"WHAT COMES AFTER *NĒWĀW*?": WHEN GENERALIZATION DISRUPTS EXPERIENCE IN MATHEMATICS

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Abstract

I (first author) explore tensions that arose with Cree elementary school teachers during mathematics class when I attempted to *generalize* Cree words they were teaching me and their students. G*eneralization* is a process in the mathematics discipline that practitioners use to create such things as theorems and formulas. For example, this might be achieved by generalizing patterns amongst specific things. While this is a conventional practice in the discipline, my imposition of *generalization* does not align with the Cree perspectives these teachers were representing, and disrupted the sharing of their experiences. By inquiring narratively into my experiences and the experiences of these teachers, I explain how a mis-educative teaching moment on my part led to an educative experience.

Résumé

Dans cet article j'explore (moi, le premier auteur) des tensions qui se sont manifestées avec des maîtres d'école élémentaire cris pendant un cours de mathématiques quand j'ai tenté de généraliser des mots cris qu'ils m'enseignaient à moi et à leurs élèves. La généralisation est un processus, en mathématiques, dont on se sert afin de créer théorèmes et formules. Ainsi, on pourrait ce faire en généralisant des régularités

dans des choses spécifiques. S'il s'agit là d'un procédé courant dans le domaine, cette façon de faire ne s'aligne pas avec les perspectives des cris que représentaient ces enseignants, et a bousculé le partage de leurs expériences de vie. En m'interrogeant de près sur mes expériences de vie comme sur les leurs, j'explique comment un faux pas pédagogique de ma part a eu pour conséquence un apprentissage nouveau.

Introduction

> It was 'math day with Stavros'. Miss Moore (pseudonym) and I (first author, Stavros) were co-teaching the lesson, as we normally do. Today, I was playing the role of an inquisitive student who wanted to learn translations of mathematics terms from English to Cree. Miss Moore patiently taught me and her sixth grade class the words she knew. "Nīswāw means *two times*, *nistwāw* means *three times*, and *nēwāw* means *four times*". She explained that this is how you talk about *doubling*, *tripling*, and *quadrupling* the quantity of something. As she wrote *2x, 3x, 4x* on the board I raised my hand and asked, "What comes after *nēwāw*? Since five is *niyānan*, then based on that pattern, wouldn't *five times* be *niyānanwāw*?" Miss Moore paused and stared at me. "I don't know. No, it doesn't sound right to me. Hmm…it sounds strange. I haven't heard it before." Then I asked, "Why does it sound weird? It should be correct. I mean, what about *six times*, *seven times*, and so on? How do you generalize this to any positive integer?" (Field Notes, October 2017).

This field note came from a mathematics lesson at a Cree bilingual school in a western Canadian prairie province. I attend once a week for an hour to do math with Miss Moore and her students. Miss Moore and her students call it 'Math day with Stavros'. When I enter the school after recess, the halls are filled with students making their way to class. Since it is my sixth year working in the school, I recognize many faces as I pass through the halls. I often carry big blue bins with activities, and so the students always excitedly interrogate me as I pass through. They ask, 'Hi Mr. Stavrou! Are you here for math?! What's in the bin?' or 'Mr. Stavrou! You used to come to my math class last year! Will you come to my class again with your games?'

Once I arrive at Miss Moore's classroom, her students see the blue container and also excitedly swarm and bombard me with questions of what activity I brought for 'math day'. The other sixth grade teacher, Miss Smith (pseudonym), was also present that day with her students. Miss Moore and Miss Smith often combine their grade six students together during the one-hour session I attend each week so that all the grade six students can participate in the session.

On one particular day, we were learning about order of operations—the all-too-familiar acronym *BEDMAS* (Brackets, Exponents, Division, Multiplication, Addition, Subtraction) reminding of the order of operations probably comes to your mind. I wanted to know how arithmetic terms like addition and subtraction are represented in Cree. Miss Moore had the numbers 1 through 20 written in Cree on the chalkboard: *pēyak, nīso, nisto, nēwo, niyānan, nikotwāsik, tēpakohp, ayēnānēw, kēkā-mitātaht, mitātaht,…, nīstanaw.*

Miss Moore explained that the word *mīna* means *and*, and *katīna* means *remove*, which are used to represent addition and subtraction, respectively. She gave the examples: *pēyak mīna nisto* is *nēwo*, and *mitātaht katīna ayēnānēw* is *nīso*. Next, Miss Moore taught us the words for *doubling*, *tripling*, and *quadrupling*: Since *nīso, nisto,* and *nēwo* mean *two*, *three*, and *four*, respectively, then *nīswāw* means *doubling*, *nistwāw* means *tripling*, and *nēwāw* means *quadrupling*. She explained the words are formed by changing the ending of the numbers to *wāw*. She wrote *2x*, *3x*, *4x* on the board. She told a story of baking with her mother as a child and doubling the ingredients of a recipe they were using.

I have always enjoyed learning languages, and seeing how phrases translate back and forth. When I am learning something new, I create patterns for myself. The students were staring at me and giggling because of my own giddiness and captivation in the lesson. Admittedly, I might have been enjoying the lesson more than they were. Miss Moore explained the way the numbers were appended by the suffix *wāw*, and since Miss Moore did not go beyond *nēwāw,* I raised my hand and asked, 'What comes after *nēwāw*?' Miss Moore paused, her brow furrowed, and said, "I don't know."

I anticipated that she was going to say *niyānanawāw*, and so the intention of my question was to set her up to continue with the pattern. When she said she didn't know, I became confused and explained that if we are just adjoining *wāw* to the end of the numbers, then it seemed natural to me that the next few should be something like *niyānanawāw, nikotwāsikawāw, tēpakohpawāw*, and so on. She kept saying that those words do not sound right to her and that she had not heard of them. I pressed with more questions, "But, how would you say *five times*, *six times*, and so on? Why doesn't it generalize? Why does it sound weird?"

I became fixated on the pattern I was seeing and pressed for Miss Moore to explain why my pattern did not seem natural to her. I figured that there must be some way to continue with the numbers by appending *wāw* at the end. I wanted to generalize. In my mind, because of how I learned Western mathematics, I wanted to see a general way to represent multiplying by any positive integer: *2x, 3x, 4x, … nx*, where *n* is any positive integer.

Miss Moore kept saying that it does not work like that. She said that she hadn't heard of any of the words that I suggested, and said she only knew up to *nēwāw*. I was so absorbed with my ideas of creating patterns and trying to generalize that I derailed the lesson and took away from the context that she was providing through her language. Miss Smith, who is also a Cree speaker, was mostly silent during this interaction between me and Miss Moore. She was also unsure about my line of questioning.

As I reflect on this experience, I am troubled by my response to Miss Moore. What experiences did I have in my education that influenced my questions? I shifted away from her sharing her language and their significance in the context of her life and the lives of the students, to a decontextualized discussion of generalization. As I inquire into this experience, I am struck by my use of the word *natural*. Indeed, *natural* is a commonplace term in mathematics that carries the connotation of something being inevitable and typical. In the context of this lesson viewed through a mathematical framework, the notion of *natural* indicates that, not only is there an expected pattern (made by appending the suffix *wāw*), but that the next step ought to be generalizing this pattern to any arbitrary positive integer. *Natural* may be *natural* to a mathematician, but it certainly derailed Miss Moore's lesson and imposed a framework that disrupted her cultural and linguistic experience.

Thinking Narratively about Education

Miss Moore and I first met as graduate students in a course we took together. We sat together during a one-month intensive summer course on anti-racism education and developed a friendship that led to us working together at her school. Part of my job for the Department of Mathematics and Statistics at the University of Saskatchewan is to teach mathematics with Indigenous teachers and students. Miss Moore explained that she just transferred to a new school (coincidentally, the school in which I was already working) to teach grade six. She invited me to co-teach mathematics with her once a week starting in fall. That is the concise background of how Miss Moore and I came to be. I met Miss Smith, the other grade six teacher, through Miss Moore. Miss Smith is also a Cree speaker. Due to time constraints, the three of us negotiated that Miss Smith and her students join our math sessions during my weekly visits.

I reflect on our experiences in her sixth grade mathematics classroom narratively through Clandinin and Connelly's (2000) three-dimensional narrative inquiry space of *temporality*, *sociality*, and *place*. The narrative inquiry space comes from Dewey's (1997) foundational work of *continuity*, *interaction*, and *situation*—Experiences are continuous because they are set and linked in the past, present, and future (experiences are temporal), experiences occur within personal-social relations (experiences show interpersonal interaction), and experiences are located in a sequence of physical places and landscapes (experiences are situated). Inquiring into experience requires the simultaneous exploration of all three narrative commonplaces (Connelly & Clandinin, 2006) because experience is lived in the midst, unfolds over time, exists in diverse social contexts and place, and is co-composed in relationships (Caine, Estefan, & Clandinin, 2013).

I often return to my feelings of uneasiness around the lived experience in Miss Moore's classroom. I wonder how my understandings of Miss Moore and our classroom lessons might change as I consider the emotions that arise within me. The personal-social dimension of narrative inquiry requires me to connect experience inward to the internal conditions of my "feelings, hopes, aesthetic reactions, and moral dispositions," and outward "toward the existential conditions, that is, the environment" (Clandinin & Connelly, 2000, p. 50). What stories of teaching and learning was Miss Moore enacting in the mathematics classroom? How were Miss Moore's familial stories of language and culture being silenced in the mathematics classroom by my questions? How have my experiences of learning and doing mathematics resulted in perceptions of doing mathematics that did not make space for Miss Moore's linguistic and cultural experiences? What are the frictions caused by our intersecting lives, and what might I learn from these lived stories?

Thinking about my response to Miss Moore brings me backward to different times and places of my university education. I have woven a sequence of experiences that highlight times in my education that shaped my perception of mathematics education in ways that I believe contributed to my response toward Miss Moore. I begin with the following memory reconstruction:

> I am sitting, confused, in a 200-level mathematics course for honors students. This class began with 28 students and has dwindled to four. I cannot remember the last lecture that made sense. I wonder if my three classmates are just as confused? Erin (pseudonym) definitely understands everything because she randomly catches the prof's mistakes, leading me to roll my eyes in envy. This prof is so long-winded. The only things he seems to write on the board are theorems. Everything is too generalized—I need to see specific examples. I raise my hand and ask him to show some concrete examples. He said, "This theorem is a powerful tool that captures so many things. On your own time, solve examples by applying this theorem." It is fall of 2007 and I am anxious for the upcoming midterm exam. (Memory Reconstruction, Spring, 2018).

My experiences in this and subsequent classes pushed me to think of solving mathematical problems by using generalized theorems. I am not denying that this orthodoxy does not serve a useful purpose, since it allows practitioners to describe and quantify some phenomenon. My contention comes with the difficulty in understanding concepts that are abstracted from context experience—the very thing I tried to do in Miss Moore's classroom. Being taught to generalize is ingrained in my education. When I close my eyes, I can see a homework assignment from one of my undergraduate mathematics classes returned to me with the following comment in red pen: *You need to generalize this*. On one particular question, I wrote *I will show that…*, to which the professor crossed out the pronoun *I* and wrote *We*. We? Why *We* when I am the one writing this? I saw in all my textbooks the use of the word *We*, everywhere.

After completing my undergraduate, I started a Master's degree in mathematics. Now the game became writing and publishing papers. I was green and humbled by the wonder of how a person comes up with something to publish.

> It is fall of 2010 and I am in the midst of my Master's degree in mathematics. I am talking with a post-doctoral researcher. She is very insightful and we are discussing how to write publishable manuscripts. We are sitting in her office drinking coffee and I ask her how she thinks up ideas to research and publish. She replies, "You just start with something that other people have published and you try to generalize them further." (Memory Reconstruction, Spring, 2018).

Retelling these memories of my struggle as a mathematics undergraduate student has helped me consider how my mathematics education shaped the way I responded to Miss Moore. I struggled with the emphasis of *generalization* in mathematics. I felt a dissonance in the way I learned mathematics in high school compared to how it was being taught at a university level. Everything is to be abstracted. My professors always provided so much theory that I could not seem to contextualize. I eventually got used to the ways mathematicians teach mathematics—*generalize* and *abstract*. Start with a general and abstracted result, then provide an example. Theorem first, example after. Wash, rinse, repeat. Certainly mathematicians see patterns and make connections through specific examples, but the goal is to abstract the pattern to a generalizable form that encompasses as many specific examples as possible. The theorem is most useful if, in its generalized state, it describes as many specific examples as possible.

I want to emphasize again that I am not contesting the importance of generalized results, but rather, I am drawing attention to the dissonance I felt learning topics that were abstracted to a point that I could not relate to the objects I was studying. I am also drawing attention to the privileging of generalization and abstraction in the discipline, which moves away from experience and context.

Carrying these experiences in my university education alongside the classroom lesson with Miss Moore, I wondered what emotions she felt when I asked her to be more general. She taught me specific Cree words for doubling, tripling, and quadrupling, and then I derailed her lesson and focused on how she could abstract and generalize these terms in Cree. I should clarify that this particular interaction never hurt our friendship and professional relationship—in fact, it is the candidness of our relationship that allows for these personal and educative discussions.

Dewey (1997) described educative experiences to be those that promote growth and push us forward on the experiential continuum, while mis-educative experiences are those that have the effect of distorting the growth of further experience. I believe that by emphasizing generalization and shifting the focus of the lesson away from her experiences, I unintentionally created a mis-educative environment by marginalizing experiences in the mathematics classroom. However, there is potential to make this experience educative by inquiring narratively into these tensions.

Thinking in a Colonial Mindset

Our interaction happened two years ago from these current reflections and memory reconstructions. I contacted Miss Moore and asked if we could have a discussion about that day. I have always appreciated how forward she can be with me in regards to the ways I see things as a mathematician, and how it is irrelevant to the experiences she may be conveying. So, I got right to it and asked if we could go back in time to the day we did that activity together. I gave a quick prompt to remind her of that lesson and then asked her to share her thoughts.

> Stavros: After you taught us *nīswāw*, *nistwāw*, and *nēwāw*, I kept asking if the words *niyānanawāw, nikotwāsikawāw,* and *tēpakohpawāw* follow in the pattern and how Cree speakers would generalize these ideas of multiplication to higher numbers. You said the words don't make sense. Can you explain more?
> Miss Moore: I can't explain it. You're thinking of it in a colonial mindset because those concepts exist in English but to me they don't exist in Cree. It doesn't mean there aren't any words. It just means I don't know.
>
> Stavros: This discussion is teaching me that my colonial mind-

> set, as you called it, involves generalizing mathematical ideas because that is what I have experienced. Cree isn't about decontextualization or generalization—it's about relationships with people and experiencing what you are learning and teaching. How did you learn the words *nīswāw*, *nistwāw*, and *nēwāw*? What was the context? Who taught them to you?
>
> Miss Moore: How did YOU learn the words for *doubling*, *tripling*, and *quadrupling*, and so on? I cannot pinpoint in my life when I learned certain aspects of my *nēhiyawēwin*.
>
> Stavros: That's a good answer! I don't know how, when, or where I learned those words and ideas in English either. I mean, I probably used and understood them well before I learned multiplication in the third grade.
>
> Miss Moore: I was born to an 18 year old nēhiyaw iskwēw. We all lived on the reserve most of my growing up years. I only spoke Cree because my grandparents only spoke Cree. I didn't start speaking English until I went to school. I can only tell you what I know, but it is in the context of my experiences and it does not make sense to talk about anything else (Field Note, May 8, 2018)

Miss Moore explained that I was thinking about what she was trying to teach me in, what she called, a colonial mindset. I took this to mean that I was trying to impose Western ideologies, such as generalization and abstraction, onto a lesson in which she was simply trying to teach us how, as a Cree woman, she experiences the processes of *combining*, *removing*, *doubling*, *tripling*, and *quadrupling.* She also pointed out the naivety of asking when she learned these words by asking me when I learned the same words in English. The take away of our interaction and of the follow up interviews is that when Miss Moore was sharing her linguistic knowledge, my responses of how she could generalize strayed away from her experiences. My attempt at generalizing moves away from her experience by imposing Western ideologies that do not make sense to her and have no place in her linguistic experiences.

By inquiring narratively into the tensions of the experience with Miss Moore makes way for an educative experience. For me, this educative experience is understanding the ideologies surrounding Western mathematics that are in conflict with the experiences of Cree teachers. It was important for me to recognize the way I moved away from the experiences of Miss Moore in the mathematics classroom. I have learned that since the Cree language is learned and understood through living and experience, that questions involving generalization and abstraction have no place or meaning in Cree and other Indigenous languages because these questions move away from lived, contextual experiences.

As I write this, I am reminded of an article by Doolittle and Glanfield (2007), who discussed the conflicts they face situating mathematics and culture. In particular, Glanfield commented on her work with pre-service teachers whom she believed had "not had a chance to explore the way that they think about mathematical ideas; that their ideas and notion of mathematical relationships have been silenced over their years in formal schooling." (p. 28). In the context of my experience, my formal schooling prompted me to overshadow the sharing of Miss Moore's mathematical relationship for the purpose of abstracting her Cree knowledge. Doolittle explained that he wants to integrate two aspects of his being: Mohawk and a mathematician, which he felt are incompatible. He spoke about the potential of school mathematics in displacing the innate mathematical understandings within Indigenous cultures:

> I don't think the question is merely academic: I believe the fear of loss may be keeping some of our people from succeeding at mathematics. Do we need to give up our natural, innate mathematical understandings when we take in school mathematics? Worse, do we lose our culture to some extent? Indigenous culture has ancient, powerful ways of understanding the world, ways that are sophisticated and strong enough to have enabled the people to survive since creation. But those ways of understanding may actually be supplanted by mathematics education, which is not just mere knowledge, but a Trojan horse full of Greek philosophers wielding *Logos*. (p. 28)

This excerpt struck me when I reflected upon my experience with Miss Moore. She was sharing Cree words she learned, passed down to her from her relatives—words that expressed ways of living and being. I was, unfortunately, the Greek coming into her classroom and displacing her sharing with my indoctrinated ideologies of generalization and abstraction. Doolittle said he thought many Indigenous people see their understanding of relationships devalued at the promotion of discourses in mathematics. This is an educative experience that has taught me to be mindful of the ways that mathematics can smother the sharing of experience.

I remember learning my multiplication tables in the third grade—I started on my 2x tables, then 3x, then struggled until I reached the 6x tables. I did not get further, although I remember most students were where I was. A few got to the end (9x tables) and a few never went beyond 3x. How did I learn it? I sat there and memorized it. In retrospect, I already knew how to double, triple, and quadruple at least a grade before this. When kids play together, they double, triple, and quadruple things like candies, cards, points in board games, and so on. The words *double*, *triple*, and *quadruple* don't even seem mathematical to me, but when it came to drilling 2x, 3x, 4x, and other multiplication facts into my mind in third grade, it seemed much more difficult.

What comes after *quadruple*? I guess *quintuple*, but I've never used that word. I don't think about *quintupling* something. Once, twice, thrice, but what comes after thrice? Frice? Does it matter? I can say four times. I wouldn't want someone asking me how I could say words beyond thrice, and distracting from me explaining the useful words I know from learning mathematics in contexts such as counting, gaming, and so on.

Conclusion

Cree and other Indigenous ways of knowing do not separate knowledge into abstracted categories. Indeed, Indigenous knowledge is derived through lived experiences that are interactional, interrelated, and cyclical (Michell, 2005; Kovach, 2010), and are understood and conveyed through languages derived within evolving, interconnected ecologies (Battiste, 2013). In too many cases, what we learn in Western school mathematics (and how we learn it), is not based on experience or contextual situations. This results in mis-educative experiences that do not acknowledge the life of the learner.

Inquiring into the tensions of this experience with Miss Moore and Miss Smith has also brought forth assumptions I have in regards to Cree and mathematics. I think we know mathematics through our everyday language and experience. Our discussions have helped me understand that there is some form of mathematics (for lack of a better term) that we experience and then there is school mathematics, which is often produced and taught in ways that disjoint it from our experiences. Much of the content learned in the classroom is independent of lived experience. Miss Moore and Miss Smith explained that the words they know come from their lived experiences and the necessity of using these words. That is, Indigenous knowing is not separated into subjects with mathematical distinctions. Mathematics is simply enacted, discussed, and embodied through living—not through categorical processes and words.

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