Culture-Based School Mathematics for Reconciliation and Professional Development

Project Report Summary

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Background

In Canada's era of reconciliation, cross-cultural respect through mutual understanding was emphasized by the Truth and Reconciliation Commission (TRC, 2015a) in its description of reconciliation. It matters *how* we do things, such as how we teach mathematics.

The project "Culture-Based School Mathematics for Reconciliation and Professional Development" responds to the TRC's calls to action by exploring *how* mathematics can be taught in a culture-based way; thereby enhancing Western mathematics pedagogy with Indigenous mathematizing[1]. These two cultural mathematical systems have similarities and differences, which create interest among most students. By learning examples of local Indigenous mathematizing, teachers and students develop an understanding of their Indigenous neighbours. And therein lies a tangible act of reconciliation.

This project was inspired by the successes of culture-based mathematics research in Alaska, Hawai′i, Aotearoa New Zealand, Norway, Sweden, and Canada's Maritimes. In these studies, Indigenous students' interest and achievement increased dramatically, while the non-Indigenous students generally responded favourably (Aikenhead, 2017a, p. 75). It is a win-win situation; also evidenced by Serena's assessment data.

Research Question One

> What supports do teachers need to enhance their teaching of Western mathematics in a sustainable way by bringing some examples of local Indigenous mathematizing into their classrooms?

The Process

Sharon Meyer (project leader) and Glen Aikenhead (project contact person) mentored and collaborated with four rural mathematics teachers Grades 5 to 12 (Serena, Danielle, Kevin, and Krysta [who went on maternity leave part way through the project]) and Principal Sari Carson at the Carrot River School. These participants took part in a two-day Indigenous culture immersion; a mandatory experience that initiates teachers into culture-based teaching.

Currently, a key missing support for teachers is the availability of any culture-based lessons applicable to Saskatchewan's Indigenous peoples and its mathematics curriculum. Thus, the development of some lesson plans was a prerequisite process to identifying the support teachers need to implement such culture-based lessons.

[1] Indigenous languages are verb-based, whereas Western languages are noun-based. This fundamental difference in cultural worldviews is respected by the use of the term "mathematizing" (verb), exemplified by activities in which counting, measuring, locating, designing, playing or explaining occur within an Indigenous culture.

Therefore, a half-day personal lesson-planning session with Sharon was held for each teacher. This provided teachers with concrete ideas about outcomes, resources, and classroom activities (i.e., usually Indigenous mathematizing). It boosted their confidence required of developers of culture-based lesson plans. The teachers were left entirely on their own to design their draft lesson plan.

This draft received feedback from Sharon and Glen before the lesson was taught. This feedback became critical to what teachers learned in their journey into culture-based school mathematics.

Then Glen observed the lessons, preceded by an audio-taped discussion about how it was developed and what was intended. A post-lesson discussion was held to learn: the teacher's reaction, the students' engagement, the teacher's insights into culture-based school mathematics, Glen's feedback, and their ideas for polishing the lesson plan further. Developing a different second lesson plan after Christmas provided more evidence regarding the type of support required by various teachers. A mentored third lesson plan is unnecessary when in-school teacher network support is in place.

The Product

Each lesson plan development revealed a need for explicit and implicit supports for all teachers who are going to teach lessons similar to the ones developed in this project; or for the teachers employed in the future to develop more culture-based lessons for the Province.

On the one hand, these supports included: (a) finding authentic Indigenous sources of information, (b) *learning* some features of local Indigenous cultures, and (c) locating examples of Indigenous mathematizing.

On the other hand, we discovered the need for teachers to *unlearn* certain Euro-Canadian ways of understanding Western mathematics and perceiving the world; ways that interfere with cross-cultural understandings found in culture-based school mathematics. Of course, this was only if teachers had not already unlearned them. Unlearning included such ideas as:

- just by including an Indigenous topic in a mathematics lesson is not enough to meet a culture-based standard for implementation.
- the popular yet erroneous assumption that mathematics itself is free from human values and any cultural features. This assumption *suppresses* a goal of Saskatchewan's mathematics curriculum: understanding mathematics as a human endeavour. The mistaken assumption either undermines or negates culture-based school mathematics.
- an unconscious cultural ethos of Eurocentric superiority that suppresses humility and marginalizes most Indigenous students.
- the unquestioned appropriation from non-Eurocentric cultures in very subtle yet disrespectful ways. It is so subtle that it seems like common sense to those who do it.
- the habit of dichotomous (i.e., "either/or") thinking only. This habit suppresses holistic thinking: "degrees of both." Holistic thinking lets us see the world with two or more different, yet co-existing, fundamental ways of thinking.

Unlearning can be as fruitful as learning, because unlearning broadens one's openness to what can be learned. Yet unlearning is the more challenging process, because it is at first invisible to most people in Canadian mainstream culture. In Antoine de Saint-Exupéry's book *The Little Prince*, we learn, "What is essential is invisible to the eye" (1943, p. 70). The teacher participants talked about the importance of approaching Indigenous ways of knowing with an open mind; and carrying out open-minded dialogues with fellow teachers, administrators, and parents. In contrast, B.C.'s Provincial Auditor-General reported, "Our 2015 report highlighted the impact of the *racism of low expectations* [for Indigenous students]" (Bellringer, 2019, p. 13).

Habits of reasoning are taught to us informally during our family upbringing and formally in our schools and universities. One example is the habit of identifying differences between Indigenous and non-Indigenous students' mathematics test scores as "an achievement gap," rather than as Canada's accumulated educational debt to Indigenous students that today falls on the shoulders of schools and teachers. It becomes an ethical financial issue for Saskatchewan's Legislature, Ministry of Education, and School Divisions responsible for supporting schools and teachers.

What is required in part, therefore, is continuous support for teachers to unlearn the habits that inhibit cross-cultural understanding. These were identified and discussed with the project's teachers as the issues arose. This often led to a revision of the original lesson plan in a few ways. Thus, the participating teachers had the immediate opportunity to put their new learning/unlearning into revising their lesson plan. Teachers who implement these lessons will be introduced to the learning/unlearning of information, perspectives, protocols, and advice. Seven culture-based lesson plans were produced.

The four participating teachers learned to feel comfortable with pluralistic thinking, by constantly going back and forth between two ways of interacting with the world mathematically (Western and Indigenous), an achievement called "two-eyed seeing." It is a matter of taking the best from each way of knowing, drawing on both (to some degree) as needed to solve a problem or issue at hand.

This predilection for two-eyed seeing will always encourage new ways for teachers to engage Indigenous perspectives and mathematizing in their teaching. A sustained impetus to innovate this way comes from students' positive reactions to culture-based mathematics.

At the same time, according to the Principal, an even stronger impetus was established by the teachers when they developed an informal "professional learning community" among themselves. Sari cited that achievement as a major support for the project's sustainability.

Lesson planning accompanied with feedback is a particularly rich context for advancing a teacher's journey into school mathematics for reconciliation.

The participating teachers demonstrated a capacity for continuing their journey into culture-based teaching into the future. Some have already made plans to continue this project informally. During the project, two teachers expanded their culture-based teaching into a *cross-curriculum* approach for selected topics.

The teachers noted a major impediment to their innovation that pervasively discouraged them from doing more than we asked for: the over-crowded and often out-dated mathematics curriculum.

Research Question Two

> What are the identifiable effects on non-Indigenous and Indigenous students, as a result of their engagement with Indigenous mathematizing?

It is unreasonable to expect that a short intervention of just one or two culture-based lessons would impact on students' *understanding of mathematics*. Any noticeable change would be remarkable. The sample size (about N = 16 per class) is too small for a meaningful statistical analysis. However, some consequences related to gaining *Indigenous knowledge* were identified in a student questionnaire and in a focus group. The school has very few students of an Indigenous ancestry. For those who participated in a focus group

at the end of the project, a unanimous appreciation was expressed for "an alternative way of learning mathematics."

Observations

Classroom observations of students learning Indigenous mathematizing pointed to students' physical, emotional, and intellectual engagement; especially students who were not normally engaged in class. A public showing of pride in their mathematizing invariably ensued.

Two comments are relevant here. First, the greater engagement of students reflects the fact that Indigenous mathematizing is naturally action-oriented due to the verb-based nature of Indigenous languages and worldviews. Most students naturally responded favourably to action-oriented events.

Secondly, along with greater engagement comes stronger student motivation to learn. When a teacher makes a clear connection between the Indigenous mathematizing and an analogous idea in the Western mathematics curriculum, this Western content is generally introduced to students who are already motivated to learn. This helps explain the international research results, mentioned above, that Indigenous students' scores on standardized tests rise dramatically while non-Indigenous students' scores improve favourably. Time taken for learning Indigenous mathematizing seems to be more than compensated by its greater motivational effect on students.

Student Questionnaires

Data from pre- and post-questionnaire responses showed dramatic increases in Grade 5 students' interest in enhancing their mathematics class with Indigenous mathematizing. In addition, there was an obvious trend toward gaining an understanding of Indigenous cultural knowledge. The former result substantiates the motivational value of culture-based school mathematics, while the latter result indicates participation in reconciliation.

In contrast, the Grade 12 pre- and post-questionnaire results showed little difference. Their open-ended responses suggest: (a) students had become rather set in their views that mathematics is unrelated to anything, including Indigenous mathematizing; and (b) students tended to oppose a change in the routine of their mathematics classes, to which they had become accustomed.

Overall, however, a majority of all participating students (Grades 5, 6, 10, and 12) expressed an openness to learning Indigenous mathematizing as part of their mathematics class. Within the remaining minority, some continued to be opposed to change, while others became more predisposed to learning Indigenous mathematizing once they were introduced to it.

Project's Objectives

1. To collaborate with four non-Indigenous teachers to help them develop a pedagogy that increases students' understanding of Indigenous perspectives by an occasional engagement with Indigenous mathematizing.
2. To mentor the four teachers as they develop a capacity to independently expand this innovation in the future, as well as transfer their knowledge and wisdom to other teachers as best practice, when given sufficient support from school Administrators, Division Administrators, and the Ministry of Education.
3. To reduce Indigenous students' feelings of marginalization by including instances of Indigenous mathematizing. Indigenous students should not devalue their own culture's worldview in order to succeed in the school's Western mathematics.

These objectives address *reconciliation*, *sustainability*, and *social justice*, respectively. The evidence in this Project Report suggests that all three were met to a reasonable degree, given a one-year project.

Conclusions

Learning to teach Saskatchewan Indigenous mathematizing and Indigenous perspectives was experienced by the teachers as a journey upon which to embark. It was accelerated each time a culture-based mathematics lesson was taught along with mentoring support. It was not so much a professional development exercise as it was a personal life journey with far reaching rewards.

The teachers discovered that the current mathematics curriculum works against the sustainability of a culture-based school mathematics. The Ministry of Education has the authority to cull the current obsolete or inappropriate content taught to most students. This would make room for 21st century innovations such as Indigenous culture-based school mathematics. It would also decrease the negative consequences that accrue for a large minority of high school students who are led to believe they are academically inadequate, and who have learned to hate mathematics (Simeonov, 2016). When they become parents, this negativity tends to be passed on to their children, who then become a challenge for elementary teachers teaching mathematics.

Continuous support for teachers must come from the school administration, School Divisions, and the Ministry of Education. Three key supports for the teachers are: a revised mathematics curriculum, Saskatchewan authentic teaching materials, and a professional development experience for Indigenous culture-based instruction. A culture immersion is an effective way to begin the journey.

A revised curriculum for the 21st century, plus administrative *support* from all administrative levels, could enhance mathematics teachers' efforts:

1. to bring Canada's era of reconciliation into their classrooms.
2. to address effectively the diversity of learners, from the math-phobic, math-shy, and math-disinterested to the math-curious and math-oriented.
3. to contextualize learning in the general public's actual experiences in *their everyday* worlds, rather than in the much narrower experiences of a mathematician's everyday world.
4. to foster two-eyed seeing in all students.
5. to teach at least six to eight Indigenous culture-based lessons a year, similar to those found in Appendix E; for each grade level to Grade 9; and then for Grades 10-12, the same number each year for each mathematics program (some programs might share a lesson plan or more).
6. to motivate all students to reach their potential in reasoning arithmetically, algebraically, and/or spatially, given their mathematical preferences, aspirations, aptitudes, and self-identities.
7. to increase the average mathematics achievement of both Indigenous and non-Indigenous students. A plethora of research demonstrates this outcome.
8. to identify math-curious and math-oriented students and encourage:
   - ✓ their preparation for future mathematics-related employment;
   - ✓ their future contribution to creating cutting-edge algorithms for artificial intelligence; and
   - ✓ their dedication to ensuring best ethical and social practices of artificial intelligence for the good of humanity.

The province's *School Divisions* have a pivotal role to play in the implementation and professional development of a culture-based school mathematics.

Our project illuminates a way foreword: a method for developing Indigenous culture-based teaching materials on a province-wide basis to match a revised curriculum. Scaling up requires more personnel and greater efficiency, of course. We provide a detailed recommendation in the last section of this Project Report.

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