aklesie'wiktuk* (in English), we tried it, it doesn't work. *Lnuimultis, Aklesie'wiemultis, Lnuimultis.* (W8)

Another challenge is that many of the teachers are English speakers. Maureen, a second grade teacher, expresses her frustration with not being able to say words in Mi'kmaq:

Maureen: The thing I find hard is that if I'm in the room by myself, obviously, I cannot speak Mi'kmaq. I wish I knew…I should think prior to when I'm doing something…And then like with geometric shapes, I'm naming stuff but like I wish I had somebody in here that could say it in Mi'kmaq so they could tie that in like there might be things that I'm not thinking of that I could be making connections with…I wish there was a Mi'kmaw math representative that I could get in here while I'm doing it and I could say okay I'm going to need you here on Tuesday. (W3)

Maureen's frustration in not being able to name things in Mi'kmaq and her desire to have someone in her classroom to support her is something I felt myself early in my career and a sentiment shared by many non-speaking teachers. There is a need to have partners in the classroom who can speak the language and who can help the teacher to make the classroom a more Mi'kmaq-friendly environment.

Many participants agreed that teacher's aides who were fluent speakers could be made available to non-speaking teachers during mathematics time as a support. This then becomes a whole school initiative, where it is not enough to work with teachers; support staff must be included as well. At the Wutank site, many of the support staff participated in our after-school sessions which enabled teachers and support staff to have productive exchanges about how to have these ideas come to fruition.

Additionally, as I know from personal experience with learning the language, a new depth of understanding can emerge when non-speaking teachers engage in conversations with speakers about the words that can be used to describe mathematical

concepts. In addition to learning the Mi'kmaw word for a concept, understanding how the word is structured and how it might be used in context in Mi'kmaq helps the non-speaker to gain insight into the worldview that is embedded in the language. Such understanding can be highly beneficial to teachers in their teaching of mathematics. I describe these benefits in much more detail in the next sections.

Learning from Language

In the opening paragraph of this chapter, I conveyed Emily's claim that it is incorrect to believe that students who speak English also think English. In my teaching experiences, the faculty at my school had spent many of our professional development hours considering this issue. Through conversations with community members and Mi'kmaw education experts, we became aware that many Mi'kmaw students have grown up speaking English, but they were being taught English by parents who were either Mi'kmaw speakers or who had been taught to speak English by Mi'kmaw speakers. Thus, even though they spoke English, the grammar structures they used and the ideas they expressed would be much more consistent with the Mi'kmaw language. For my own professional development, this was a profoundly significant observation that I realized in hindsight, but I believe can greatly impact the teaching of Mi'kmaw students.

A Mi'kmaw speaker has Mi'kmaw grammar structures and Mi'kmaw ways of expressing ideas. When these Mi'kmaw speakers teach their children to speak English they will teach using these Mi'kmaw ways of expressing ideas and Mi'kmaw grammar structures. Thus, Mi'kmaw children who speak English are not using that English in the same way as someone with English grammar structures and English ways of expressing ideas. And it is problematic to assume that Mi'kmaw children who speak English also

think with English structures, even if they have limited Mi'kmaw vocabulary. I suggest acknowledging this distinction and learning from it can have potentially promising effects for Mi'kmaw learners.

Denny (1981) and Barton (2008) have made the argument that having educators study the structure of indigenous languages can give insight into ways to support mathematical understanding for indigenous students. Through studying Mi'kmaq and the ways in which concepts are talked about (or not talked about), teachers can gain insight into the worldview that is embedded in the language. Such insight can broaden understanding of mathematical concepts and can provide new strategies to bridge the space between school-based mathematics and Mi'kmaw concepts of mathematics. Furthermore, understanding the grammar patterns of Mi'kmaq can provide useful resources for transforming mathematics education for Mi'kmaw students. In the following sections I detail some instructive stories that emerged as we attempted to learn from language.

What's the Word for...?

In my own teaching I often found it beneficial to learn Mi'kmaw words for mathematical concepts. Often, I would ask for words and occasionally I would discover that either the word did not exist or it was much more complex than I had anticipated, as in the case with learning how to count. No matter what the result of my inquiry, I found the mere discussion had a profound effect on deepening my understanding of how my students might view mathematics.

Many of the research participants agreed that in order to better understand mathematical concepts our group needed to explore the Mi'kmaw ways in which we

talked about these concepts. Richard proved to be a particularly helpful participant for this purpose as his knowledge of the language was often called upon. Many of our sessions would turn into mini language classes with Richard sharing his knowledge. In this section I outline some of the words we explored and unpack them to show how we were able to use these words to make sense of concepts that participants felt their students were struggling with. Later, I give some examples of English words that have no Mi'kmaw translation and some of the resulting conversations that arose from these discoveries.

Often, the discussion related to Mi'kmaw words would arise naturally from a discussion about a mathematical challenge teachers were experiencing. Such an example arose when we were talking about fractions. Fractions are difficult for many children to learn. Yet through our conversations, we explored words that many children often hear at home when being asked to share treats with family members or friends. Richard explained "*pukwe*' is part of something but when you say *aqatiyik* that is half of it … now if a child understood Mi'kmaq very well, it'd be a lot easier for them to understand." Emily agreed, claiming "I was just thinking when you say *pukwe'*, that language is still used in the homes *pukwe' iknumi kandiamul* (give me a piece of candy) you still hear that … it is used for everyday language." (W2). It was suggested that using these kinds of words might help students connect more with the often challenging concept of fractions.

This idea of rooting to and learning from the home language has been advocated for in the literature on mathematics education in multilingual classrooms (Moschovich, 2002; Setati, 2005). In much the same way, one day when we were engaged in a

conversation about multiplication and division, we again found ourselves reflecting on how these concepts might be talked about in the home.

Both schools, like many elementary schools, were struggling to help students to learn multiplication and division facts. Emily expressed her frustration over this challenge, claiming "So multiplication, that's something that drives me nuts. I feel sorry for the kids because that either makes or breaks you as a mathematics student" (W2). This prompted Ma'li to recount a scenario she had witnessed recently in the class where she was assigned. Ma'li is a teacher's aide from the community and at the time was a part-time Bachelor of Education student.

Ma'li: Well, I was in the class last week and there was a substitute that came in and the teacher said we were going to do division; we had these worksheets to do. Anyway we got into class and the kids had a hard time with division; they weren't at that level yet, when I was observing. So the substitute took them back to multiplying. First she asked them "Why are they dividing?" and the kids couldn't respond and then after she explained why they would divide and then they were talking about the chocolate bars and how they were divided into so many pieces. And after that we went back to multiplying and they were having a hard time like, you know, where you put your ones and your tens, they were struggling, kids were still struggling, like with multiplications.

Lisa: Like with traditional algorithms, like, were they struggling with the rules or are they struggling with the concepts?

Ma'li: The rules, yeah, the rules? Yeah they were struggling with the rules and they didn't know their multiplication. So that's what I observed in one of my math classes.

Richard: Maybe you should have the word divide coincide with the word "share." You know it'll be a lot easier to focus on that idea of why am I dividing. Oh ok, I'm dividing because I want to keep this much and give this to Catherine, give this to Emily and then it would be all even but when you're talking about multiplication, well (pause) like where does it go? You get mixed up. Like there's the concrete factor about dividing but multiplying, like, where does that come? The only place where a person would see multiplying is like, when you have cats at home (laughter) that's multiplying. You know there is no other way how you can picture multiplying, but dividing yes.

Maureen: But they need to understand multiplication before division. You know they have to have that as their....

Emily: Maybe. Uncle would you say maybe? We really don't need to know, your multiplication, if you took -

Lisa: That's an assumption

Emily: That's an assumption, yeah, if I divide -

Lisa: We say that in school math

Emily: Maybe we're teaching it all wrong. Like I'm not going to say like I'm right and they're wrong but...

Lisa: But you're having a good thought so you're going to go with it.

(Laughter)

Emily: So I have a brainer (excitement in voice) so we're going to try it, especially because when Uncle said it - that's how I learned

Richard: Umhum

Emily: And who taught me was Dad. Mom sat with me all the time at the kitchen table all the time and said "the only way you're going to enjoy multiplication is you've got to memorize, memorize, memorize," because she's a teacher. Dad said "what are you trying to learn?" Dividing. And Dad says "okay you have a big number, Emily, and you've got to share it equally okay, you've got to share it with your *kikmaqk msit* (all of your friends)" and I said geez, then I would be okay, seven, I have 21 pieces and I need to share that 7 times, how many people could I share that with, if I had seven pieces, I wanted to share, 3. So I work backwards when I do multiplication, 7, 21, 3 and I go backwards, 7 times 3 is 21, and that's how I remembered multiplication.

Richard: Umhmm, and that would be something similar to the way I think, I work backwards, then I get the answer. (W2)

Although there are no specific references in this passage to Mi'kmaw words, the Mi'kmaw ways of thinking are emerging. Richard's thought of working backwards can be traced back to the language. He subsequently explained to us the word *nesinemikatun* which means "divide it into three parts." There are similarly constructed words for share it in four parts (*newinemikatun*), and five parts (*na'ninemikatun*). The notion of fair

sharing is embedded in the word and it is this notion of sharing that led to Richard's suggestion that learning to divide might make more sense than learning to multiply. Understanding how a number can be broken into equal groups can help students to understand their multiplication facts. Since sharing seems much more natural and is spoken about in the language, it seems like this is a natural point to begin in constructing the concepts of numeracy associated with multiplication and division.

Another interesting observation about the word *nesimenikatun* is that the preposition is embedded in the word. There are no stand-alone prepositions in the Mi'kmaw language; instead prepositional components are built into the word. Barton (2008) has described the complexity of preposition use in mathematics and commented on how difficult subtle differences in preposition use must be for students who are English language learners. This is especially true if one's first language does not contain prepositions.

I am reminded of a conversation I once had with a student in one of my mathematics classes in 2004–2005 when I was teaching grade 8 Mathematics. She was working at a problem and she asked me "Okay miss, now I take that number and divide it into six?" I knew that she was taking a large number and dividing into six equal groups so I responded "Right!" I wonder how many teachers would have told her she was wrong, and I wonder how that would have impacted her view of herself as capable of solving the problem. In conventional terms we would describe what she was doing as dividing by six not into six, but her sentence was structurally consistent with the grammar of her own language. Her expression made perfect sense and was, for her, the appropriate way to talk about this concept. Given Barton's (2008) claim that mathematics and language develop

together, the ways in which mathematical ideas are expressed will be consistent with the grammar structures of the first language. This point is addressed in more detail later in this chapter.

A possible future project may be to continue to explore the mathematical words in Mi'kmaq, an idea which I will return to in chapter 9. I have included only a few Mi'kmaw words here to give some examples. Other interesting Mi'kmaq words are embedded throughout this thesis, but developing the complete mathematics register for Mi'kmaq is a much larger project than the scope of this research.

Is there a Word for...?

In addition to knowing the Mi'kmaw words for concepts, it is also helpful to know when the concept does not have a direct translation. As Barton (2008) argued:

> Different concepts are expressed in different languages, and some concepts are extremely difficult, some say impossible to translate between languages. The implication is that different quantitative, relational, and spatial concepts may also not be easily transformed into each other. (p. 69)

If a mathematical concept does not have a direct Mi'kmaw translation, then it is likely that the concept is not part of the everyday language of the child. The result of this can mean that a concept that is thought to be quite simple in mainstream mathematics can in fact be quite complex for the child who is unfamiliar with the concept. This is an example of the type of taken-for-granted assumption of the school curriculum that may lead many Aboriginal students to have challenges with the subject matter or to disengage from it as has been discussed in the literature (see Cajete, 1994; Lipka, 1994; Nicol et al., 2006;

Yamamura et al., 2003). An awareness of these potential conflicts may help teachers to mitigate them.

The word *flat* is one example of a word that has no Mi'kmaw translation. I have asked on numerous occasions if there is a word for flat and I have attempted to generate scenarios whereby we would need to use the word flat. I asked about a flat tire but I was told that in Mi'kmaq we would say it was losing air. I asked about the bottom of a basket, suggesting it was flat, but I was told that it was the bottom; it had to be flat so that it does not roll around. Understanding that there is no word for flat enabled us to think differently about how we describe a flat surface in mathematics.

An interesting connection to this notion occurred for me during a grade 3 lesson on prisms and pyramids (W7). This lesson is described in more detail in the next section of this chapter. As we sat on carpet with students and asked them to say one thing about the prism that was being passed around, one young girl placed the prism on the floor and stated "It can sit still!" Instantly I began to get excited by her answer. It made perfect sense that she would not talk about the flatness of the face but rather its usefulness. This connects directly to the relational way in which Mi'kmaw language is used and constructed. When I later recounted this story during an ad hoc session at the Canadian Mathematics Education Study Group Conference in Sherbrooke, Quebec (May 2008), Whitely (personal communication) mentioned to me that the word polyhedron actually is derived from the Greek word *hedron* which means "seat," and polyhedron means many seats or many ways to sit.

There were other concepts with no direct translation that we grappled with as well such as *more* and *less*, which are often seen as foundational in school-based mathematics.

These words often present stumbling blocks for Mi'kmaw learners. During one session, Ma'li explained a challenge that she had encountered while helping a student in class deal with the ideas of more and less. Richard added his own insight on how in the English language we also tend to put these seemingly contrasting words together to make expressions such as the expression "more or less" often used in informal speech to answer in the affirmative. The group found humour in our conversation and we reflected on the conflicting ways in which words are often used in English.

Ma'li: Like for instance today I worked with a student and the question was more and less. *Ni'n* (Me or I), when I was young I had a hard time with word problems, I didn't like them and *lpa kesatimu* (I really don't like them). Word problems. And, okay, for the words *more*, okay, I made the plus sign and for *less* I made the take away sign, and he knew just by that. Little thing *kutay kejitoq me'* (It looked like he understood more). "Oh yeah okay" so then he goes this way.

Emily: And that goes back to Uncle with the concrete.

Richard: And you put those two words together in speech.

Emily: More-or-less

Richard: You get confused "more-or-less" (Laughter)

Emily: There's a lot eh, no wonder we make our kids confused uh? (Laughter) But I was thinking the same thing but that's what we would say "more-or-less".

Richard: Same-difference. (Laughter)

Maureen: No wonder we make our kids confused. (W2)

While the group had found humour in the ways in which we use these words in English, it is true that these concepts can be confusing for children who do not hear them as part of their daily language. During an ensuing discussion, this issue rose again and we inquired as to how these concepts might be translated into Mi'kmaq and several words were suggested, although again, we returned to the notion that context matters and that how we talk about *more* and *less* really is dependent on what we are talking about.

As with *more* and *less*, it is not always the case that a direct translation does not exist but occasionally a concept may be spoken about differently depending on the context. Some terms that are considered universal or commonplace in English may be more complex in Mi'kmaq as outlined in the conversation below. In this transcript we see that Donna arrived for the conversation on this day ready with a question. She and the speech language pathologist had encountered difficulty when working with a student on an assessment earlier in the week. The child had been asked to point to the object in the middle of a row to assess language processing skills. When the child could not perform this task, Donna wondered whether the child had difficulties processing the language or whether the child simply did not understand the word *middle*. During our conversations in her classroom earlier in the day, she had talked with me about this matter and explained that once she had explained the term and provided the child with some experiences of middle, he was able to execute the task of pointing to the object in the middle quite easily. She said that she wanted to know if there was a word for middle in Mi'kmaq.

Donna: This is my question: In Mi'kmaq, if you have a row of something, right? So this is your row (lays out some forks in a row). This is

the first thing in the row, this is the last thing in the row and this is the middle of your row. It doesn't have to be forks, it could be anything.

Richard: *Amskwesewey* (points to first), *kespitek* (points to last), *mukoqiekewey* (points to middle).

Donna: Okay, so if you say to someone to go get something on the middle shelf?

Richard: *Mukoqiekewey.*

Donna: Would you say it's in a row?

Richard: Not necessarily.

Donna: Yeah, and this is a concept that the kids are trying to get in math right. You're looking at a row and you're asking them: What number's in the middle? What's the first number? What's two more than that number? Those kinds of things and, I mean…

Elaine: *ketloq pemankitekl*?

Richard: Ah, not necessarily, you could, if you had a page of…

Elaine: It depends what it is.

Richard: Yeah. You could use that word *pemankitekl*; if you know what's right there you can say *pamankitekl wula tekn mukoqiek etek.*

Elaine: Or *ke'kwitekl.*

Richard: *Kisna ke'kwitekl.*

Elaine: When you say they're on the shelf: *ke'kwitekl.*

Lisa: *ke'kwitekl*?

Elaine: They're there right?

Richard: Yeah, if they're **on top** of the shelf.

Lisa: They're there and they're on it?

Elaine: If they're not in a row then you wouldn't say that. *Kekwite'k*: They're up there.

Lisa: So can you ever imagine a scenario whereby you would need to talk about something being in a row in Mi'kmaq?

Richard: I probably would have to say *pemankitekl.*

Lisa: *Pemankitekl*?

Richard: *E'e, pemankitekl*: in a row…Same thing with days of the week; days of the week are *pemankitekl*

Lisa: So are they in a row or are they in a cycle?

Richard: Well, you already know that they're lined up; they're one after the other.

Donna: Right, so it's a word you wouldn't typically use. (W5)

While it may not be necessary for a non-speaking teacher to know all the different Mi'kmaq words that could be used to talk about the concept of middle, it is helpful for these teachers to understand the potential for unexpected layers of complexity that may emerge for students as they struggle to understand such a concept. This example of discussions that occurred often, points to a need to have non-speaking teachers engage in this type of conversation to enable them to better understand why the students may have seemed confused by words that many English speakers would take for granted as known.

When this type of language conversation happened, participants seemed to become aware of the different ways in which relationships are explained in different languages. This exposes the taken-for-granted assumptions embedded in school-based mathematics and allows teachers to begin to question this hegemony. English language has a way of talking about middle and uses this word in a variety of contexts; Mi'kmaq has several different ways of talking about the concept of middle but none of these words directly translate to the word *middle*. Given this complexity, it makes sense that Mi'kmaw children may not find this concept as simple as the curriculum writers would assume it to be.

Although Donna has been working at this school for approximately 15 years and is familiar with the structures of the Mi'kmaw language, we can see from the example above that this conversation helped her understanding of the complexities that arise when we assume concepts are similar in English and Mi'kmaq. Similarly, after participating in our *Show Me Your Math* Professional Development day (SMYM), Amy told me that she had learned a great deal from listening to the conversations several elders and participants were having around Mi'kmaw language and mathematics. She told me that she had excitedly told the rest of the Phillips Lake staff about it when she got back and she expressed a great interest in having more opportunities like this. Ellen was also anxious to share with me the story of Amy's excitement after that session and also suggested that more of this is needed for her staff. (PL4)

It is noteworthy that the first-hand experience of hearing from elders impacted Amy in a much more significant way than the second-hand language information she and her colleagues had been receiving from me in our ongoing discussions. This again raises

questions about what supports might be needed in schools with limited language resources as they move toward decolonization.

Drawing on the notion of the importance of context, we spoke numerous times about the ways in which numbers may be used in Mi'kmaq. The words for numbers are conjugated based on the context in which they are being used. Mid-way through the research, I helped to organize a professional development day for teachers involved in the *Show Me Your Math* event. This was the session that had Amy returning to her school in Phillips Lake with such enthusiasm. Maria, a Mi'kmaw elder and language instructor attended this session. During this session she shared her thoughts on the topic of numbers:

> In Mi'kmaq there are not numbers as such. You say *ne'wt* which means once. If you talk about an animate thing you say *ne'wtejit. Ne'wt* and *Ne'wte'. Ne'wt* is once. *Ne'wte'* is when it is inanimate and *ne'wetejit* when it's animate. … in immersion we have a harder time in Mi'kmaq with that because you don't really teach 1, 2, 3, 4, 5; you have to teach fifteen numbers. In order to teach them you have to know what they go with too. (SMYM)

She went on to explain that difficulties emerge when simple mathematical ideas are translated into Mi'kmaq because often we tell children not that one plus two equals three, but that once plus twice equals three times. This can cause confusion for children.

Maria also explained that when problems are translated from English into Mi'kmaq there are often conflicts between what is animate and what is inanimate. She gave the example of adding apples and oranges. Apples are inanimate and oranges are animate in Mi'kmaq. If we want to add apples and oranges in Mi'kmaq, confusion results

because it will be unclear whether the answer should be animate or inanimate. Children would not know which word, the animate or inanimate version, would be used to represent the total.

The contextualized nature of the Mi'kmaw language presents layers of complexity for concepts that are taken for granted as simple in the school-based mathematics curriculum. Understanding the structure of the Mi'kmaw language and these ensuing layers of complexity can help teachers to rethink the ways in which they may teach some of these concepts.

The "Verbification" of Mathematics

Mi'kmaq is a verb-based language. In Mi'kmaq, words for shapes and numbers act as verbs. Other indigenous languages including Maori share a similar grammatical structure (Barton, 2008). Alternatively, mathematics as taught in most schools has a tendency toward noun phrases and turns even processes such as multiplication, addition, and square root into things (Schleppegrell, 2007). The dominance of English in school-based mathematics results in this objectifying tendency. "We talk of mathematical objects because that is what the English language makes available for talking, but it is just a way of talking" (Barton, 2008, p. 127). What would happen if we talked differently in mathematics? What would happen if we drew upon the grammar structures of Mi'kmaq instead of English?

It has been well documented in research relating to mathematical discourse that there is a need to support students as they move from everyday language to more formal mathematical language (Schleppegrell, 2007). While there is merit in this, for the purpose of my research, this approach does not go far enough. It is not simply a matter of using

everyday words, there is a need to go further and incorporate the grammatical structures of the students. It has been argued that mathematics could have developed differently and that "a non-objectifying mathematics is possible" (Barton, 2008, p. 127). In this case, given that Mi'kmaq is a verb-based language, I would argue that mathematical discourse in the Mi'kmaw classroom should draw on the extensive use of verbs. I refer to this possibility as the "verbification" of mathematics.

It may be difficult for non-Mi'kmaw speakers to understand how shapes and numbers can act as verbs, but in my own teaching experiences I often noticed students in my classes using nouns as verbs. For example, it was not uncommon to hear students say "camera me" meaning they wanted someone to take their picture. Although this expression may seem odd to an English speaker, it is completely consistent with the grammar structures of Mi'kmaq.

As I began learning more about the Mi'kmaw language, I realized the ways in which student discourse was more verb-based than noun-based and this led me to change my own discourse so that I would speak more with verbs than nouns. I am certain that I did this quite unconsciously initially, although I am also sure that I was listening to the ways students were talking and tried to model my language with similar structures. It was only upon reflection that I realized what I was doing. Students often understood better when I used more verbs and when we talked about how things were changing, moving, and so on. Within our group sessions in Wutank, this notion of using more verbs and understanding the ways in which motion is embedded in Mi'kmaq became a regular topic of conversation. I describe some of these discussions here and then describe ways in which this "verbification" can be enacted in the classroom.

There is a sense of motion embedded in the Mi'kmaw language (as noted in the previous chapter) especially as it pertains to shape words. I have personally spent a considerable amount of time talking with Mi'kmaw speakers about the word for triangle. The word *nesikk* is commonly used to mean triangle but many community elders have trouble with the word because, it seems from our conversations, it lacks this sense of motion. It is seen as a static shape and not in keeping with the grammatical ways in which shape would be described in the Mi'kmaw language. It seems to be a new Mi'kmaq word to represent an English idea.

Changing this grammatical structure is problematic as the structure impacts how a concept is visualized by a learner. Barton (2008) has reported similar challenges in attempting to translate mathematics terms into Maori. Richard imparted some thoughts on this issue:

> There is a sense of motion when you are speaking of shapes in Mi'kmaq. Like that there—*nesikk*—it doesn't mean anything but when you say *kiniskwikiaq* there is a sense of motion. Then we know that *kiniskwikiaq* means it sort of moves into the point, I can see it. (W9)

Maria, during the *Show Me Your Math* professional development day had suggested that it might be better to use the term *nesikkiaq* which has a sense of forming into three and thus maintains that sense of motion. When this observation was communicated to speakers in the Wutank group, all were in agreement that this word made more sense and there was a sense of motion in it. This connects back to Richard's discussion about straightness described in the previous chapter.

To understand how speaking more in verbs may be beneficial in the classroom, I return to a lesson about prisms and pyramids that I co-taught with Ma'li to a group of grade 3 students (W7). Ma'li had asked me to help her with her lesson and so, we sat together in the staff room and planned the activities for the students.

We decided to begin the class with the students on the carpet to explore what they knew about prisms and pyramids. As I described in the last section, it was on the carpet that one student told us that the cube could "sit still." We also used the carpet opportunity to re-introduce some vocabulary that the students would have learned in grade 2. They had already talked about the sides and the corners and a few of them had counted edges although this vocabulary term did not seem to be understood by all. I asked the students if they remembered a fancy word for corner that started with the letter V. It took a few guesses but we did get *vertex* eventually. I also said there is a fancy name for side and I held the cube up next to my own face. "What is this?" I asked fanning my hand in front of my face. They all shouted "Face!" "That's right," I said. "I use my face to look at you and the cube can look at you with all six of his faces." I rotated the cube a few times so that they could see each face looking at them in the same way I was looking at them.

I then wanted them to get the word edge but I was determined not to tell them. "Does anyone know what we call these parts where the sides come together?" I asked running my fingers along the edges. Many of the students wanted to call them corners but I told them there was another word we use for these in mathematics. Then in a moment of inspiration I held up the cube and began to run my hand across the top face and as I moved toward the edge I said "I go over the…?" "Edge!" they all shouted. "Yes," I said, "we go over the edge as we move across the top. These parts where the sides come

together are called the edges." I heard Ma'li quietly say to herself "Oh my God" with a sense of amazement.

As the carpet activity drew to a close, Ma'li asked students to pair up and let her know who they wanted to work with. Each group was given a geometric solid (either a prism or a pyramid) to explore, and then they were asked to return to their tables. We had planned which solids we would use for the lesson and we carefully chose which group received each solid varying the complexity of the task to some extent. Those groups that we felt needed additional challenge were given hexagonal prisms and pyramids.

The student groups were asked to complete three tasks. Each group was asked to make footprints of each side in sand and record the footprint shapes on a paper that had a picture of their solid on it. They were each also asked to report on how many faces, vertices, and edges their object had, and were also asked to add any other properties they felt were important. They were also asked to build the object with toothpicks and clay, and to report anything interesting they noticed while completing this task. Ma'li had modeled the first and third activity with the cube so that the students had the opportunity to watch and then do. This draws on traditional Mi'kmaw pedagogy which is described in more detail in chapter 8. The second activity had drawn on the work from the carpet.

Each group was asked to say why they felt it was a pyramid or a prism and the responses were quite interesting. One pair of students declared that they had a pyramid because it looked like a pyramid. When prompted to explain what they meant by that they said "well it goes like, into a triangle." This involved a hand gesture showing how the sides were merging. Another student also used a hand gesture to explain her declaration that her group had a prism "because it goes like this" and motioned her hands up and

down in uniform fashion. A real challenge arose when it came time for the group with the triangular prism to report back. There was some debate about whether this should be a prism or a pyramid. "It kind of forms into a triangle," suggested one student, but this seemed to be not enough to commit to it being a prism. "What if we look at it like this?" I asked as I rotated the card on the board so that it now appeared to be standing on its triangular base. "Oh! It's a prism" a girl from the back offered, "Because it goes like this" and she motioned again with her hands up and down in a uniform manner. This seemed to convince her classmates who offered supporting arguments such as "Yeah, it's not coming to a point all around like the other ones." They all agreed that although it kind of looked like a pyramid in some ways, it was definitely a prism.

We then began to talk about the properties of these two types of solids based on how we had classified them on the board under the two headings. I asked students to tell me some things that all prisms had in common and some things that all pyramids had in common. We talked about some of the strategies they had been using earlier such as being the same thickness up and down or coming to a point. I asked students if they thought pyramids could stand on their heads and they all agreed that they could not because they come to a point. They did however believe that prisms could stand on their heads. This became an important way to distinguish between the two types of solids they had been exploring. I explained how these faces that we were referring to as feet and heads were known as bases and students were able to recognize that a prism had two congruent bases and a pyramid had only one base.

So where is the "verbification" in this classroom episode? The first moment of verb-based discourse came from the student on the carpet who stated that the cube could

"sit still." While on the carpet we also spoke about looking with the face and going over the edge. More verbs appeared as the students talked about the pyramids "coming to a point" or "forming into a triangle." Even the students' descriptions of the prisms as "going like this" indicated the motion embedded in their conceptual understandings. Talking about these properties with a sense of motion made them much easier to understand. The children also were able to make more sense of the shapes of the faces by talking about the appearance of the footprints the object could make in the sand. Ma'li later commented about the sense of motion she noticed, as she recalled some of the moments from this class during our group discussions.

As the ideas of "verbification" became more prominent in our conversations many teachers began making an effort to do this more often in their classes. Sarah, a teacher of grades 4 and 5 at Phillips Lake describes how it has begun to change her classroom:

> Sarah: I have definitely got my kids to be more active like physically and by the way the tape on the floor to grid off a graph worked really well. … The kids loved it and they started doing things on their own like when we had 5 minutes and were waiting for lunch like they got out toys and were graphing them and stuff and just being much more active. The other thing that I think we were talking about I've just had everything focused on what are we doing? Why are we doing it? What are we doing? Where is it going? More of those verbs. And they're just like way more enthusiastic like **way** more enthusiastic. And I've noticed a big change and I'm

> hoping it's because of the stuff like taking some of your recommendations and stuff. But I have two students that never, they were very—one's very strong in math, one has a hard time but likes it, never participate ever, and they have their hands up, they're calling out and when the class answers as a whole their voices are in there. So. And I've talked to them a lot more too about like- We're in the classroom I close the door during math now and we all sit at our desks, we don't go to carpet anymore which we used to, we all sit at our desks and I talk to them about how we're figuring it out. We're not trying to get the right answer, we're figuring it out and we'll see where it goes. So their anxiety about making a mistake is like gone. They still get upset of course sometimes but they're like darn instead of (big inhale) freaking out and shutting down and everything. So math is going really, really, really well in my room, like across the board like instead of it just being those same few kids it's actually like every single voice consistently. (PL2)

Sarah's comments point to the benefits she has seen from using more verb-based discourse in just a short time in her classroom. She seemed to be focusing her talk more on how things are changing and encouraging students to think about figuring it out through a process of examining the changes. She did not give specific details about what this looked like in her classroom, but generally seemed positive about the results of focusing more on thinking and reasoning. Talking about the sense of motion and change

has enabled her students to connect in a more meaningful way with the mathematics that is being learned.

As mentioned earlier in this chapter, the tendency in mathematics is to turn processes into objects. This pervasiveness of nominalization stands in direct contrast to ways of thinking about and doing mathematics in Mi'kmaq. Often in my own mathematics teaching experiences my Mi'kmaw students would tell me I was "talking crazy talk" which I came to realize often meant that I was using too many nouns. To my students it made no sense to talk about all of these static objects; there was no sense of motion; nothing was happening. There is perhaps a pervasive belief that mathematics is about objects and facts, things that can only be described as nouns. Could it be different?

Byers (2007) has argued that mathematics is a creative endeavour that is far more about the *doing* than the objects of mathematics. He referred to mathematics as "a way of knowing" (p. 14). It seems to me that this idea of mathematics is hardly the mathematics of applying procedures correctly and using the rules of logic to achieve a pre-determined outcome.

Mathematics is about being creative. It is about observing change and puzzling over ambiguity. Mathematics happens in the doing, the thinking, the changing, the patterning, and so on. Mathematics is a verb-based activity. Turning mathematical processes into objects may provide some people with a way to talk about them in a more efficient manner but it also denies the journey of discovery from which the process emerged. If mathematics happens in the doing, why then do we present it in school as a static, unchanging set of rules and procedures? How could the "verbification" of

mathematics shed light on the dynamic nature of mathematics and enable more students, in particular Mi'kmaw students, to better understand mathematics?

I believe there is much more work to be done with respect to the notion of "verbification." During our discussions, our group suggested that we need to examine further what this means and how it can be enacted in our classrooms. There is a need to explore the ways in which language is used in mathematics classrooms currently and how it might be transformed to be more in line with Mi'kmaw grammar structures. That being said, verbification shows tremendous promise as a way to support Mi'kmaw learners as they negotiate their space between school-based mathematics and their own cultural ways of knowing and doing mathematics.

In this chapter I have considered the need to learn from language to support Mi'kmaw students in mathematics. I have given evidence to show that some Mi'kmaw children have responded more positively when they heard their language being spoken in the classroom. I have also argued that many Mi'kmaw students, despite the fact that they come to school speaking English, are drawing on Mi'kmaw ways of communicating and, therefore, ways of knowing. By learning from language, exploring the structure of words, the presence or absence of translations, the nature of Mi'kmaw mathematical descriptions, and so on, teachers can gain insight into potential areas of conflict in worldview for Mi'kmaw learners.

In this chapter I have suggested that particular attention should be paid to the prevalence of dense noun phrases in school-based mathematics and have argued that a potential strategy to counter this nominalisation might be to instead turn to the "verbification" of mathematics. Much more work is needed to explore the full impact of

the language on mathematical learning for Mi'kmaw students. However, it is evident from our conversations that a deeper understanding of the language may in fact be the key to transforming mathematics education in MK schools. In the next chapter I describe another important concern, value conflicts.

CHAPTER 6: WHOSE MATHEMATICS? A QUESTION OF VALUES

> "[A]s something is gained, something might be lost too. We have some idea of the benefit, but do we know anything at all about the cost?"
>
> (Doolittle, 2006, p. 19)

Drawing on the literature of ethnomathematicians (Barton, 2008; D'Ambrosio, 2006), I chose to conduct my project based on the belief that mathematics is culturally rooted, privileging some ways of knowing over others. I believe that mathematics as a subject has enjoyed a misleading sense of universality over the years, and frequently touted in popular culture as the universal language. In more recent years, however, mathematics has undergone some critical examination that has brought to light some of its embedded cultural biases, with some researchers (e.g. Barton, 2008; D'Ambrosio, 2006) arguing that mathematics could have evolved differently if different cultural ways of knowing had been valued.

It is not always as easy to see the cultural biases embedded in the mathematics curriculum as it would be in subjects like language arts or social studies. In language arts, for example, teachers might readily acknowledge that there is a need to be conscientious about choosing literature that represents different cultural perspectives. In social studies, many teachers try to examine historical events from a variety of cultural perspectives. In my teaching career, I even saw a significant change in the approach to science in many schools in Nova Scotia, particularly in the MK schools, as indigenous science initiatives began to find their way into the science curriculum. Mathematics seems to be the last hold out.

In exploring strategies to support Mi'kmaw students in learning mathematics, our research conversations often turned to conflicting values that were apparent between school-based approaches to mathematics and Mi'kmaw ways of reasoning about mathematical questions. These value differences can provide teachers with insight that may enable them to anticipate points where two worldviews might bump up against each other and cause students to be conflicted and possibly disengage. In this chapter I communicate some of the ideas that emerged as the participants in each group explored some of these value differences and their potential impact on children's participation.

Spatial Sense as the Foundation of Mathematical Thinking

When I first began talking with elders about mathematics, I would often ask questions to try to understand how number concepts were used within the culture. I would ask questions that involved "How many?" or "How much?" in an attempt to get a numerical answer, but they rarely responded with a number. The answer was almost always "*tepiaq*" (enough) and typically included a spatial gesture to demonstrate the size of enough. I later asked an elder about this and she told me that a number does not give enough information because there can be so many variables; a spatial description is much more consistent. Space and not number becomes foundational for mathematical reasoning because space and shape take into account the variables that connect to the notion of *enough.*

School-based mathematics by contrast holds counting and numerical reasoning to be foundational to mathematics learning. This is evidenced by a high priority placed on numerical concepts in provincial curriculum. Even in the two participant schools, the primary focus seemed to be on number and operation and not on concepts of shape or

space. The teachers were anxious to learn strategies to support the teaching of multiplication and division, place value, fractions, and other numerical concepts. This is not unusual; I would expect to find similar concerns in just about any school I enter. What this does indicate is the value placed on numerical concepts in school-based mathematics. What does this mean for children who have been raised in a culture where space, and not number, is the primary basis of mathematical reasoning? It only makes sense that these children might find the emphasis on number to be inconsistent with their own ways of thinking and, therefore, present them with challenges as they approach the assigned tasks.

What would it mean for mathematics teaching if we could build from a basis of spatial sense rather than number? Is it possible to use concepts of shape and space to build number concepts? This is an area that needs to be explored more deeply. "Measure Up", a Russian mathematics program that uses measurement as a context for learning mathematics, is currently being used in Hawaii with some success (Dougherty & Venenciano, 2007; Slovin, Olson, & Zenigami, 2007). This is perhaps an area worth exploring in the future.

While in the Primary and Grade 1 class in Phillips Lake one day, I worked with Amy, the classroom teacher, doing an open activity that had students exploring measurement using a standard countable unit. We had provided students with linking cubes (measuring approximately 2 cm on all edges) and base-10 blocks that were able to link together. Students were asked to choose one to measure across the top of their desk. They were not told which dimension to measure and they were not told which material to use; they could choose for themselves. All students were to work in partners.

The students were able to find the length and width of their desks quickly and some pairs decided to measure across two desks pushed together; some desks were side by side and some were back to back—again giving different measures. One group decided that they wanted to measure around the perimeter of their desk. Students were showing through their free exploration that they truly understood the dimensions that could be measured and were demonstrating some number sense including a sense that putting the two desks together would result in a measurement that was twice as long.

Some students decided that they wanted to see how many of the linking cubes could cover their desk. They told me that they chose the linking cubes because they were bigger so it would not take as many but then they ran into a problem with their covering plan because they did not have enough. I suggested they go look in the box of base-10 materials and see if they could find something in there that might help them cover the desk. They returned with the flats and quickly began covering the desk. When they approached the edges and saw space that was too small for a flat, they began to fill it with rods and then little cubes, eventually building an array of base-10 materials on their desk.

They struggled a bit with how to count it to determine the total but when I asked them how much the flat covered they made the connection to 100 and then began counting the total. Some confusion arose when they got to 10 hundreds and were not familiar with the term 1000. I had to help them a bit with this. They eventually came up with the detail that it takes approximately 2816 little cubes to cover the desk.

In speaking with Amy after this class, she told me that she does not normally ask such open questions; typically the task would be tightly structured to lead to the desired conclusions. Through this class, however, she saw the learning opportunities that can

emerge when children are allowed to freely explore. In this case, a measurement task provided a motivating opportunity to develop both spatial sense and number sense.

Approximation and Estimation, Being Fair not Exact

Closely connected with the notion of enough is the idea of estimation or approximation. Enough is not an exact amount, but rather a best guess estimate as Richard explained in the example below:

> We don't think of it as math and we don't think in the line of math because it just comes automatically. My grandmother takes so many basket strips, and we've always said this time and time again—enough—she will know exactly how many handfuls of strips she takes to make a certain size basket. She didn't really sit down and count how many strips, all she did was just take some in her hand and say, "Well this should be enough." That's the historical side of math like you don't think in exact numbers but whatever is enough. … We don't use actual numbers. How could we explain this is the right amount of approximate? (laughs) This is the exact amount of the approximate; how do you explain that? (W6)

In this comment, Richard has pointed to estimation in the context of a real situation as being meaningful and useful. It is important for his grandmother to have had enough. Baskets strips vary in size and quality so it is not really possible to know exactly how many one will need. Once the basket maker begins working with the strips, he or she may find that some of the strips are unusable, thus, it is important to have perhaps a few extra but not so many as to be wasteful or greedy.

In contrast, school-based mathematics values exactness because it values getting the right answer, regardless of the context. Richard claimed that this is a significant value difference that appears in school-based mathematics. He explained:

> In school, one equals one and two equals two. In native, one equals enough for you and I. Two equals enough for you and I and maybe somebody else. In school math it has to be an exact number to equal an exact number. The native way of thought is a number is equal to approximately enough. (W6)

The notion of approximation is not only embedded in ways in which number is used to describe quantity but also in concepts of measurement such as capacity, length, and time. There are many stories told about how women who are cooking often use approximate measures. I recall in my own experience being taught by a friend how to make *luskinikn*, a traditional bread similar to bannock. All of her measurements were approximate. "You use about this much flour," she said as she dumped it into the bowl. I jokingly asked her what I would do if I did not have that bowl at home. She had a spatial understanding of how much flour she needed, I did not. I wanted to know how many cups that much flour was. She thought I was just silly.

A similar sense of approximation is involved in dividing up land. The exactness of acres did not matter, what mattered was a sense of fair sharing of the land which often would take into account features of the land as Richard and Ma'li discuss in this passage:

> Richard: The non-native culture, when they divide land, "He wants 10 acres, you take 10 acres" That's the exact number; the number 10 is exact. That's the non-native way. The native way is that you look at the land. "Okay from here to there walk about half ways and that's what

you own, the rest is mine, and that's half. There is no exact number or exact measuring but it is "This is what you got and this is what I got. It is about half, okay, I'm happy with that."

Ma'li: When I moved to my place, Dad said "Okay, you're going to take from the brook right to the driveway," and that's where I am.

Richard: You had no surveyors. (laughter) (W6)

This notion of fair sharing is embedded in the language and is a strong value held within the culture.

At one meeting I tried to set up a situation whereby I would use a newly-learned word. Richard had taught me about *nesinemikatun* (divide it into three) and I was curious about how we might use this word in the mathematics classroom. I had taken 27 two-colour counters and placed them on the table saying: "So if I had 27 counters and I said *nesinemikatun*, then you would divide it into three groups?" "No," Richard said putting the counters I had taken out back into the pile and pulling some out again without counting them, "If you had *some* counters and you said *nesinemikatun*, then you would just mean put it in three approximately equal piles." And he quickly divided the counters into three piles that he felt were about equal. I felt the need to count them: 12 in the first pile, 12 in the second pile, 11 in the third pile. He explained that exactness is not necessary, it is just about being reasonably fair. (W5)

Perhaps exactness is seen as a need that has emerged from the need to mass produce products such as cars and jet engines. Measurements are needed to be exact if parts are to be manufactured in one place and assembled into vehicles or airplane engines in other places. Pieces need to fit exactly. This is not necessarily the case for products

that are made by hand, such as the baskets that are an integral part of the traditional economy. Richard explains:

> General Motors deals with exact, so that means they build one car and tomorrow they will build another car and that will be exactly the same as the other, so that's where the exactness comes in. The Native makes a basket, uses this many strips. Now tomorrow, makes another basket. When you look at them, they are almost the same but they are not exactly the same because each one is unique. (W6)

Enough is for Survival, Number is for Play

The meaning of *tepiaq* (enough) points to more than a mere connection to a spatial sense of quantity; it also points to a significant value difference that exists between school-based mathematics and Mi'kmaw community cultural values. The idea of enough continues to define a way of life for many Mi'kmaw people, a way of life that has strong ties to their historical roots. As Richard explained "The native way of life is you have just enough and to share. The non-Native way is 'I got this much plus'." (W6) He was careful to point out that he was not trying to imply that non-Native people are greedy but just that he saw this as a cultural difference. Ma'li built upon his comment and connected this with a need for survival explaining that enough really means "enough for survival, and that's *Lnu*." (W6)

The idea of enough for survival points to a problem with number being the basis for mathematical learning. Number does not take into account all the variables that can affect the notion of enough for survival. Richard wondered aloud how we would get students to think about number from a Mi'kmaw perspective:

> Richard: I'm still thinking natively. I don't know how we can explain

something like in math that would get kids to think numbers in a Native way. Like somebody mentioned playing cards—it's an automatic knowing that this is how much you get and this is what you should do to get this. I would consider that thinking natively because games were automatically um, you thought in numbers, um not necessarily in numbers but you knew that there was this picture that represented a certain amount. Like even playing cribbage, you open up your cards and you look at them, you automatically know what to throw away and what to keep to hopefully to better your hand. So something like that.

Lisa: So number is really more used in play?

Ma'li: Where would you use number?

Richard: Yeah, like where would you use numbers? Numbers worked *in* play.

Lisa: Like, historically where would number have been used?

Richard: In games. (W6)

Thus reasoning with shape and space is seen as essential for survival and reasoning with number is seen as something for play. The traditional game of *waltes*, for example, has very complex ways of counting embedded in the game but it is a game played for fun. In more modern times, card games have become increasingly popular in the communities and are seen as a source of number play. Cribbage is a popular game in many Mi'kmaw communities and, as Richard pointed out above, playing cribbage can help players visualize pairs of numbers that might go together to earn points. This kind of playing with numbers was brought up several times in our Wutank conversations.

In Phillips Lake, Sarah described how she found mathematical games to be an effective starting point in mathematics class.

> Sarah: We always used to play a lot of math games and stuff but now if we do a math game I build the whole lesson around it. Instead of "Here's the lesson, here's what we're doing, here's what this is called," I've reversed it so we do the math game and then we talk about "So what about this what does this remind you of?" and then when I give them a work sheet or something like pen and paper. There's not that "What do we do?" It always used to be that all the time and I haven't heard that since we've been back after Christmas so it's like a whole big good change.(PL2)

School-based mathematics often treats number concepts as the foundational piece of mathematics learning and positions students as incapable if they do not master the basic facts. It seems as though number concepts are treated as essential for survival in school-based mathematics. How does this value difference impact students who have experienced number as play, and often very sophisticated play at that?

The complexity of number concepts in Mi'kmaq cannot be over-stated. There are many ways in which numbers are used; many of them similar to English usage, but each of these ways take on different conjugations of the root words. I have shared in chapter 1 my own story of learning to count, something I have yet to master due to the complexity of number use embedded in the language.

Whereas school-based mathematics often treats number as basic and simple, Mi'kmaw uses of number are much more complex in their structure. Perhaps it is this

complexity that led to numbers being used in games, allowing people to engage with them in a more light-hearted way. Such an approach to understanding number concepts allows for mindful play in a risk-free environment. I wonder about the pedagogical implications of thinking of number as something for play. I wonder how it would be different for students if they were exposed to fun and engaging activities that allow them to play with number concepts in a way that is not threatening.

I tried to embed this sense of play when working in classrooms with teachers and students. One example of this occurred in a Grade 5 class working on division facts in a way that focused more on playing with number ideas in a safe and supportive environment. I had been invited into this class to work on division. The teacher felt the students were struggling with understanding the concept and it was my goal to give them an experience where they could feel successful and show me what they know.

It began with a simple equation on the board and a story. I wrote $24 \div 4 = 6$ on the board and explained to the class that I had recently told someone this and they said they did not believe me and I needed to find ways to show this person that it was true. I challenged this group to help me. Students were seated in small groups at tables and I gave them various materials including two-colour counters, square colour tiles, graph paper, base-10 materials, and scrap paper. I asked them to think of different ways to show my friend why this was true.

After letting them explore this problem for a few minutes I began to invite students to share their responses. Some students had used the two-colour counters to show 4 sets of six; others had shown six groups of 4. Some students used arrays to show six rows of four or four rows of six. These models enabled us to discuss contexts in

which each picture would represent the division sentence. We also explored jumps on a number line as another way to represent division. I then decided to focus in on arrays.

We talked about the fact that we could make different rectangular arrays with 24 squares. We had two already: 4 by 6 and 6 by 4. I asked students to use their colour tiles or counters to explore what other ways we could make a rectangular array with 24 counters or squares. Students quickly began exploring with their concrete materials. Some students had difficulty initially and asked for clarity. The pre-service teacher and I were able to move about the room and answer clarifying questions. Other students were quickly able to find a different array as they began calling to me with enthusiasm: "Lisa, I have one!" and "Lisa, Lisa, over here, come see mine!" I asked students to record what they had found on grid paper and to continue finding another one.

Soon thereafter, we began recording our arrays on the board. We had 3 by 8 and 8 by 3 and 2 by 12 and 12 by 2 along with our original arrays of 4 by 6 and 6 by 4. We talked about the way in which we could rotate one array to get another and how that told us about relationships between facts. We recorded our division facts that we knew from the arrays: $24 \div 4 = 6$, $24 \div 6 = 4$, and so on. I told the students that I thought perhaps our list was not complete; it seemed that something was missing. The students thought about it for a few minutes then suddenly an excited exclamation came from one little girl sitting close by: "We could just put one in each row!" "Yes we could just put one in each row," I replied "and how high would it be?" "Six feet tall!" she exclaimed as she reached her hand as high as she could. I giggled a little. Her excitement over her discovery was infectious. "But really," I asked, "how high would it be?" "Twenty-four," she exclaimed. So we were able to add 1 by 24 and by rotation 24 by 1 to our list. The students were all

very proud and excited about our accomplishments. I then challenged them to do other arrays with different numbers. I assigned each group a different number for their table. Some students were given larger numbers with more factors and other groups had smaller numbers that were easier to manage but were still focused on the same task.

As we engaged in the task, each group was able to generate a list of arrays for their number; some students were able to get them all while others were proud to discover a few. One young student had initially found the task difficult to complete. She had to ask for help with our arrays for 24. The pre-service teacher had sat with her and showed her a couple of solutions using the tiles. She was then able to do one on her own. After the initial task her group was given the number 16 and asked to find arrays. She grappled with this initially but because she had seen the solutions for 24 she was able to test different possibilities. She really wanted one of the arrays to have 5 in each row and was displeased when it did not work. Smiling at the pre-service teacher, she shook her head. She then was able to rearrange the tiles so that there were 4 rows of 4. When asked to find another one she then moved the bottom two rows and attached them to the end of the top two rows to make an array that was 2 by 8. She was very excited to see that she was able to build from one array to another. Her confidence began to grow. Her group had found all the possible arrays for 16 squares and she was excited that she had contributed to the discussion. She wanted to do another one. I put 18 on their table and she began to work on it. I walked to another table thinking she would need time to think about it and in just a few seconds she had her hand up and wanted me to come see what she had done. On her own she had quickly built an array that was 3 by 6. She was very

excited that she was beginning to understand these activities. We were very excited for her.

In this class, there were some students who were struggling with mathematics and others who found it quite easy; I knew this not by what I saw during this lesson but by how the students pointed out to me who was "good at math" in the class. During this lesson however, none of these differences were apparent in any real way. Everyone was playing with numbers and everyone was contributing to the discussions that were ongoing in the room. The students were able to play with a number in a way that ensured they could be successful. The fact that the representation of number was spatial is also significant. This episode convinces me that teachers need to do more of this kind of activity in mathematics classes to enable all students to play with number in a safe and fun environment.

On this particular day I did not have the opportunity to have a long discussion with the classroom teacher; however, we met briefly after this class and talked about how the class had gone. She seemed pleased with what her students had done, and I left her a series of other activities to use to follow-up on this day's lesson. Ma'li, was also present in the class that day as she was doing her field experience in this class for her Bachelor of Education program. She and I had more opportunities to talk about the class and she was very enthusiastic about what she had seen happening. She was especially impressed with the way some of the students who normally struggle with mathematics were able to engage in the task in meaningful ways. She especially commented on the way that one little girl's understanding seemed to rapidly increase with this activity. She was quite

excited to see how the use of the concrete materials and the differentiation of the task provided a space for this young girl to achieve success.

Grounded in Necessity and Experience

Throughout our conversations the notion that mathematical reasoning emerges from necessity, a notion that became more clear in the conversations with my advisor and Mi'kmaw leaders (Wagner & Lunney, 2006), recurred for me. I was reminded of the late Dianne Toney who was a renowned quill box maker. She had learned most of what school-based mathematics would deem circle geometry through her experience in making quill boxes. She knew that to find the centre of a circle she simply needed to fold it in half twice. She also knew that to "To make a ring, you need to go across the centre of your birch bark [the diameter] three times and allow about the width of your thumb [i.e., π] to make a perfect round" (as cited in Wagner & Lunney, 2006). Her mathematical knowledge arose from her experience with her craft.

Numerous other stories were told throughout our conversations about community elders who had developed good mathematical reasoning skills from their experience with real world needs for learning this reasoning. Ma'li told the story of her uncle who had developed a deep knowledge of the local waterways and who could navigate with ease incredibly complex regions of the Bras D'Ors lakes, often helping boaters in distress. Other stories were shared in Wutank about grandfathers who had little formal schooling but who could build houses with ease and who were very quick with calculations, especially with fractions. Stories of mathematical reasoning emerging from experience were recounted time and time again. Moreover, from the experience arises a need that

sparks the mathematical reasoning. This connects to D'Ambrosio's (2006) notion of ethnomathematics.

If mathematics arises from a need that emerges as we experience our world, I wonder what then happens to children who are asked to understand mathematics devoid of such needs and experiences. In many mathematics classrooms students are often asked to perform calculations, apply procedures, and solve abstract problems without context or reason. I am not suggesting that all mathematics needs to be grounded in a real-world problem, I am rather arguing that beginning with a reason and a context might provide a reasonable starting place for learning mathematics. Even games, as described above, can provide a context or purpose for using the mathematics.

Context and Connectedness

The discussion of necessity and experience brings me to the idea of context. It is common in mathematics classes today to talk about the importance of making connections and drawing from meaningful contexts; however, the importance of this cannot be over-emphasized for Mi'kmaw children. Much of the Mi'kmaw language is constructed relationally and word structure is dependent on context. Words often change based on the context in which they are being used. The word for window, for example, varies depending on what side of the window you are standing on. One word is used to describe being on the outside looking in and another word is used to describe being on the inside looking out. The relational nature of the language could prove to be a strength for mathematics learning if it were attended to in the classroom, but often times, children are presented with mathematics that is completely devoid of contexts that are relevant to

their needs or desires. How can children make meaningful connections with mathematics if it is not presented to them in a meaningful way?

Emily had talked about the importance of connections on the very first day of our discussions; she explained her belief that children need to make a personal connection with the mathematics and to be able to connect it to something in their own life that makes sense for them. Months later, I thought of this again as Richard recounted a story of mathematics learning that happened as a result of a peanut butter sandwich.

Richard: I think it was yesterday, no the day before, I went into the staff room to get myself a peanut butter sandwich and I saw [a student] sitting there. His face was all red and just looking at this paper. I said "*Tela'tikn* (what's wrong)[student's name]?"

"Ugh these fractions!"

"Is that why you are in here?"

"Yeah"

"How come you don't do them in your classroom?"

"Cause I was sent down here to do them."

So I said "Okay. Let me sit down. Do you want me to help you?"

He says, "Sure."

I looked at his book and it had one-half, it equals, I think it was two-fourths and three-sixths and, you know, it's the same thing. And he couldn't relate to that. So I was sitting there and I said "Okay, how about this?" and I cut my sandwich in half. "There's my sandwich, it says half." And then it said three-sixths so I cut my sandwich again. I

> said "Okay, my half sandwich is still here, but it is one-half, but still it's three and six, you got your six pieces and your three and you look at my sandwich, it's still the same sandwich, like it's still half." So finally we got to working. There was a blank number here and a number here. So I just said "Okay, just change that blank to what? Okay, what is equal to…? And then multiply or divide what to make…?" and I watched him and then I finally took a marker, then I wrote in marker. I just had a piece paper which I folded into I don't know how many pieces like a half a quarter and a third. So finally I started writing it. Slowly, he got it. And then next thing you know I just let him be. I said "Okay, you do that one and I'll just go make myself another sandwich." (W8)

In this example, the connection was quite simple yet it helped the student make sense of what had previously been an abstract and seemingly arbitrary procedure. The sandwich-cutting helped him make sense of the concept of equivalent fractions which helped him to connect to the procedure in a more natural way. This is similar to the way in which the students in the classroom episode described previously were making connections between division and the rectangular arrays they were constructing on their tables.

Throughout our conversations we frequently returned to the discussion of connections and making sense of mathematics in meaningful ways. We also discussed the need to make connections from one grade to the next and across concepts within a particular grade. The idea of seeing mathematics as a way of thinking and reasoning, as

an integrated whole, seemed to be emerging through these discussions. This of course is not unique to Mi'kmaw students; however, the cost of what happens when this is not attended to seemed to take on a much more urgent feel. What is being denied to these students when they are not invited into mathematics with connections to their experiences?

The Cost of Participation

I return now to Doolittle's quotation at the beginning of this chapter and I raise the question: what is the cost of participation? I attended the 2008 "Investigating Equitable Discourse Practices in Mathematics Classrooms" in Rochester, New York, where this issue of the cost of participation arose and became a recurring notion throughout our time together. Often times children choose not to participate because they want to save face and not reveal that they are lost or do not know, or perhaps they are looking to belong and do not want to admit in front of peers that they are capable and do know. These costs are social costs and can prevent a child from participating. There are, however, much larger costs for some children. For some children there is a cultural cost, a more deeply personal cost. In some cases the cost of participation means denying self and community to participate in the dominant view of mathematics (Gutiérrez, 2007). Often times these costs are seen by students as too great and children choose not to participate.

In this chapter, I have described some of the value conflicts that may arise for Mi'kmaw children learning mathematics and I wonder how these children might be supported if their teachers were more aware of these potential areas of tension. I have raised some of my own wonderings about how things might possibly be different if

school-based mathematics took a critical look at its embedded values. Although there is much more exploration to be done in this area, I would argue that mathematics education needs to address these value differences head on if it is truly to serve Mi'kmaw students.

I have suggested several potential strategies to address the value conflicts in mathematics. One approach is to find a balance between the current numerical foundation of school mathematics and the potential spatial foundation of Mi'kmaw mathematics. I do not suggest replacing one with the other but rather finding ways to value both. Similarly, school-based mathematics needs to attend to estimation and approximation as valid ways of reasoning mathematically. I have argued that it is completely possible to develop number concepts through play in safe and engaging environments. I have also argued that there is a need to allow mathematics to emerge from the real-world experiences and the needs of the students. Finally, meaningful connections and contexts need to be employed that enable students to make sense of mathematics in personal ways. Employing some of these strategies may significantly lower the cost of participation for Mi'kmaw students.

In the next chapter I explore other strategies associated with ways of learning that may also prove to be helpful in supporting Mi'kmaw students in mathematics learning.

CHAPTER 7: WAYS OF LEARNING

> Indigenous teachings provide that every child, whether Aboriginal or not, is unique in his or her learning capacities, learning styles, and knowledge bases (Battiste, 2002, p.15)

"My administrator told me to bring back three good ideas, so I need three good ideas." These words were spoken by a participant in a high school mathematics workshop that I was leading for teachers of Aboriginal students. The need for three good ideas was sparked by a recent move within her province to be more culturally inclusive in all areas of education, with a particular focus on including indigenous knowledge. She seemed somewhat let down when I told her I did not necessarily have three good ideas but, if I had to make up some, I would suggest "Know your students, know their communities, and believe that they can learn." I think she was looking for three pre-packaged lesson ideas or perhaps three tricks that would guarantee success in mathematics for her Aboriginal students. Tricks are no substitute for real commitment to transformative pedagogical practices.

The idea that there are specific ways to teach Aboriginal children most likely is sustained by research designed to identify native learning styles of Aboriginal children. This kind of work has been quite popular in the past 25 to 30 years (Pewewardy, 2002), yet it is has also been critiqued as being over-generalized resulting in a simplistic belief that a one-size-fits-all approach exists. Battiste (2002) has cautioned teachers and researchers to avoid such over-generalizations, claiming that:

> Aboriginal children [are] diverse learners. They do not have a single homogenous learning style as generalized in some teaching literature from the

> 1970s and 1980s. Teachers need to recognize that they must use a variety of styles of participation and information exchanges, adapt their teaching methods to the Indigenous styles of learning that exist, and avoid over-generalizing Aboriginal students' capabilities based on generalized perceived cultural differences. To maximize participation of Aboriginal students in the educational process, teachers need to experiment with teaching opportunities to connect with the multiple ways of knowing these students have and multiple intelligences. (p.16)

While it is helpful to understand and explore some of the preferred ways of learning of Mi'kmaw children for the purpose of this work, it is also important to maintain a critical approach acknowledging the risk of over-generalizations that can lead to misconceptions that may in fact do more harm than good. There is as much diversity of learning styles within a Mi'kmaw class as there is in any class, so there cannot be a one-size-fits-all approach. That being said, our discussions in both research groups often turned to questions about children's preferred ways of learning and how they might influence the design of tasks for learning mathematics. Similarly, stories were told in Wutank about traditional teaching practices that many participants argued could provide potential for current classroom teachers.

In this chapter I describe some of the discussions raised concerning traditional apprenticeship models and mastery approaches to learning, as well as those related to visual-spatial styles of learning and hands-on learning. I recount some stories of classroom episodes that draw upon the interaction of these various learning styles. I also share observations that were raised about the role of gestures and embodied cognition

and put forward questions about the various pedagogical approaches. I conclude with some thoughts on how understanding more about these different ways of learning could be helpful in supporting Mi'kmaw students in mathematics.

Apprenticeship and Mastery

Alex, an informant in my Masters research (Lunney, 2001), told a story about learning how to fix furnaces by watching his father fix furnaces. At a very young age he would go to work with his father; at first, his job was to hold the light, but as time went on, his father would let him do a little more. Eventually he was able to fix the furnace by himself. This type of apprenticeship learning came up often in the ongoing conversations associated with this current research as well. Many of the Mi'kmaw participants talked about learning by watching when they were growing up. Often this watching was done with little descriptive explanation, the focus was on observing.

As I worked one day in the resource room in one of the schools, helping to support students who were struggling in mathematics, I noticed myself employing some apprenticeship strategies. One young student was working on his twos multiplication facts. It was clear that he had learned how to skip count by twos, or rather he could recite the sequence of numbers. What did not seem obvious to me was that he understood what multiplication meant. As we worked together he skip counted and I built the models using two-colour counters. I did not tell him what I was doing but he watched me as I added two counters to my array with each new number in the skip counting sequence and then suddenly he reached out his hand and began to do it himself. It seemed like he had finally made a connection between this set of numbers and the

concrete representation of those numbers. This was an important connection for him as he was shortly thereafter able to do the same thing with threes.

Closely tied to apprenticeship is the notion of mastery learning. Being able to master a skill was important in traditional Mi'kmaw culture. Over the years I have heard many stories told about children learning to make baskets and each time they presented the basket to their teacher (an elder, parent, grandparent) it would be taken apart and they would be told to do it again. This process would repeat again and again until the basket skills were mastered. During our second session in Wutank the conversation turned to ideas for supporting struggling students. Emily tapped in to her own memories of making baskets and shared her concerns that the perceived need to move on often conflicts with the needs of the learner:

> We tell our kids "Ok, I have to move on now; I have to move on to division." I think any child—it's been a native concept—like you couldn't continue to the next level of baskets or the next level—like wreaths—I can't make a wreath if my life depended on it. I've been taught over and over, so for me I never took the time to keep doing it because I'm so impatient. I should have gotten this, and that's the mastery level. Like Uncle, you would never make anything unless you could master it. Or anybody does any baskets. I remember *eltu'n* (making) baskets *winik* (ugly) *telumuit* (they would tell me) "Look" and they'd take it apart and I just couldn't handle anybody taking it apart, taking it apart and telling me to do it again. That would just drive me nuts because that's the person I am. And that's what I learned at school. School didn't let you finish … it was okay to make that mistake at school but you couldn't make it at home, but then again a

few years later school expects you to make sure you don't make that mistake. So it's contradicting itself. I think if we could learn to teach our children to add until they're good at adding and then they could move to the next level. There is a level in anything we learn (W2).

Problems caused by the need to move on and rush through the curriculum is a complaint I have often heard from not only the teacher participants in this project, but also from many teachers in the public system. Is the prescribed curriculum allowing students enough time to grapple with concepts and deepen their understanding before we jump to the next topic? Recent changes in provincial mathematics curricula across Canada have moved to reduce the number of outcomes in an attempt to allow more time for concepts to be developed. Perhaps children might benefit from having more time to become proficient with a concept before moving on to the next concept.

These concerns about time and proficiency raise questions about the structure of classrooms. How do we organize our classrooms so that all children are able to progress at their own rate on their own time? This topic of discussion also arose during our conversations. Some teachers in both groups reflected on the current levelled reading program in the school and suggested that something similar for math might help to address this challenge. Overall, however, our conversations focused far more on questions of pedagogical approaches rather than content to be delivered.

Visual-spatial Learning

One pedagogical issue that emerged often in our conversations was related to how to teach mathematics so that it addressed a more visual-spatial style of learning. In the previous chapter, I described the value that is placed on spatial reasoning within the

Mi'kmaw culture. Similarly, in chapter 4 with the description of the emerging themes was Donna's claim that many of the children in the school have been assessed as gifted visual-spatial thinkers. While these assessments are limited in their predictive capacity due to inherent cultural biases, it is interesting to think about addressing this style of learning so as to meet the needs of more learners in the classroom. It was felt by many participants that our current provincially-mandated curriculum does not value visual-spatial learning styles and make limited allowances for such ways of learning. Donna shared her frustrations with this perceived problem:

> Spatial and visual learning styles don't fit into the curriculum and that is the problem; that is the whole problem. You can be gifted spatially and visually and it doesn't fit into the way that we present information. Why is that? Why is it not valued as much as the oral or the symbolic? (W4)

Donna's frustration raises important questions about how we present information and, closely connected to this idea, how we assess the learning. Challenging the inherent privileged ways of knowing in the curriculum is a key step to transforming education so that it meets the needs of all students. But what then would mathematics education look like if it gave equal value to the visual-spatial style of learning? How can we adapt task design and instructional strategies to address this need?

Both groups discussed a desire to understand more fully what it means to be a visual-spatial learner and how this might transform pedagogical practices. While we all acknowledged that a variety of approaches is important—not all students have this visual spatial strength—we felt strongly that not exploring beyond traditional pedagogical practices that do not privilege visual-spatial learning styles is denying a

significant portion of Mi'kmaw students the opportunity to draw on their own strengths for understanding and making sense of the world. While going deeper into this area of study was outside the realm of this current project, it is definitely an area that we hope to pursue in future projects. In this section I will share some of our conversations related to this topic to flesh out how participants were grappling with this idea.

One aspect of a visual-spatial strength is a desire to see the "big picture" (Silverman, 2005). As I think of this aspect I am reminded of our first day of discussion in Wutank when Emily asked me to describe my vision for the entire research project including what would happen after the research. She expressed to me "We need to see the whole picture, we understand the whole picture, and then we can move on" (W1). Of course, this also connects back to the value of necessity talked about in the previous chapter.

A related aspect of visual-spatial learning styles is the need to work from the whole to the parts (Silverman, 2005) which reminds me of the conversation we had about using division facts to teach multiplication (see chapter 5). This type of whole-to-parts process which the group referred to as "working backwards" seemed to make more sense to many Mi'kmaw participants who felt that working from a large group to the smaller parts by fair sharing was a much simpler way to understand the corresponding multiplication facts.

Silverman (2005) also suggests that visual-spatial learners tend to think in pictures, relate well to space, and understand best through seeing relationships among other things. Many of these topics arose either formally or informally in our

conversations which leads me to think this is an area of research that may provide greater insight into strategies to transform teacher practice for Mi'kmaw children.

I note, however, a curious connection between visual-spatial learning styles and the nature of the Mi'kmaw language which also values spatiality over numeracy and is itself a relationally constructed language. I wonder about the connections between the language and the learning styles. This is an area I would like to explore in more detail.

Holding it in your Hand

Another pedagogical approach that was discussed in our research sessions was the idea of hands-on learning in mathematics; many participants noticed that their students were able to understand better when they used concrete materials to model mathematical problems. This is not unique to Mi'kmaw schools of course, but most participants felt that it was an aspect that was absolutely essential for their students. Emily shared her concern that we tend to take away concrete materials from students too soon: "If you get it, good for you, keep going. But if I still need it, let me have it." (W2). There was also a desire for the concrete materials to be personally meaningful to the students, and one group suggested it might be helpful to have the students make their own concrete materials. There were numerous examples within the classroom activities that I observed or participated in that reinforced the need to use lots of hands-on approaches to learning mathematics. I share a few of them here.

One day I was working with Sarah in her grade 4/5 class in Phillips Lake. She had shared with me her concern that her students had not developed a solid understanding of finding the mean of a set of numbers. She had done some examples with the class but they did not really seem to understand the concept. I asked her if she

had any candy. She did. We gave each child some candy. They were given different amounts ranging from 5 candies to 12 candies. There were 9 students in the class. They were asked not to eat any candies until the end of the activity and they cooperated with this request.

We asked each student to tell us how many candies they had and we recorded these numbers on the board. We then asked them how they could make it fair for everyone. Through some guided discussion the class came to the conclusion that we should see how many candies we had all together and then figure out how much each person should have to make it fair. Once this number was determined, those students who had too many candies gave appropriate amounts to those who did not have enough. There were a few candies left over that they agreed Sarah and I could eat. We then told them that this value they had found is called the mean and we led them in a discussion to reflect on the process. This activity seemed to improve their understanding of this process and they were able to do a second problem with relative ease.

When Sarah and I spoke about this activity after the class, she was excited by what she had observed her students doing. Providing students with concrete objects that needed to be fairly shared enabled them to engage in a hands-on experience with finding the mean. Sarah remarked that she had never thought about the mean in that way but would be adding this activity to her repertoire in the future.

In the next two sections I illustrate ways in which attention to various ways of learning broadened the opportunity to learn for many students. One story involves working with a whole class while the other involves a one-on-one encounter with a student receiving support in the resource room.

Fact Learning: A Reprisal

As our sessions progressed in Wutank, I found our conversations focusing more and more on big pictures ideas like language and culture; however, when I arrived for one of our sessions late in the year (W9) the group had returned to a practical question: what to do about basic facts. There had been a brief staff meeting after school on the previous day where concerns had been raised about the lack of automaticity with addition and subtraction and multiplication and division facts.

Donna shared her fears that "Right now what we're trying to do is build quickly on skills before they've mastered a skill. … and this is not the kids who are struggling, this is our average kids." (W9). Again we see a question about mastery. I suggested that if we were to reflect on our conversations to date, this challenge makes sense because the approach that has typically been used to teach these facts has been based on recall of symbolic presentations of the facts and not on conceptual understanding that builds on the visual-spatial strengths on the students.

Donna wanted strategies to redesign fact learning with students' strengths in mind. I reminded her of the conversation we had in one of our earlier sessions about the idea of what the group had called "working backwards" connecting this with Silverman's (2005) idea of working from the whole to the parts. Donna and I both wondered if such an approach could connect this learning more to the spatial strengths of the students.

Richard picked up on the idea of spatial representations of number with example of a way to make a number line come to life by using landmarks in the community. He had attended a session presented by a man from a neighbouring community who had

used this approach. He was quite enthusiastic about the things he had learned at this session and explained that the workshop facilitator:

> had a cool way of teaching math. … Instead of a number line, he uses the reserve. Like let's say here at the reserve. [Bob]'s would be -10 and the school would be 0. [The new subdivision] would be +10, and you get them to think what's half ways, let's call that 5. And he can get them to count from a minus to a plus five using the reserve. (W9)

We continued to discuss the need to draw on patterns, spatial concepts of numbers, and the use of concrete materials to help students make sense of their facts and remember them. As a result of this conversation, Donna asked if I could come into the grade 6 class to work with the students on their fact learning, which I agreed to do the following week. This generated an example of the importance of hands-on learning and attention to visual-spatial learning styles.

These students were struggling with recall of multiplication facts. Their teacher had invited me in to see if I could help them. I asked the class which facts they found the hardest to remember and they not surprisingly said the 7s and 8s facts. I gave each group a set of 9 10-frames and some two-colour counters. I asked them to begin building sets of 7 on each of the 10-frames. I drew the corresponding picture on the board. I then asked them to look at these images and tell me what they noticed; could they see anyway to easily count these up? I asked them not to shout out their ideas but to share them with their group members.

As I floated about the room I heard many students noticing that the set of seven was made up of a set of five and two. They could easily see that four sets of seven was

equivalent to four sets of five and four sets of two to make 28. They were excited by this. After I was sure each group had come to a discovery I had them share their ideas. They talked about how they could use groups of five and groups of two to find groups of seven. We practiced this on a few other 7s facts like 6 x 7, 7 x 7 and 8 x 7. They thought this to be a very useful strategy. They liked the visual representation and it was through building it that it truly began to make sense for them.

A student in the room then asked spontaneously "So for eight, could we use five and three?" Other students chimed in with agreement. They were able to build the student's suggestion and see that yes, this would work.

Suggestions were also made by some students that one could think of seven as a set of 10 and take away a set of three and you could use a set of 10 and take away a set of 2 for the eights. From this line of thinking we built the nines facts and realized that this subtraction approach was especially useful for the nines. The students quickly realized that they could multiply 9 by any number by using the 'multiply by 10 and take away a set of that number' strategy. They were able to quickly multiply 9 by very large numbers using this approach. These students had learned multiplication facts in earlier grades but had not seen this concrete approach to learning these facts.

Supporting Struggling Students

This next example also involved the use of two-colour counters. I was working with a grade 4 student in the resource room. He had many difficulties with mathematics and the resource teacher had asked me to help her figure out what we could do to help him move forward with some of the things they had been working on. Through some initial discussions with this student it became apparent to me that he was not able to

quickly recognize spatial arrangements of numbers past three or four. Given an arrangement of dots, his strategy was to count every time. We decided to work on this concept with him using a series of dot cards (Van de Walle & Folk, 2007). We discovered that he was not able to quickly recognize many of the larger numbers without counting so I thought that it would be helpful to give him concrete representations of these patterns and show him how he could use skip counting strategies to recognize the numbers rather than counting by ones.

On this particular day we worked on skip counting by twos and threes. We had a hundreds chart and two-colour counters. I asked him to say every second number in the hundreds chart and colour them in with the highlighter. As he said the number sequence I built the array of counters and he watched. He was then able to extend this array with the counters himself. We then moved to the threes and repeated the activity. He coloured in every third number and said the number sequence and we built the arrays for the threes while saying the number pattern. It was interesting that he quickly picked up on the diagonal pattern that the threes facts make in the hundreds chart and quickly coloured it in. He repeated the skip counting pattern for the threes a few times (up to 30) while building the arrays by adding a column of three dots to the array with each new number in the sequence. The resource teacher and I could see that he was really beginning to understand.

We then went back to the dot cards that he had found difficult and were impressed by the improvement he had made. He was able to look at different arrangements of nine dots (a three by three array and a set of three groups of three) and said "three, six, nine, there's nine!" He was also able to use these skills to see variations

such as a three by three arrangement with one missing the centre, noting this was almost nine but there is one missing so it was eight. Or similarly he was able to add additional counters quickly such as counting three groups of three and adding one more on to make 10. He was also doing an impressive job of articulating his strategy for counting. We were particularly pleased when he at one point said, "Well, every time I see two sets of four, I know that's eight."

Through building the sets with two-colour counters he was able to make sense of these dot arrangements. It seemed as though by building just a few arrays he was able to generalize to other arrangements of dots. The experience of building it with his hands seemed to make all the difference in developing his understanding.

We did a few other activities with him that day that involved counting on and counting back using ten frames and two-colour counters where he was asked to predict what would be one or two more or one or two less and then check (from Van de Walle & Folk, 2007). Although getting him to work on mathematics activities was often a struggle, on this day he was very attentive and seemed to be excited by the fact that these concepts that had previously been a mystery to him, were starting to make sense for him. He truly seemed to be having fun—probably encouraged by the excitement and praise directed towards him by myself and the resource teacher—and he was pleased with his own progress. I truly believe the experience of holding the mathematics in his hands made all the difference for him.

Later that day, when our group met, Donna shared her excitement about what she had witnessed with this particular student on that day and explained that "It was really good because he had the opportunity to explore that with a bunch of different

things" (W5). She was particularly impressed with the ways in which he was able to articulate his thinking. She went on to suggest that this students' success should be informative to the teaching of all students generalizing:

> And it's nice to be able to see that working with kids that struggle; because if kids that struggle can get it that quickly then that means we should be doing that with all our kids. Right, if someone that struggles as much as he struggles with number—and he can get it that quickly then we should be really working on that technique or strategy or whatever with lots more kids. (W5)

It Goes like This: Gestures in Mathematics Learning

In addition to holding mathematics in their hands, many children also use their hands in mathematics class to make gestures. This is an area of study that may provide insight into transforming pedagogical approaches for Mi'kmaw students. While the topic never arose in our discussions, in reflecting on some of the classroom observations, there was considerable use of gestures by students as they explained their thinking and reasoning. In talking about prisms and pyramids for example the grade 3 students made gestures to show what they referred to as "forming into a triangle shape" or "coming to a point." The students moved their hands in such a way as to show that the shape was coming to a point on all sides. Similarly, to describe the prisms, they would move their hands up and down, holding them in a uniform shape and explaining "it goes like this."

Gestures were also embedded in the responses of *tepiaq* (enough) that elders gave when asked questions about how much or how many. They would explain the amount needed with a spatial representation using their hands to gesture the size of the

space. Richard also shared that gestures are used to describe the size of things when using different words. We talked about the concept of roundness and he explained to me that *piptowa'q* is used to describe anything that is round and long like a cylindrical shape. This word literally means "it has length and it goes around" although there were many other words to describe roundness as well. He explained that if he wanted to talk about something that is round he might say *teloqpna'q* as he gestured with his hands to show roundness. This means "how round it is." I asked if I would use this word to describe the roundness of a stick and he told me that for a stick I would use *tela'q*, again gesturing this time with one hand to show a small circle. "It's that big around, *tela'q*," he explained. "So I would use *tela'q* for a tree trunk?" I asked. He told me that for a tree trunk I would have to say *teloqsit* and again he gestured with his hands to show the roundedness of the tree trunk. I asked if he needed to have the gesture to explain the size and he told me that really each of these words describe roundedness and that they each really mean "it is this round" so the hand gesture demonstrates what "this" means. This indicates the importance of gesture in developing mathematical understanding. I feel that more attention needs to be paid to understanding the importance of gestures in future projects.

I have presented in this chapter a few practical approaches to learning that hold some promise for transforming pedagogical practices for Mi'kmaw students in learning mathematics. I am sure there are some others that have been overlooked but will hopefully emerge in future collaborations. Each of these areas requires additional study to clarify the connections. Participants in both groups have expressed a desire to deepen

their understanding of some of these approaches and hopefully this will come to fruition in due time.

In the next chapter I describe the importance of making connections between mathematics in school and mathematical practices in the community, both modern and historical connections.

CHAPTER 8: MY ELDERS KNEW MATHEMATICS TOO: THE IMPORTANCE OF CULTURAL CONNECTIONS

When I was teaching I often found it difficult to get students to see mathematics as an evolving way of thinking and communicating about the world. They held tightly to the view that mathematics was about memorizing and applying rules. I got the sense that they believed that mathematics belonged to someone else and that it had little to do with their lives. I often found myself in the early days explaining to my students that the mathematics we study is just a small sample of the mathematics that has been developed by various cultures all around the world. When the issue arose in class, I would tell my students that the absence of Mi'kmaw mathematics in textbooks does not mean that the Mi'kmaw community did not use mathematical reasoning, but rather that much of their mathematics has yet to be documented. I would often challenge my students to think about exploring the mathematics in their own community although at that time I was myself unsure of how to go about doing this.

In considering what it means for students to make a personal connection with mathematics, I felt one important piece was to reveal the mathematical thinking that is, and has always been, evident in their own community. In this chapter, I explore some of the evidence of mathematical thinking that exist within the community daily practices—although admittedly there is far more to be done in this area. I also explore some of things that have been done in both schools to strengthen the connection between school-based mathematics and community cultural and everyday practices. Finally, I conclude with a description of some of the challenges to such an ethnomathematical approach that were shared by participants.

What is Mi'kmaw Mathematics?

Barton (2008), D'Ambrosio (2006), and others have argued that mathematics evolved as it has because of its connection with the dominant worldview, but that mathematics could have evolved differently. Barton envisions mathematics as a braid of many different mathematical worlds, each with their own ways of dealing with reasoning related to quantity, space, and relationships. Within Mi'kmaw culture and history there exist many ways of reasoning that could be seen as mathematical. What then is Mi'kmaw mathematics? It is most likely impossible to completely answer this question given that there is no word for *mathematics* in Mi'kmaq. It might then be better to think about the ways in which meaningful connections can be made between Mi'kmaw cultural practices and mathematical concepts.

In considering ways to bridge between indigenous thought and school-based mathematics Doolittle (2006) has suggested it would be helpful to "consider the question of how we might be able to pull mathematics into indigenous culture rather than how mathematics might be pushed onto indigenous culture or how indigenous culture might be pulled onto mathematics" (p. 22). This idea of pulling in mathematics involves identifying aspects of community culture where the already present, inherent ways of reasoning within the culture can help students to make sense of the "school-based" concepts of mathematics in the curriculum. Thus it is important to work from the reasoning that already exists within community to make sense of the western mathematics that comes from outside the community. What would it look like to pull mathematics into Mi'kmaw culture? To do this, it might help to understand the ways of

thinking that are already evident in the culture that might provide a home for mathematics.

Baskets and Other Crafts

In Wutank, basket making was a traditional part of the economy. Many basket makers from Wutank made a good living selling their baskets that had a reputation of being well-made and able to pass the test of time. There are still some community elders who make baskets and some schools have incorporated this skill into *Show Me Your Math* projects—perhaps in an attempt to pass along this skill to the younger generations. There are, however, few young basket makers in the communities and I know during my time as a teacher and administrator in one school, many community elders expressed this as a concern, hoping the schools would do more to pass along these traditional practices. The art of making baskets requires logical and spatial reasoning that could be seen as having connections to mathematical reasoning. There are skills involved that share connections with aspects of school-based measurement, geometry, and patterning. Other traditional trades such as wreath making, quill box making ,and bead work share connections with forms of mathematical reasoning. If considered respectfully, these traditional crafts might provide a place to pull in mathematics.

It is also noteworthy to connect the emergence of basket making with the notion of necessity presented in the previous chapter. Making baskets was not simply a craft; baskets served a practical purpose in traditional Mi'kmaw society. They were used for storage and carrying a wide variety of items, and were also a key piece of the economy. While baskets, and other items for that manner, may not serve the same purpose in modern society, they may still arise from a need. Perhaps the need is to create a product

for tourists to support the local economy, or the need may be to preserve a skill that was once so dominant in the community. This connection to an ongoing need for these products provides an authentic reason for learning the associated mathematics while still respecting the craft. This provides a way to pull mathematics in to the culture.

Emily shared one of her beliefs with the group on the second day of our conversations, that working with these crafts helped Mi'kmaw people develop strengths in mathematical reasoning. She also expressed her fear that the loss of these traditional activities might mean that children are not going to develop those strengths in reasoning that generations before them had. Emily argued:

> In the home people are not making baskets anymore, they're not making wreaths, they're not cutting, they're not using their hands anymore. ...I think that's being lost in the home so we're losing that. So I think that's something that has to be brought back because that's the personal connection they can make with the mom or the grandmother, or somebody who is still strong in that concept. I've noticed it more now than ever (pause) cause I used to have a bunch of kids that were great at math and now I'm getting a bunch of kids that, they're so book knowledge now that it's not real. (W2)

Her comment about "book knowledge" points to the way that children in the community are moving away from traditional ways of knowing, making attempts to learn more school-based knowledge, but she sees this as not working. Her comments point to the lack of grounding in a meaningful context as was discussed in the previous chapter. The need to make baskets provided a meaningful context to do authentic mathematical reasoning. The loss of this connectedness is of concern to Emily.

Playing Games

It is not just craftwork that provides meaningful contexts for mathematical reasoning, however. Connections to mathematical thinking are also evident in the games played in the community whether they are traditional games like *waltes* or modern games like cards and darts. Many of our research conversations in both Wutank and Phillips Lake turned to the notion of playing mathematical games. Stories were shared about people who could add and subtract quickly, despite the fact that they had little formal education, because of the skills they had developed in playing games.

Waltes is a traditional bowl and dice game in which participants play numerous rounds, first to gather wood (win sticks) and then to trade. The counting system associated with this game is very complex and only a few elders still know how to count the game. I have heard that the counting system actually changes bases in different rounds. Some younger generations are making efforts to learn how to count the game so that this knowledge will not be lost.

Trades

In addition to the games and crafts, another area that shows promise for pulling in mathematical reasoning is the trades, in particular construction, fishing, and forestry. Many of the men in the communities worked in construction trades over the years as welders, bricklayers, and carpenters. Many stories were told of men who could estimate measurements with incredible accuracy, and who could build just about anything you asked for and often without any formal measuring tools. A great deal of mathematical reasoning is involved in these trades, especially when the work is done without

manufactured measurement tools. Many community members, both historically and in modern day, have found success in these trades.

Fishing is an industry that is quite strong in both communities, but is more prominent in Phillips Lake. During one of my days in Phillips Lake, the grade 6 class asked for help with their *Show Me Your Math* project. They wanted to interview a fisherman about the math he uses in his job. They invited the father of one of the boys to come to the class. They prepared questions for him and created a video of him talking about the estimating and measuring he does in a typical day. They were quite proud of the video they created and seemed pleasantly surprised to learn about the mathematics that was involved in the fishing industry.

Navigation and Place Names

Another aspect of traditional knowledge that might provide a good home for mathematical reasoning is that of traditional ways of navigating. There are many words in the Mi'kmaw language that describe ways of navigating the land and in some cases these words are used to name various regions of the land. The name of the community *We'koqma'q* for example, means "where the water meets the land if you are traveling *in* the water." The community also has been referred to as *We'kopa'q* which means "where the water meets the land when you are traveling *on* the water." It is a subtle difference but as the community has made moves to return to a traditional Mi'kmaw name, some debate in recent years has been held over which name should be used.

The art of navigating requires complex reasoning skills that share connections with mathematical reasoning. Barton (2008) described stories of Pacific Island navigators who have developed very sophisticated ways of navigating the ocean and has

suggested that this might provide insights into ways of mathematical reasoning. The MCC series has recently added a mathematical resource book for Yup'ik children based on traditional ways of using navigation (Adams, Kagle, & George, 2007). Stories have been told in the Mi'kmaw community about people who have very sophisticated knowledge of both the waterways and the land.

A former colleague once shared with me his belief that understanding the ways of reasoning about navigation might provide insight into mathematical reasoning. He also shared his belief that this connection is being lost as younger generations are participating less frequently in the kinds of activities that presented a need for such skills. He has made efforts in his own Mi'kmaw language and culture classes to bring back some of these traditional activities as a way of strengthening and reclaiming this sense of connectedness to the land. He sees this as a place where mathematical reasoning exists in sophisticated forms.

The theme of loss of traditional practices and the need to reclaim these practices was evident in many of our discussions. The desire is not to move away from traditional knowledge to more school-based or mainstream knowledge, nor is it to replace mainstream schooling with only traditional knowledge. Rather there is a need to look to traditional ways of knowing to make sense of the school-based knowledge in a way that is culturally consistent.

All too often modern school practices do not value these traditional ways of knowing. In our discussions the discourse was quite the opposite. Traditional practices are believed to be the route to deepening school-based knowledge as well. Many of the participants see this as a dual benefit, reclaiming knowledge that is at risk of being lost

and giving Mi'kmaw children a strong foundation upon which to build an understanding of school-based knowledge. Pulling mathematics into these traditional practices might provide a path to accessing mathematical knowledge while minimizing the cost of participation.

Show Me Your Math

In recent years the Mi'kmaw schools have embraced the idea of exploring mathematical connections to everyday cultural practices. As part of a related project, I worked with my doctoral supervisor, David Wagner, to develop an annual event known as *Show me your Math* that invites Aboriginal children in Atlantic Canada to find mathematics in their everyday environment. Using Bishop's (1991) notion that mathematics is counting, measuring, locating, designing, playing, and explaining, we ask children to explore these ideas in their community context and create presentations about what they found. In 2008 over 1000 children from 5 different communities participated in the event with about 150 children, between kindergarten and grade 12, selected to present their projects at our annual mathematics fair. The enthusiasm of students and teachers in participating schools has been overwhelming.

Both of the participant schools were also participants in *Show Me Your Math* for the second year in a row. Both schools chose mostly to do whole class activities for their projects so that this ethnomathematical work could be part of the regular mathematics class. Working together, teachers and students selected activities to explore, invited in community resource people in some instances, and went out to the community in other instances. The projects were incredibly diverse but all drew on some aspect of the community culture or everyday practices.

In each school there was a class that explored the patterns in traditional dances and connected them with patterns in mathematics. A grade 3 class in one of the schools applied mathematics to something that they saw as incredibly important to them, exploring the design and measurement of the new school that was being built in their community. There was the group of grade 6 students mentioned above who explored the mathematics that is used in the fishing industry.

Sarah, a grade 4/5 teacher in one of the schools, began a unit of transformational geometry by looking at bead work designs on wampum belts. She explained how her students found this to be quite engaging as they shared stories of grandmothers who did bead work similar to the designs they had explored. As the students worked through developing their own designs using reflections, rotations, and translations, Sarah said she noticed that some of her students who often struggled with mathematics were finding this particular activity to be very interesting and they were spending considerable time working on their designs, even outside of the allotted mathematics time. One student in particular, had shown significant talent with this activity. He normally struggled with school-based mathematics as well as other subjects, but with this task he was able to draw upon his visual spatial skills to create intricately detailed designs.

Sarah claimed that she saw the benefits of making these kinds of meaningful connections to community cultural practices. It gave the children a personal connection to the mathematics and allowed them to see some mathematical thinking that is part of their cultural heritage. This new awareness is just one of the many benefits from participation in the *Show Me Your Math* event.

In my discussions with teachers who have been involved and some of their students, I am aware that participants are more regularly talking about the ways in which they see mathematics all around them. Also, from my experiences with the regional mathematics fairs, I can see that they are excited to share what they have learned. In talking with a grade 10 participant I was struck by how she talked about her non-native friends teasing her and telling her that her people were not smart. She said that by participating in this event she realized that her elders knew mathematics too and have been using it for a long time. She felt great pride in this new discovery. Making this kind of meaningful connection provides students with a new insight into mathematics and helps them to see that mathematical reasoning is a part of their heritage.

The Challenges of Ethnomathematical Work

Thinking of these benefits, I come back again to Doolittle's (2006) reminder that although there are benefits, we must also be mindful of the costs. There are many challenges involved in making meaningful connections between school-based mathematics and indigenous knowledge. Participants in this research project were quite mindful of these challenges and often articulated some of their concerns with respect to this work.

One key risk is that attempts to make cultural connections often have the effect of trivializing the indigenous knowledge and subsuming it within the dominant view of *real* mathematics. While I have suggested in the previous section that baskets, bead work, and other crafts can provide sources of making mathematical connections, there is a danger in this if these connections are not made respectfully. There can be an oversimplification that makes these complex activities seem like exotic and trivial crafts

where the dominant society can see mathematics. Such an oversimplification of this indigenous knowledge denies the real complexity of thought that was involved in the development of the cultural artefact. Doolittle (2006) has warned about the dangers of oversimplification:

> Aside from being wrong, oversimplifications such as calling a tipi a cone or analyzing the peach pit bowl game only in terms of probabilities and odds may have other serious implications in an educational context. My feeling is that Indigenous students who are presented with such oversimplifications feel that their culture has been appropriated by a powerful force for the purpose of leading them away from the culture. The starting point (tipi, game) may be reasonable but the direction is away from the culture and toward some strange and uncomfortable place. Students may, implicitly or explicitly, come to question the motives of teachers who lead them away from the true complexities of their cultures. (p. 20)

The participants were quite mindful of this risk and expressed their fear that, in an attempt to do something positive, they might in fact get it wrong. In chapter 4, I recounted Sarah expressing her concerns in this respect saying that she wanted to be able to make connections but felt that she needed more knowledge about the community context and more support from community insiders so that she does not risk oversimplifying these complex ideas. Her fears were echoed by her colleagues.

The fear of oversimplification is closely tied with a feeling of a lack of deep knowledge. If one does not have a deep understanding of the knowledge and history of the community, the risk of doing injustice to that knowledge is increased. Many

participants expressed a concern that they simply did not know enough to make these sorts of meaningful connections.

For teachers who come from outside the Mi'kmaw community, this often stems from a limited knowledge of community practices. As Sarah expressed above, there is a need for support people from within the community to help these teacher participants as they make attempts to incorporate more indigenous knowledge in mathematics. Maureen described a challenge with her experience doing the *Show Me Your Math* projects, saying "I think the hardest part of that is getting help. Like, it's extra special to do the *Show Me Your Math* because you're getting a new person in your room, … [but] it's hard to know who's available all the time." (W4)

This expressed need helped make it evident that non-Mi'kmaw teachers needed support and opportunities to learn more about the community culture and heritage in order to develop confidence in making connections between school-based mathematics and cultural practices. This was not surprising of course, because I know from my own experience as a teacher, and again as a researcher, that the opportunity to ask questions of community elders provided me with many insights about teaching mathematics and helped me to build my own knowledge base so that I was able to make these cultural connections in a more authentic way.

Yet even for teachers who come from within the community, there is still a need for support to make these cultural connections. Some Mi'kmaw teachers perhaps have not been exposed to some of the traditional activities described above, or if they have been, they may not know how to make evident the connection to the mathematics. All participants, regardless of their own personal background, have learned mathematics in

school. It was never made evident how this mathematics connected to community cultural practices. While many participants were able to suggest possible topics where mathematical connections might emerge, they were often unsure as to how to make evident the mathematics. This is another significant challenge to this type of work.

I am reminded of some of the early ethnomathematical work that my advisor and I did with some of the community elders (e.g. Lunney & Wagner, 2006; Wagner & Lunney, 2006). While the elders were quick to think of activities that involved counting, measuring, locating, designing, playing, and explaining, they often did not refer to these activities as mathematics but rather called them "common sense." In fact, they occasionally went so far as to contrast these common sense activities with school mathematics, seeing them as very different—perhaps even mutually exclusive—ways of knowing.

Related to the concerns about trivializing is the challenge of pulling the mathematics into these cultural activities making evident the mathematical connections in a way that continues to honour the complexity of the associated indigenous thought. Doolittle (2006) provided a second word of caution in suggesting ways to proceed with this kind of mathematical work:

> I would say we need to recognize that mathematics is an essentially simple (not complex, although often complicated) way of thinking. Mathematics is all about simplifying, clarifying, analyzing, and breaking down. On the other hand, Indigenous thought is all about developing and building up sophisticated, complex responses to complex phenomena such as the weather, animal migratory patterns, healing, and human behaviour. (p.22)

Perhaps in light of these comments, it is necessary to think of ways in which mathematics emerges as some of the tools of reasoning used to understand complex phenomena. Perhaps there is a need to explore complex cultural phenomena and use these as a basis for making sense of mathematical reasoning, in effect uncovering the kinds of reasoning that are used and connecting them with various aspects of mathematics. Perhaps this would be pulling mathematics into indigenous culture.

But Worth Doing

While it is important to acknowledge the challenges associated with ethnomathematical projects and to take steps to mitigate the potential problems of trivialization, it is also important to not let these challenges deter the efforts to connect mathematics and community culture. As has been seen from some of the stories in this chapter, the students seem to respond well when learning from community suggesting that they appreciate learning about the mathematical ways of knowing of their elders and community members. They also benefit from this learning as it creates both a more positive attitude towards mathematics and a greater sense that mathematical thinking is part of their own cultural ways of knowing. There were numerous discussions throughout this project about the perhaps renewed desire to explore the complex cultural practices of Mi'kmaw people and to draw out the mathematical connections.

Chris, a grade 6 teacher expressed interest in working with his class to build a *wi'kwam* (wigwam) and thought this might provide an opportunity to make some mathematical connections. Other teachers suggested that we need to include more community elders in our discussions about this issue and even to invite them to share some of their knowledge in an effort to better understand that ways in which we can

make mathematical connections. It was suggested that we should in fact be recording on video tape some of the community elders, trades people, and crafts people as they go about these complex activities of making baskets, wreaths, and bead work, navigating the waterways, sharing knowledge about the natural world, and so on. Participant teachers expressed an interest in seeing what kinds of reasoning were being used and how this knowledge might help to generate meaningful connections to school-based mathematics. While these types of activities were not within the scope of this current project, plans are being made to engage in some of this work in the future.

Encouragement for such ideas can be found in Lipka's (Lipka et al., 1994) ongoing work with the Ciulistet group from Yup'ik communities in Alaska. In this project that has lasted over 30 years now, such ethnomathematical resources have been developed and have met with considerable success. In seeking out common cultural practices where mathematical reasoning found a natural fit, this group was able to develop a series of books for teachers and children in schools that build mathematical concepts through exploring cultural practices (Lipka et al., 1994). The research and related MCC resources provide insight and guidance for our work as we move ahead.

Our groups saw importance in helping students see mathematics as a part of their own cultural heritage and everyday practices. Dispelling the myth that mathematical reasoning belongs to someone else enables students to better see themselves as mathematically capable. There are a number of challenges associated with making this happen but with deeper understanding of indigenous knowledge and a respectful approach to exploring the relationship between this knowledge and mathematics, I believe there could be great benefit to Mi'kmaw children. We must proceed with this

aspect of mathematical exploration being mindful of the risks but also hopeful of the potential benefits. Furthermore, such a move will not only help students to make more meaningful connections with mathematics but it will also help them to deepen their cultural knowledge which many teacher participants fear is being lost.

This and other chapters have explored the important themes that emerged in this research project. Hopefully the interconnected nature of these themes has also become apparent, but I do discuss this interconnectedness further in the next chapter. I also share some concluding thoughts and lingering questions, and make recommendations for future directions for this work.

CHAPTER 9: THOUGHTS, QUESTIONS AND RECOMMENDATIONS

In this chapter, I reflect on the development of the four themes, language, values, ways of learning, and cultural connections, that were detailed in the four preceding chapters and discuss the potential ways these might be used. I share some emerging questions that were raised during this research project but were never fully answered. Finally, I make some recommendations for future research that may emerge from this work.

Understanding the Potential "Bumps"

When I first began planning this research project I thought it might be possible to develop lesson ideas and modules that would be living examples of how to transform mathematics education for Mi'kmaw students. I had visions of developing resources similar to those that had been developed amongst the Yupik for the Math in a Cultural Context program (university of Alaska Fairbanks, n.d.). I quickly realized that this could not be the first step. It was apparent to me that before I could begin working with participants to develop Mi'kmaw mathematics materials similar to those developed for the MCC series, I needed to have a greater understanding of where the conflicts were arising for Mi'kmaw students.

This dissertation has been a journey to uncover these areas of concern and to learn together with participants as we created a model (see Figure 3) that can be a guide toward the envisioned Mi'kmaw mathematics materials. At the heart of the model is making personal and meaningful connections to the mathematics and the four themes surround the centre, signifying each are equally important and interconnected. In chapters 5 to 8, I described one of the four overarching themes and the related

conversations that helped to clarify the meaning and significance of each theme. It would be inappropriate to take the separate treatment of these themes to imply that they can be taken as stand-alone ideas. They are interconnected and no one idea alone will hold the answer. Furthermore, it is inevitable that the model is incomplete. I am certain that as the participants and I continue to learn together in future projects, new ideas will emerge that will increase our awareness of this issue.

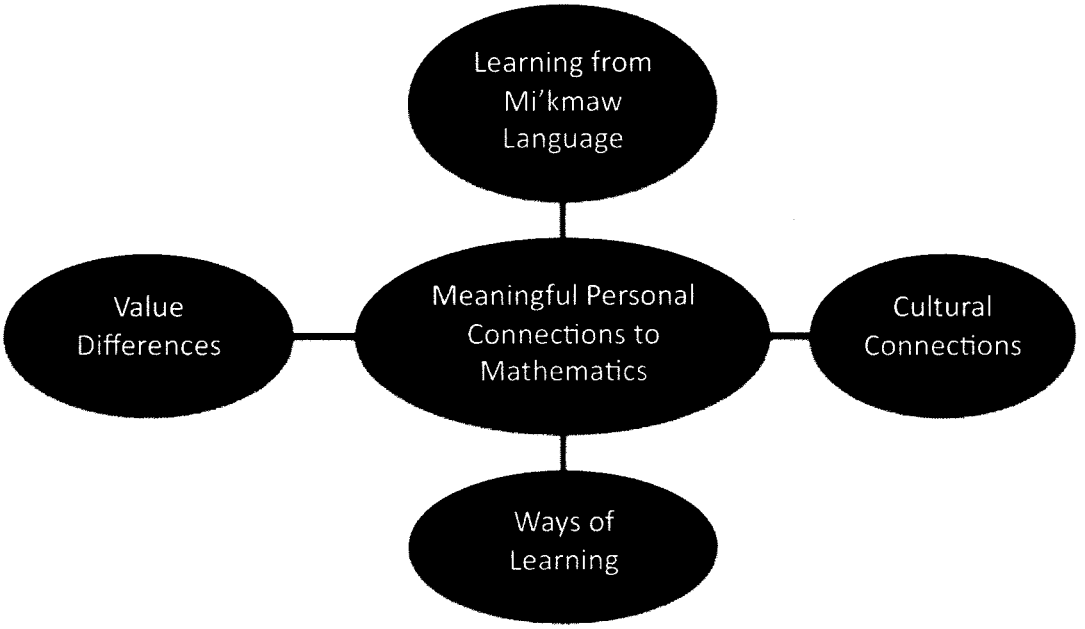

Figure 3: **Model of Potential "Bumps".**

It is my hope that these themes draw attention to the areas of potential "bumps" for Mi'kmaw students. By "bumps" I mean the value conflicts, the incompatibility of teaching/learning styles, the "crazy talk" moments, and so on. These are the potential incidents that may cause conflict for Mi'kmaw students in a mathematics classroom. By attending to these potential bumps, I would argue that educators can take steps to mitigate them and thus support Mi'kmaw students as they negotiate their space between school-based mathematics and Mi'kmaw cultural concepts of mathematics.

Ultimately, I see that this was an important step in my personal journey toward the kind of work I aspire to do as it helps me to take the next steps with greater awareness. That being said, I see that this model also holds potential for others as well. Certainly the participants in both participant groups have expressed their pleasure with the themes and have expressed a great deal of interest in drawing from these themes to make changes in their schools. Similarly, these themes have been embraced by some teachers in other MK schools that were not a part of this work. I hope to have the opportunity to share these themes with more MK teachers in the coming year.

Implications for Developing Culturally Mathematics Curriculum

It is also reasonable to think that these themes may prove to be informative to educators working in other indigenous communities. It may not be the case that these themes provide an exact fit for other communities, but the process of working together to reveal the "bumps" for students in their respective contexts may provide them with greater insight. And perhaps starting with a discussion about the themes from this project, identifying which apply and which do not, and building from there may be a reasonable approach. These themes might even serve as a set of guiding principles for those who wish to develop culturally based mathematics curriculum.

Although interconnected, each of the themes can be linked to the idea of learning from language, which emerged as an overarching theme in this work. Thus, examining the indigenous language of a community context would provide a starting place for such curriculum development projects. Given that the ways of thinking are embedded in the indigenous language, it would be helpful for curriculum developers to understand how the language is structured and used within the community.

It may be helpful to ask questions such as "What is the word for…?" or "Is there a word for…?" to better understand how mathematical concepts are described in the language. Gathering words that can be used to describe mathematical concepts, provides insight into concepts that may prove to be potential strengths for building a mathematics program. Similarly, awareness of mathematical concepts that have no translation in the indigenous language exposes the taken-for-granted assumptions that are often present in existing curricula.

It will also be important to understand the underlying grammar structures of the indigenous language. This project has shown that the prevalence of nominalisation in mathematics stands in direct contrast to the verb-based ways of thinking inherent in the Mi'kmaw language. This is an important issue for curriculum developers to consider. Looking to "verbification" as an alternative may help to create a more engaging and rich curriculum for indigenous learners.

It is also important for curriculum developers to think about how mathematical ideas are used and valued in the community context. It is important to understand how numerical and spatial reasoning emerge in the context of the community culture. This study has shown that spatial reasoning was highly valued as it pertained to matters of survival. Numerical reasoning was seen as useful in play. If we consider mathematics to be about examining quantity, space, and relationships (Barton, 2008) then it becomes important to build a curriculum that values these concepts in a way that is consistent with, rather than in opposition to, the way these concepts are valued within the culture. This work points to a need to build mathematics curriculum from a basis of spatial

reasoning. Curriculum developers in other contexts will need to see what types of reasoning are valued within the community.

Language and values also influence the preferred ways of learning in any community context. It was evident in this community context that a mathematics program should provide children with opportunities to be involved in learning focused on apprenticeship with time for mastery, and hands-on engagement with concrete representations of mathematical ideas. Furthermore, building from a valuing of spatial reasoning, it was recommended that a mathematics program should place visual spatial learning approaches on equal footing with the already dominant linear-sequential approaches, providing more ways to learn so that more students can learn.

In addition to community language, values, and ways of learning being included in a mathematics program, it is also essential to make meaningful and non-trivializing connections to the community cultural practices. This involves examining how the school-based mathematics can be pulled in through identifying types of reasoning inherent in the community that can help students to make sense of the school-based mathematics. It also means creating a curriculum that helps students see that mathematical reasoning is a part of their everyday lives, and has been for generations. The success of *Show Me Your Math* suggests that inviting students to be mathematicians who investigate mathematics in their own community contexts could also be an important component of a culturally based mathematics program.

Overall, however, it is most important to remember at the heart of the model is always the importance of making meaningful personal connections for students. Thus, it is important to know the students, knowing the community context in which they live,

and work toward developing a program that will engage them in meaningful ways that respect their past, present, and future.

The Emerging Questions

Attending to the themes has resulted in a number of subsequent questions throughout the research.

In chapter 4, I described the two school contexts and noted some significant differences between the two. Wutank had access to elders and Mi'kmaw speakers within their own staff. They had many elders in the community they could turn to for support with language, history, and culture, and had strong community support with almost 100% of community children attending the school. Phillips Lake, by contrast, had few people to draw on for support with language, history, and culture. They competed with two nearby provincial schools for students, and as such had a smaller pocket of support within the community. While Phillips Lake aspired to increase the incorporation of cultural, practical knowledge, they often expressed to me that they felt unsure where to begin. This is probably much closer to the norm for many Aboriginal community schools.

This contrast raises several questions for me as the researcher. Most importantly however, is what can be done to support schools like Phillips Lake along this journey to transformation? As I stated previously, I was often positioned as the expert in our conversations, yet my experiences in Wutank where I was often among the least culturally knowledgeable, give an indication that my expertise is seriously limited. I appreciate that my limited knowledge and experience was beneficial to the Phillips Lake group, yet I wished that they could have had more access to truly expert knowledge.

One need only reflect on Amy's excitement about her time with the elders at the *Show Me Your Math* professional development day, to see what inspiration and potentially transformative power such interaction can have. Could this be possible to do on a regular basis with more teachers in more schools that could provide ongoing support, instead of just one day of interaction for a limited number of teachers? Is there a way to draw on the capacity in some communities to build the capacity in other communities? Could the creation of an elders' advisory group that could be called upon to visit these schools on a regular basis be a possible solution to this challenge?

Many of the schools drew upon elder knowledge and expert knowledge during the *Show Me Your Math* preparation times, but as was pointed out in our discussions, this was often done as a special event. I can envision a project that would see elders and other Mi'kmaw experts coming together to support these schools more regularly. While ideally members of this group would be available to make regular in-person visits to these schools, this could also be facilitated by the use of the MK's existing video conferencing network. One participant teacher even suggested that she would enjoy having the opportunity to watch videos of elders having some of these discussions about mathematics words and ideas. Many different approaches are possible, but it seems apparent to me that there is capacity within the MK communities to provide such support, although it may require additional funding.

Both Sarah from Phillips Lake and Maureen from Wutank expressed concerns about their lack of expertise and suggested that teachers need support staff in the classroom who can help them to incorporate language and culture. In reflecting on their comments and the success of the *Show Me Your Math* event, I would suggest that these

teachers may have valuable resource people sitting in their classroom. If the students were given homework tasks that positioned them as researchers who had the task of going home or to the home of a relative to explain the mathematics they are learning in school and find connections to community practices, Mi'kmaw words, and so on, this could have many benefits. The students would be provided with a context for engaging in conversation with elders and family members about mathematics and they would need to understand the mathematics well enough to explain it to others. Students would then be required to present their learning to the teacher in an authentic way because the teacher would not possess this knowledge already. The teacher would benefit by learning from the community via the children. This approach might also strengthen the relationship between the school and the community.

Connected to this idea of bringing elder/expert knowledge to communities is the idea of bringing language to communities. Many communities like Phillips Lake have limited language supports. The elder/expert group could provide some additional language support to communities, but what is needed is ongoing Mi'kmaw language support and instruction for both students and staff. Phillips Lake does have a language teacher but only one and she has to teach Mi'kmaw language to all grades with limited resources. This is not the same as having teachers in the classroom who can speak bilingually for all subject matter.

Recall Emily's desire to have dual language use in every classroom described in chapters 4 and 5. This vision is challenging for Wutank where there are many teachers and support staff who can speak the language. The challenge is even greater for schools that do not have such supports. This challenge is often addressed by participants at the

bi-annual *Lnui'sultinej* (Let us speak Mi'kmaq) Conference, where revitalizing language is the goal. Some strategies to address this have been put in place by MK including the teaching of language courses via video conferencing for communities without language teachers, in-community part-time Bachelor of Education programs designed to train more Mi'kmaw teachers, as well as the ongoing development of language resources. With the exception of the video conference language classes these programs tend to increase the capacity in those communities that already have capacity more so than in the others. Perhaps some of the schools in communities without speakers can recruit some of the new graduates from the Bachelor of Education programs who are speakers. The complexity of this issue, however, does not lend itself to easy answers.

Ideas for Future Research

I have already raised some questions that point to resource development needs of the schools which I believe require associated research. In order to develop culturally responsive mathematics materials for Mi'kmaw schools, there needs to be a research base from which to draw the ideas. The model I have laid out provides a foundation for such work but each theme will need to be explored more deeply in both the participant communities and other Mi'kmaw community contexts. Research will also need to be done during the resource development phase to monitor and report on the process, and research will need to be done to monitor the effectiveness of such resources, I see this development of culturally responsive resources as the primary goal of future work, yet throughout this process the list of questions and ideas continued to grow.

One potential new project idea is to develop a more extensive list of Mi'kmaw words that can be used in teaching mathematics. Such an exploration of the Mi'kmaw

mathematics register could provide great insight into the development of Mi'kmaw mathematics materials for classrooms in MK schools and it would be particularly beneficial to schools with immersion programs or schools aiming to initiate immersion programs.

Another potential research project, also related to language, that has emerged as a real curiosity for me relates to the "verbification" of mathematics. I wish to explore the differences between noun-based and verb-based approaches to mathematics teaching and invite teachers to work collaboratively to develop strategies to verbify their mathematics classrooms. I am curious about how this might support student learning in both Mi'kmaw classrooms and public school classrooms.

As I stated in chapter 7, there are multiple factors associated with ways of learning that need greater exploration as well. In particular, I would like to explore the effects that greater emphasis on spatial representations of mathematical concepts might have on student learning. I have conducted many professional development sessions where I presented activities that draw on some of the visual-spatial ideas and the hands-on learning that I described in chapter 7, and many teachers have responded positively to them. This was not surprising, because I had done similar workshops before beginning this research. The research conversations strengthened my belief that hands-on learning is important through the new experiences and a further understanding of the experiential nature of the Mi'kmaw language. It would be beneficial to analyze more closely the impact of this type of activity. This would be especially valuable if it connected to the development of culturally responsive mathematics materials.

When I began this work, my desire was, and continues to be, to make this part of an ongoing project that continues to grow and expand. As such, I would like to share these themes with a wider MK audience and include more schools in the process as we move forward. It will be important to see if the themes resonate with participants in other schools both locally and internationally and to see what other communities could add to the work I have done to date with the communities in this research project. It will also be interesting to see how each of the participant schools as well as other MK schools will make use of the themes in their context. For example, some schools may draw more heavily on language because they have the capacity to do so, whereas others may chose to focus on other ideas, knowing that their language capacity needs to build more before they can fully implement similar ideas. Because *mawikinutimatimk* affords each participant to grow as one needs in the direction one needs, many options for growth from these themes are possible.

Overall, this work is just the beginning of a move toward improved mathematics education in Mi'kmaw communities, and perhaps public schools in Nova Scotia. This dissertation stands as a guide and raises some necessary questions to explore as I further my own understanding and continue my ongoing commitment to the Mi'kmaw communities that have provided me with so many valuable learning experiences.

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Sterenberg, G; Barrett, L.; Blood, N; Glanfield, F; Lunney Borden, L.; McDonnell, T; Nicol, C.; Russell, C. and Weston, H. (forthcoming). To become wise to the world around us: Multiple perspectives of relating Indigenous knowledges and mathematics education. *Delta K*

Refereed Presentations

Lunney Borden, L. (2009). The "Verbification" of Mathematics. *Proceedings of the 33rd Conference of the International Group for the Psychology of Mathematics*, Thessaloniki, Greece.

Wagner, D., Johnson, N., and Lunney Borden, L. (2009). Show me your math: Inviting community knowledge of mathematics. *Dreamcatching Conference*, Winnipeg, MB, May 2009

Lunney Borden, L. (2009). Transforming Mathematics Education for Mi'kmaq Students through *Mawikinutimatimk.* (A poster presentation) Life long learning – from youth to elder: Conference on Aboriginal education. Atlantic Policy Congress Of First Nation Chiefs Secretariat, Fredericton, New Brunswick.

Lunney Borden, L. and Wagner, D. (2009). Show me your math - Inviting community knowledge into the mathematics classroom. Life long learning – from youth to elder: Conference on Aboriginal education. Atlantic Policy Congress Of First Nation Chiefs Secretariat, Fredericton, New Brunswick.

Nicol, C., Andrew-Ihrke, D., Archibald, J., Brown, L., Burton, D., Cajete, G., Commodore, J., Dawson, A., Kelleher, H., Lipka, J., Nielsen, W., Owuor, J., Rigney, L., Wagner, D., & Yanez, E. (2008). Creating sustainable change: Alternative perspectives on culturally responsive approaches to mathematics teaching and learning with/in Indigenous communities. *Annual Meeting of the American Educational Research Association, New York, New York,* March 2008.

Lunney Borden, L. and Wagner, D. 'Show me your math': inviting children to do ethnomathematics. *Proceedings of the 29th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Lake Tahoe, USA,* October 2007.

Lunney Borden, L. and Wagner, D. (2007). "After this research": Questioning authority when non-Aboriginal people do research in Aboriginal communities. presentation

at *The 24th Annual Qualitative Analysis Conference*, St. Thomas University and the University of New Brunswick, May 2007

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Academic Conference Contributions:

- Working Group Participant for "Relating Indigenous Knowledges and Teaching Mathematics" at the *Canadian Mathematics Education Forum*, Vancouver ,BC, May 2009.
- Invited panellist for *Investigating equitable discourse practices in mathematics classrooms*, Rochester, NY, May 2008. This was an NSF funded conference in which brought together a group of 34 distinguished researchers, new researchers, graduates students, and teachers to discuss issues relating to discourse and equity in mathematics classrooms.
- Ethnomathematics and audience. Ad hoc presentation with David Wagner. Proceedings of the Canadian Mathematics Education Study Group Conference, Calgary, Canada
- Working group discussant, Special Forum on Mathematics and Science Education, Canadian Aboriginal Science and Technology Society Conference, September, 2005.
- Working group facilitator, "Supporting teacher success" (with Brent Davis & Eric Muller), *Canadian Mathematics Education Forum,* Toronto, ON, May 2005.

Professional Conference Presentations and Workshops:

- High School Mathematics Workshop based on Transforming Mathematics Education for Mi'kmaq Students through *Mawikinutimatimk. Dreamcatching Conference*, Winnipeg, MB, May 2009
- Designing Tasks for All Students, Presentation at the Mathematics Teacher Association Provincial Conference, Cambridge, NS, October 2008
- 4 to 6 Mathematics Workshop and Resource Teacher Mathematics Workshop at the Mathematics Summer Institute in Antigonish, N.S., August 2008
- Show me Your Math: Mi'kmaw children engaged in ethnomathematics. An invited presentation as part of a conference on Mi'kmaw Education for teachers from the Cape Breton Victoria Regional School Board, Membertou, NS. April 4, 2008.

- Show me Your Math. An invited talk for the Mi'kmaw Kina'matnewey Annual Symposium, Halifax, NS, March 2008.
- Mathematical connections: Past, present, future. An invited presentation for secondary mathematics teachers from the Cape Breton Victoria Regional School Board, Sydney, NS. February 5, 2008.
- P to 3 Mathematics Workshop at the Mathematics Summer Institute in Antigonish, N.S., August 2007
- The art of making mathematics meaningful. DreamCatching 2007, Regina SK, May 2007
- Mathematics 10 Plus Workshop Facilitator, Nova Scotia Department of Education, Halifax NS, October 2006
- Grade 3/4 Mathematics Workshop on Early Algebraic Thinking at The Mathematics Summer Institute in Antigonish, N.S., August 2006
- Junior High Mathematics Workshop at the Mathematics Summer Institute in Antigonish, N.S., August 2005
- Math You Can Hold In Your Hand. DreamCatching 2005, February 2005, Concordia University, Montreal, Que.
- Math Mentorship Workshop Facilitator (with regional math leaders team, NS Dept. of Education) Citadel Hotel, October 2004, Halifax, NS.
- Grade 5-6 Mathematics Workshop at The Mathematics Summer Institute in Antigonish, N.S., August 2004
- "Using your Smart Board in Your Math Class P to 6"at the ANTEC Conference, May 2004, Pictou Landing, NS.
- "Using your Smart Board in Your Math Class 7 to 12"at the ANTEC Conference, May 2004, Pictou Landing, NS.
- "Incorporating Mi'kmaq Culture and Language in Your Math Class" at Lnui'sultinej Conference, May 2003, St. F.X., Antigonish, NS.

Professional Development Workshops:

- Math Professional Development sessions for Teachers in Atlantic Canada's First Nation Schools, 12 sessions held via video conferencing Oct. 2005 – April 2006, for more information explore the web site at www.wfnss.ca/math.
- Two-day Intensive SMART© Board In-service, John J. Sark School, Lennox Island, PE
- "Linking Math in the Atlantic Region" a professional development initiative supported by Mi'kmaw Kina'matnewey and the Atlantic Canada First Nation Help Desk, on-going, see wfnss.ca/math.
- "Teaching Mathematics Using a Constructivist Approach" In-Service Day at Mi'kmawey Elementary School, November 2004, Potlotek, NS.
- "Math You Can Hold in Your Hand: Fractions" at a regional in-service day, October 2004, Wagmatcook, NS.
- "Teaching Mathematics Using a Constructivist Approach" In-Service Day at Eskasoni Elementary School, April 2004, Eskasoni, NS.