THE 'VERBIFICATION' OF MATHEMATICS: USING THE GRAMMATICAL STRUCTURES OF MI'KMAQ TO SUPPORT STUDENT LEARNING

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"Miss, you're talking crazy talk again!" My students would sometimes say this to me during the ten years I taught secondary mathematics in a Mi'kmaw [1] community school in Cape Breton, Nova Scotia. The accusation of "crazy talk" was always an indication that I needed to rephrase my explanations and find new words, new ways, to help students make sense of a concept. Like most indigenous languages in Canada, Mi'kmaq is a verb-based language. Over the years, the accusations of crazy talk lessened as I shifted my way of explaining concepts to be more consistent with the verb-based linguistic structures of Mi'kmaq even though I was teaching in English. In this article, [2] I will share one aspect of a larger research project focused on transforming mathematics education for Mi'kmaw students. In particular, I will describe the concept of *verbification* as a linguistic process that stands in contrast to the predominance of nominalisation in the teaching and learning of mathematics. I will argue that *verbification* holds promise as a means of supporting Aboriginal students in mathematics learning.

Establishing the context

The Mi'kmaw people are Aboriginal inhabitants of Atlantic Canada. Mi'kmaw communities in Nova Scotia have a unique jurisdictional agreement with the Government of Canada, referred to as the Mi'kmaw Kinamatnewey (MK) agreement, which gives them control over their education system and collective bargaining power. These MK communities have a stated goal of decolonizing education by incorporating indigenous knowledge, culture and values into their curricular and pedagogical practices. A decolonized approach to education that allows for the inclusion of indigenous worldviews has been advocated as a necessity to meet the needs of Mi'kmaw students (Orr, Paul & Paul, 2002; Battiste, 1998, 2000). At the same time, these communities are also bound by the agreement to offer provincially transferrable curriculum and to demonstrate measures of success based on provincially developed assessments.

Disengagement from mathematics and science is a concern for many teachers in the MK schools as they grapple with the tensions between school-based mathematics and Mi'kmaw ways of reasoning about things seen as mathematical. During my ten years of teaching mathematics in an MK school, I had witnessed these tensions myself. I wanted my students to be successful learners of mathematics, yet I also suspected that the disengagement I sometimes witnessed in my classroom emerged in response to conflicting worldviews.

It has been argued that disengagement from mathematics emerges as a result of the conflict between Aboriginal culture and the cultural values embedded in school-based mathematics programs (Cajete, 1994; Hankes & Fast, 2002). Gutiérrez (2007) has shown that when students do not see themselves reflected in the curriculum and see how their cultural mathematics connects to the broader mathematical context, the result may be further disengagement for many students from marginalized groups who feel that their identity is being denied and that they lack power to influence the curriculum. She has argued that for these students, the cost of participation may be a need to deny their cultural ways of knowing and community values in order to participate in the dominant view of mathematics. Often these costs are seen as too great and children choose not to participate. Doolittle (2006) has echoed this idea, cautioning that, in learning mathematics, "as 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?" (p. 19).

Engaging with the community

As the granddaughter of two Acadian women who stopped using their language when they married English-speaking men, I understood language loss on a personal level and wanted to show my students that I valued their language. During my ten years of teaching, I immersed myself in the Mi'kmaw community culture and developed a functional use of the language. By the time I began this research, I had been a teacher and an administrator in the school, had conducted my Masters' research with support from the community council, was a member of the church choir

where I was known for singing Mi'kmaw hymns, and had been a mathematics leader within the MK schools. I had spent a considerable part of my career exploring the complexities of teaching mathematics from a Mi'kmaw perspective. Yet I still 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.

I shared my concerns about my role in this work in a conversation with two Mi'kmaw colleagues, Richard and Sa'n [3], prior to beginning the research conversations. Their responses were reassuring. Richard 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. Sa'n 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 we 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, 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.

Lipka *et al.* (1998) have used the term "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, my kinship relationships extend beyond the community where I worked 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.

Research for many Aboriginal people has been intimately connected with colonization and imperialism (Smith, 1999) and thus, any attempts to conduct research in Aboriginal communities are often met with resistance and skepticism, and probably rightfully so. As a response to this challenge, a new paradigm of decolonizing research or indigenist research has emerged (Denzin, 2005) and is seen as a way 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) and has 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). Such paradigms create space to privilege indigenous knowledge (Denzin, 2005; Smith, 2005) and acknowledge that knowledge production must happen in a relational context (Denzin, 2005).

In search of an appropriate indigenist paradigm, I sought the advice of many community elders. I searched for a way to describe the activity of people coming together to discuss an issue or solve a problem. During an informal conversation with one community leader, it was suggested that I 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. 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 a circle where all members are equally important and necessary. Each participant that joins in the circle has something unique to contribute. Thus *mawikinutimatimk* became the methodology for this project.

The project was conducted in two rural Mi'kmaw communities in MK elementary schools. One community, Phillips Lake [4], had about 500 residents and the other community, Wutank, had a population of approximately 1000 residents. After-school conversations were held once or twice each month over a nine-month period. Teachers, support staff and elders were invited to participate. In Phillips Lake there were 7 participants, 6 of whom were non-Mi'kmaq teachers with between 1 and 10 years experience at the school, while the other was a Mi'kmaw support worker. In this school, children spoke little Mi'kmaq and the language of instruction was English. In Wutank there were10 participants; 8 were Mi'kmaq (6 teachers and 2 support staff) and 2 were non-Mi'kmaw teachers who had 12 and 18 years experience in the school. In this school, many children spoke some Mi'kmaq. The language of instruction was English but it was common to hear both Mi'kmaq and English being used in classrooms. Both schools are striving to increase Mi'kmaw language use. Not all participants attended every session. Ten after-school sessions were held in Phillips Lake and twelve in Wutank.

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. After-school conversations were recorded and transcribed. Classroom sessions were not recorded but field notes were kept and experiences from the classroom sessions were often discussed during our after-school sessions. Our conversations were often stimulated by inviting participants to simply notice and reflect on the tensions and challenges with mathematics for their students and to share their thoughts with the group.

The emergence of a model

Through our conversations, four key areas of concern emerged as themes: 1) the need to learn from Mi'kmaw language; 2) the importance of attending to value differences between Mi'kmaw concepts of mathematics and school-based mathematics; 3) the importance of attending to ways of learning and knowing; and 4) the significance of making ethnomathematical connections for students. Within each of these categories, teachers identified conflicts that arise when worldviews collide and identified potential strategies to address these tensions (see the model shown in Figure 1).

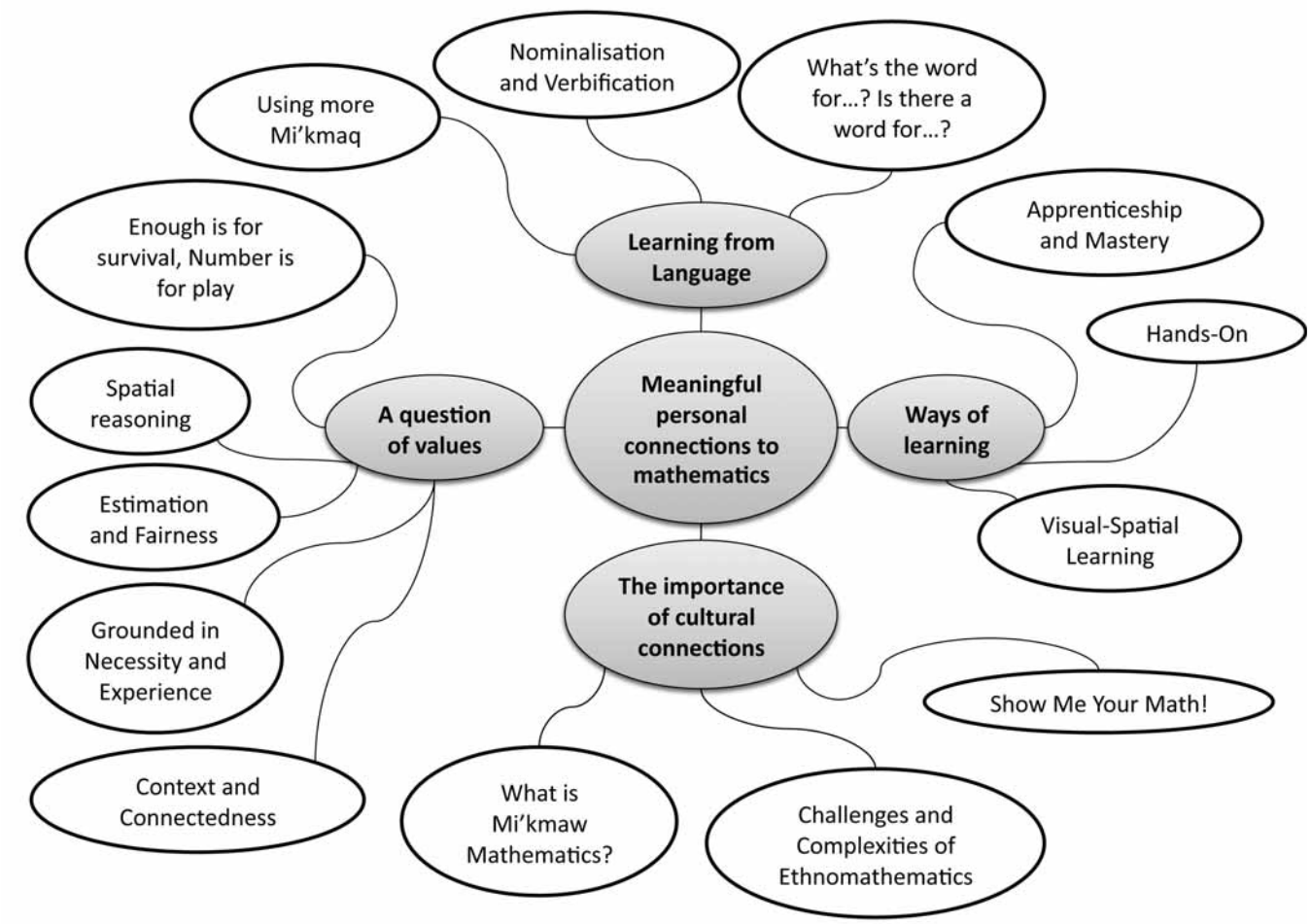

Figure 1. Model for examining the complexities of mathematics learning for Mi'kmaw students.

For this article, I focus on the need to learn from Mi'kmaw language and in particular the phenomenon of *verbification*.

Learning from language

The important role of indigenous language in understanding mathematics was demonstrated by Denny (1981) who used a "learning from language" approach while working with a group of Inuit elders in northern Canada to explore mathematical words in the Inuktitut language. Rather than developing curriculum and translating it into Inuktitut, they used the mathematical words to develop the curriculum and associated mathematics activities. More recently, Barton (2008) has shared the stories of his similar struggles in translating mathematics concepts into the Maori language. He has argued that mathematics evolves with language and claims that:

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

During our *mawikinutimatimk* sessions in Wutank in particular, our conversations frequently turned to the need to learn from the Mi'kmaw language. There was a belief that understanding how the language was structured would enable teachers to better understand how students might think about a mathematical concept.

As Leroy Little Bear (2002) has explained "Language embodies the way a society thinks" and "Aboriginal Languages are, for the most part verb-rich languages that are process- or action-oriented" (p. 78). Henderson (2000) has argued that this verb-rich structure allows for "an active relationship between the elements of a particular environment" (p. 262) which are considered to be in constant flux. In Mi'kmaq:

> speakers build up verb phrases from what we could call implicate roots, containing the action or motion of the flux, and have hundreds of prefixes or suffixes to choose from to express an entire panorama of energy and motion. The use of verbs rather than a plethora of noun subjects and objects is important: it means that very few fixed and rigid separate objects exist in the Mi'kmaq worldview (or landscape). What they consider instead is great flux, eternal transformation and interconnected space. (Henderson, 2000, p. 264)

This sense of change, motion, flux is embedded in the words used by Mi'kmaw speakers to explain mathematical concepts.

During one particular session in Wutank, Richard, a technology teacher and Mi'kmaw language expert shared with the group some ideas about the concept of "straight". He explained that the word *pekaq* means "it goes straight". There is a sense of motion embedded in the word. Similarly *pektaqtek* is a word to describe something that is straight such as a fence. He explained that there "is a sense of motion from here to the other end – *pektaqtek* [it goes straight]."

By contrast the word *nesikk* (triangle) has been recently developed for use in Mi'kmaw schools, but some community elders have expressed trouble with the word because it lacks this sense of motion. It is seen as a static shape and is thus inconsistent with Mi'kmaw grammar. 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 mathematical terms into Maori. Richard shared 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.

Nominalisation and 'verbification'

Pimm and Wagner (2003) have explained that a feature of written mathematical discourse is nominalisation with "actions and processes being turned into nouns" (p. 163). 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). This objectifying tendency in school-based mathematics created tensions for my Mi'kmaw students who sought *actions* but were presented with *things*. Barton (2008) has argued that this situation could be different, claiming "We talk of mathematical objects because that is what the English language makes available for talking, but it is just a way of talking" (p. 127). What would happen if we talked differently in mathematics? What would happen if we drew upon the grammatical structures of Mi'kmaq instead of English?

Research relating to mathematical discourse suggests that there is a need to support students as they move from everyday language to more formal mathematical language (Schleppegrell, 2007). I argue that it is not simply a matter of using everyday language; there is a need to go further and incorporate the grammatical structures of the students' language. Mathematical discourse in the Mi'kmaw classroom, for example, should draw on the extensive use of verbs. Based on the idea that mathematics could have developed differently and that "a non-objectifying mathematics is possible" (Barton, 2008, p. 127), I refer to this approach as the *verbification* of mathematics. I share the story below as an example of how the *verbification* of mathematics supported student understanding.

Prisms and pyramids

Mary, a pre-service teacher in Wutank, had asked me to help her with her lesson on prisms and pyramids in her grade three class, mostly 8 and 9 year olds. She was particularly worried about the quantity of vocabulary terms in this unit. We planned the lesson activities together and co-taught the class.

We began on the carpet, passing around some solids and inviting students to tell us something about them. We chose a cube and a square based pyramid. Each student was asked to say one thing about the solid when it came to them. Some counted vertices and reported how many corners; others counted faces but called them sides. One student offered that the cube was red while another was pleased to report that it felt soft as he rubbed it against his face. One young girl placed the prism on the floor and stated "It can sit still!"

We also used the carpet time to re-introduce some vocabulary that the students would have learned in Grade 2. I took the lead on reviewing these terms. I asked the students if they knew 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."

Later, students were asked to work in groups to explore a given geometric solid (ether a prism or a pyramid) at their tables. Each group was asked to make footprints of each face in moon sand (a moldable sand) and record the shapes they made on a recording sheet. They were each also asked to report back on how many faces, vertices and edges their object had, and were 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.

After their exploration, each group was asked to tell the class whether their solid was a pyramid or a prism and to support their choice. 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 this [*gesture*], forming into a triangle." With this, they made a hand gesture showing how the sides were merging to a point. 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 was time for the group with the triangular prism to report back. There was some debate about which category it belonged to.

"It kind of forms into a triangle" suggested one student but this seemed not to be enough to commit to it being a prism. "What if we look at it like this?" I asked as I rotated the picture 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.

Exposing the verbification

So where is the *verbification* in this classroom episode? The first moment of verb-based discourse came from the student on the carpet who noticed that the cube could "sit still". It is worth noting here that the word *flat* is one example of a word that has no Mi'kmaw translation. I have asked respected Mi'kmaw speakers 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. When this student announced that the prism could "sit still" I thought about the bottom of the basket, it let it sit still. It made sense that she would not talk about the flatness of the face but rather its usefulness which connects directly to the relational way in which Mi'kmaw language is used and constructed.

When I recounted this story during an ad hoc session at the Canadian Mathematics Education Study Group (CMESG) meeting in May 2008, Walter Whiteley mentioned to me that the word polyhedron is derived from the Greek word *hedron* which means "seat," and thus it may be the case that polyhedron originally meant many seats or many ways to sit.

Other examples of *verbification* emerged as we spoke about looking with the face and going over the edge. 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 seemed to make them much easier for students to understand.

Similarly, *verbification* can be seen in how the children spoke about how the objects were forming. The students talked about the pyramids "coming to a point" or "forming into a triangle." The students' expressions used to describe their shapes are very similar to the Mi'kmaw word *kiniskwiaq* shared above by Richard, thus exemplifying the sense of motion that is embedded in descriptions of shape in Mi'kmaq.

This classroom episode gives just one example of how increasing the use of verb-based discourse patterns supports Mi'kmaw children's linguistically-structured way of understanding. In ensuing *mawikinutimatimk* sessions, Mary and I frequently referred to this lesson and shared our enthusiasm about the effects of our *verbification* with the group who concluded that more investigation in this area was necessary.

Conclusion

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? What does it mean to do mathematics? Byers (2007) has argued that mathematics is a creative endeavour that is far more about the doing than the objects of mathematics. It is about observing change and puzzling over ambiguity. 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. It could be argued that turning processes into objects is useful as it allows us to then perform new processes on these objects; performing action on actions. Unfortunately, in school-based mathematics, much nominalisation ends there, and students are presented with these ideas as things to know rather than processes to use.

This pervasiveness of nominalisation in mathematics stands in direct contrast to ways of thinking about and doing mathematics in Mi'kmaq. My reflections on the grammatical patterns used in my own classroom have led me to believe that "talking crazy talk" 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. As I transitioned from asking noun-based questions such as "What is the slope?" to asking verb-based questions such as "How is the graph changing?" I found that students often understood better. I came to this notion of *verbification* by listening to the way students were talking and modelling my language with similar grammar structures.

Doolittle believes that recognizing the challenges of nominalisation may provide "a way forward in Indigenous mathematics education" (Doolittle, Lunney Borden & Wiseman, 2010, p. 88). Indeed, there is a need to explore the ways in which language is used in mathematics classrooms and how it might be transformed to be more in line with Mi'kmaw and other Indigenous grammar structures. As shown in the larger context of our *mawikinutimatimk* conversations, attention to language is even more helpful when connected to other issues at play in the local context. Even so, the issues relating to the structure of language alone helps us to see potential tensions for Mi'kmaw students in mathematics and potential resolutions to these tensions.

Barton (2008) has referred to mindlocks as the pathways

to thought made available to us by our language structures. He has argued that by becoming aware of these mindlocks we can break out of them. Being aware of alternate pathways to understanding made available by Indigenous language structures could provide teachers with a way to question taken-for-granted assumptions and find alternative approaches to teaching and learning mathematics. Verbification stands as an example of an alternate pathway to support Mi'kmaw learners (and perhaps other Indigenous learners) as they negotiate the space between school-based mathematics and their own cultural ways of knowing and doing mathematics.

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Notes

[1] Throughout this article, Mi'kmaq is used as a noun and can be either singular or plural. Mi'kmaw is used as an adjective. While the rules for creating adjectival forms of words in Mi'kmaq is considerably more complex, it has been agreed to by a working group on Mi'kmaw language learning that, when writing in English, these conventions will be used.

[2] This article is an expansion of a paper originally presented at the 33rd annual meeting of the International Group for the Psychology of Mathematics, Thessaloniki, Greece, July 2009.

[3] Pseudonyms have been used to ensure confidentiality.

[4] Pseudonyms have been used for these communities.

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Clearly there is a challenge facing us. We have on our side, however, a strength which is often underestimated: the immense capacity of young children to grasp difficult ideas if they are presented in ways which interest them and make sense to them. It is not always easy to design situations which meet these criteria but, as I have tried to show in this book, the attempt to do so is usually worthwhile. If we can redesign our educational environments in the same way so that, instead of nullifying and ignoring young children's strengths, we are able to bring them into play and build on them, then I am confident that we will be able to meet the challenge currently facing us.

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