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Indigenous Culture-Based School Mathematics in Action: Part I: Professional Development for Creating Teaching Materials

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Abstract: This first of a pair of articles describes a professional development project that prepared four non-Indigenous mathematics teachers (Grades 5-12) to implement Canada's Truth and Reconciliation Commission's (TRC, 2016) notion of reconciliation: cross-cultural respect through mutual understanding. The researchers collaboratively mentored the teachers to enhance their mathematics teaching with Indigenous mathematizing[3]. The teachers' focus was on developing and revising lesson plans for other teachers to teach. This process explicitly and implicitly revealed precise supports that need to be in place for a teacher to succeed at innovating with this Indigenous culture-based school mathematics (ICBSM). Part I is a template for scaling up the development of much needed Indigenous resources for mathematics teachers. Part II reports on the research results of this year-long research project.

Key words: Indigenous, culture-based, school mathematics, reconciliation, professional development

Introduction

The Mathematics Enthusiast article "A 21st Century Economic, Educational and Ethical Mathematics Curriculum Policy" (Aikenhead, 2017a) made a case for, among other issues:

1. Renewing Saskatchewan's mathematics curriculum to reflect the social justice ethic of "Canada's 21st century era of reconciliation" (p. 569) defined by Canada's Truth and

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[3] Indigenous languages are verb-based, whereas Western languages are noun-based (Lunney Borden, 2013). This fundamental difference in cultural worldviews is respected by the use of the term "mathematizing" (a verb), exemplified by the mathematical activities in which counting, measuring, locating, designing, playing or explaining quantitatively (Bishop, 1988, pp. 148-150) occur within an Indigenous culture. "Indigenous mathematizing" also describes Indigenous students doing Western mathematics in their native language as much as feasible, and in which Indigenous "verbification" (Lunney Borden, 2013) of English is used when possible to represent in English or French the Indigenous students' action-oriented worldview and language grammar.

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Reconciliation Commission[4] (TRC), so that school mathematics does not continue to cause the inequities currently faced by many Indigenous students;
2. Establishing a professional development program for producing "teaching materials collaboratively with Indigenous Elders and Knowledge Holders so the materials convey valid Indigenous knowledge and reflect [a renewed] curriculum's reconciliation goal" (p. 572); and
3. Expressing a critical mathematics education perspective on understanding Western mathematics as a human endeavor.

Our research study, "Culture-Based School Mathematics for Reconciliation and Professional Development," investigated these issues in the crucible of mathematics classrooms by collaborating with four non-Indigenous teachers in a rural Saskatchewan town, as they developed lesson plans and taught Indigenous culture-based school mathematics (ICBSM). Early on in the project, the teachers experienced:

1. A cultural immersion with a Nakawē (Saulteaux) Elder, in which they learned how Indigenous wisdom deals with the world; and
2. A personal mentoring session with a Nehiyaw (Plains Cree) Knowledge Holder who led teachers to make connections between Indigenous mathematizing and analogous content in Saskatchewan's mathematics curriculum.

When teaching their personally developed lesson plans, teachers were rewarded with the increased engagement of their Indigenous and non-Indigenous students. The two cultural mathematical systems, Indigenous and Western, have similarities and differences that created interest among many students. Indigenous mathematizing is action oriented and thus, students naturally became engaged.

By learning local Indigenous perspectives and examples of Indigenous mathematizing, the four teachers increased their understanding of their Indigenous neighbours; understandings they taught to their students. Therein lies a tangible act of reconciliation, according to the TRC's (2016) emphasis on cross-cultural respect through mutual understanding. Simply put, the word "reconciliation" is a noun, but the teachers' and students' actions made it into a verb.

School mathematics, more than any school subject, typically has a social justice problem. It tends to undermine Indigenous students' graduation rates from high school by marginalizing those students in mathematics classes; thereby contributing to systemic racial inequities (Abrams, Taylor & Guo, 2013; Aikenhead, 2017b, pp. 83-85; Anderson & Richards, 2016; Meaney, 2002; Perso, 2012). One specific inequity was singled out by the Auditor General of British Columbia when she wrote, "Our 2015 report highlighted the impact of the *racism of low expectations* [for Indigenous students]" (Bellringer, 2019, p. 13, original emphasis). The phenomenon was noticeably absent, however, for the four co-researching teachers in our study.

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[4] The TRC (2016) emphasized developing a cross-cultural respect through mutual understanding.

Our research project aimed to inspire changes to school mathematics that will ameliorate, and hopefully eliminate, this *invisibly systemic* historical racism pervasive in school mathematics.

This aim is not ethereal. In Nova Scotia's province-wide Indigenous school division "Mi′kmaw Kina′matnewey" where most Mi′kmaw students attend, the high school graduation rate has risen from about 40% in 1997 to 88% in 2013 (CBC, 2013; Simon, 2014), and reached 90% for the 2017-2018 school year (Lunney Borden, 2018). This is what the Mi′kmaw Kina′matnewey School Division was able to accomplish since 1997, the date that planning began to implement their Mi′kmaw culture-based school program.

Our social justice rationale for implementing Indigenous culture-based school mathematics (ICBSM) is to ensure that Indigenous students should not have to devalue their own culture's mathematizing and worldview in order to succeed in the school's Western mathematics.

Literature Review

A few mathematics educators in the USA and Canada have already begun their part to develop ICBSM (Aikenhead, 2017b, pp. 75, 104-118). Major international research studies demonstrated that when Indigenous ways of knowing and mathematizing are introduced into school mathematics, two consequences are observed.

First, for *Indigenous students,* there is an "increase in the mastery of … math concepts, deeper levels of student engagement in … math, and increased student achievement in … math" (U.S. Congress House of Representatives Subcommittee on Early Childhood, Elementary and Secondary Education, 2008, p. 13). This increase was usually dramatic (Lipka & Adams, 2004).

Secondly, *non-Indigenous students* tend to improve their achievement in those same classrooms (Adams, Shehenaz Adam & Opbroek, 2005; Beatty & Blair, 2015; Lipka, Webster & Yanez, 2005; Lipka, Wong & Andrew-Ihrke, 2013; Richards, Hove & Afolabi, 2008). In short, taking time to teach some Indigenous mathematizing about six to eight times a year generally produces a win-win result in the improvement of student academic achievement.

Such was the case: in Aotearoa New Zealand (Meaney, Trinick, & Fairhall, 2012); in Hawai′i's Ethnomathematics and STEM Institute (ESTEMI, 2016; Furuto, 2014); in Alaska's extensive and highly influential "Math in a Cultural Context" (CCM) project (Lipka et al., 2005, 2013; MCC, 2016); in Sweden (Jannok Nutti, 2013); in Norway (Fyhn, Sara Eira, & Sriraman, 2011); in Canada (Beatty & Blair, 2015; Lunney Borden, 2013; Lunney Borden, Wagner, & Johnson, 2020; Richards et al., 2008; Wagner & Lunney Borden, 2015); and in countries located in, and bordering, the Pacific Ocean (Nicol, Archibald Q'um Q'um Xiiem, Glanfield, & Dawson, 2020). One outcome common to most of these studies is teachers' and students' capacity to engage in two-eyed seeing.

Two-Eyed Seeing

The powerful metaphor "two-eyed seeing" (Hatcher, Bartlett, Marshall, & Marshall, 2009) emphasizes a person learning the strengths of both Indigenous mathematizing and Western mathematics so that the person can idiosyncratically view the world through two different lens; drawing bits and pieces from either knowledge system, or choosing one over the other, in order to solve a problem or make sense out of an issue.

A challenge for teachers that accompanies two-eyed seeing is the fact that their journey into ICBSM includes *adding* some *place-based* (non-generalizable and non-absolute) Indigenous knowledge to their repertoire of understanding the world (Michell, Vizina, Augustus, & Sawyer, 2008; Nicol, Archibald, & Baker, 2013).

In contrast, conventional Plato-based mathematics teaches an absolute *universal* way of knowing. It is inundated by the binary "true or false" found in deductive reasoning. But Indigenous cultures recognize a plurality[5] of understandings established by time-honoured place-based ways of knowing. Instead of thinking only in terms of deductive reasoning, Indigenous peoples tend to see the world in terms of varying degrees of both true and false, depending on the place and circumstances (Battiste & Henderson, 2000, Ch. 2).

Students' Individual Differences

Teachers are well aware of a spectrum of student characteristics related to learning mathematics. At one extreme are those students who generally have an inclination, aspiration, preference, aptitude, or interest in mathematics. Some Elders call it a gift. These math-oriented students feel no culture clash between their self-identities and embracing a mathematics identity.

At the other extreme are those students who experience psychological stress when forced to engage in Western mathematics because it is so foreign to who they are (Aikenhead, 2017b, pp. 83-85; François & Van Kerkhhove, 2010). These math-phobic students experience a severe culture clash between their self-identity and their perception of Western mathematics, or of people who think, talk, and believe like a mathematician. In high school, they tend to drop out of mathematics classes, even though it prevents them from graduating. As mentioned above, high school mathematics, more than any other high school subject, is the reason students drop out of school.

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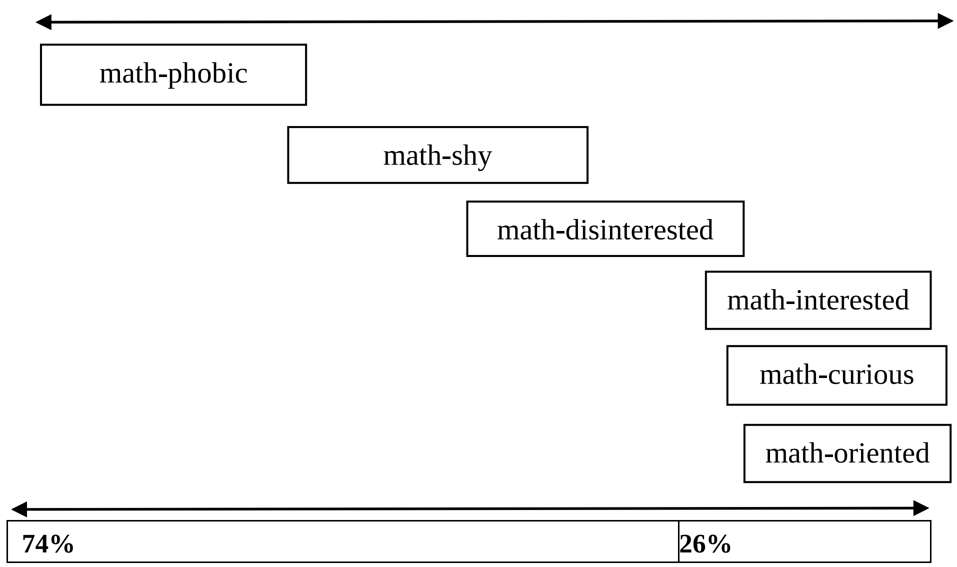
[5] Pluralism should not be confused with *relativism* – defined by the Cambridge English Dictionary (2019) as, "the belief that truth and right and wrong can only be judged in relation to other things and that nothing can be true or right in all situations". This relativistic knowledge is independent of any systematic way of knowing. We mention this distinction because people who subscribe to the absolutist or universalist view of knowledge, tend to think that pluralistic knowledge is equivalent to relativistic knowledge. Notice the hidden binary in their way of thinking. Their binary is: **either** absolute universal knowledge **or** *not* absolute universal knowledge. That latter half of the binary refers to both pluralism *and* relativism, grouped together as one category. Culture-based knowledge is not relativistic, it is pluralistic. The equivalent pluralistic feature of science is well established (Aikenhead & Ogawa, 2007; Higgins, 2019), although rejected by universalist science educators who embrace scientism, realism, or radical realism.

Between these two extremes of math-phobic and math-oriented students, those remaining fill the complex region in between. To avoid a false dichotomy (e.g., math-oriented vs non-math-oriented), six arbitrarily vague categories[6] are proposed (Figure 1, next page), along with the assumption that a student's category identification is flexible. Categorizing depends on many factors such as the teacher; the domain of geometric, algebraic, or arithmetic mathematics being studied; students' perceived capabilities; etc.

Figure 1 has a skewed distribution toward the psychological stress (math-phobic) end of the spectrum. Evidence comes from several sources. Two are considered here. The PISA *Grade 9* data (OECD, 2016, p. 447) concerning the proportion of students in the STEM pipeline (i.,e., the math-oriented, math-curious, and math-interested students) can be transposed to apply to *Grade 12* graduating students, in order to account for the percentage of students who drop out of the STEM pipeline by the time they graduate from high school. This percentage comes from Frederick (1991) who quoted data from a U.S. Office of Technology Assessment's 16-year longitudinal study that began with four million grade 10 students. First of all, 18 percent of these students expressed an interest in continuing toward university STEM courses. Of these interested students, 19 percent lost interest during high school (i.e., they moved out of the pipeline), leaving 81 percent of the original STEM group to continue their interest in STEM. Thus, the Grade 9 PISA data (35, 32, 38 percent for Canadian, Saskatchewan, and American STEM-oriented students, respectively) can be transposed to Grade 12 data by a correction factor of 0.81. Based on these results, the predicted proportion of Canadian, Saskatchewan, and American STEM-oriented students graduating from high school would to be: 28, 26, and 31 percent (OECD, 2016, pp. 362, 447, & 362, respectively).

Figure 1. Distribution of Saskatchewan Grade 12 Students' Degree of Culture Clash between Their Self-Identities and Their Views of School Mathematics.



[6] These are heuristically suggested for future use. Fine distinctions are not made in this article.

These results suggest that a small minority of approximately 26 percent of Saskatchewan high school graduates are confident in mathematics, leaving about 74 percent who are not, *to varying degrees*.

This conclusion is confirmed by a second study. According to an AP-AOL News poll conducted by Ipsos, an international polling firm, 25 percent of adult respondents stated mathematics was their favourite subject[7], while 40 percent declared they "hated" mathematics (CNN.Com [Education], 2005). Obviously, the remaining 35 percent were somewhere in between. The margin of sampling error was plus or minus 3 percentage points. The skewed distribution of students certainly favours those who would likely avoid high school mathematics if they could.

The flexible six categories can improve clarity in certain contexts. For instance, the math-phobic, math-shy, and math-disinterested students may be capable in certain mathematical "smartnesses," such as "estimating, measuring, making conjectures, and seeing patterns" (Louie, 2017, p. 505). These could be cultivated, of course. But generally, this large student majority's academic "gifts" likely steer them toward the abstractions, insights, and rewards found in the humanities, commerce, or the trades. These students are seldom ill-informed, lazy, or academically challenged. Instead, their worldviews and self-identities are different than, and clash with, their math-interested, math-curious, and math-oriented counterparts.

Simeonov (2016, pp. 442-443) pointed out that most students memorize their mathematics without meaningfully understanding the content when they are pressured to master a "foreign" Plato-based abstract mathematics course. As a result, students learn to hate mathematics (about 40%). And then as parents, they infuse their attitude into their children for elementary teachers to confront. Many children develop permanent feelings of failure in mathematics classes. Negativity permeates their feelings of agency and often undermines their self-confidence. Simeonov concluded, "If a certain gift is needed in order to master mathematics, then why should we teach all those people who do not possess this gift" (p. 443)?

How well is mathematics education doing in North America for Grades 6 to 12? According to Oesterle (2018):

> For experienced teachers, it can be difficult to alter the way we have been teaching, especially if it seems to "work" for at least some significant portion of our students [e.g., 26 percent in Saskatchewan]. But generations of students who become adults who "hate math" and pervasive avoidance of mathematics in North America, suggests that what we have been doing is not "working." (p. 161)

The recent past president of the National Council of Teachers of Mathematics (NCTM), Larson (2016), seems to agree about school mathematics not working, but for a very different reason:

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[7] Interestingly, the students in our study were asked on a questionnaire what their favourite school subject was. Of those 71 students, 17 chose mathematics, which is 24 percent.

> For far too long *high school mathematics has not worked for far too many students*: too many students leave high school unprepared for college or a career, particularly a STEM career; too many students do not see how math is useful in their lives; too many students leave high school without an affinity for doing math. (website quotation, emphasis added)

Interestingly, Larson's observation, "high school mathematics has not worked for far too many students," is shared by other mathematics educators. But while the NCTM (2000) generally blamed students, teachers, and parents, Skovsmose and Greer (2012, p. 383) concluded, "For too many people, their experience of school mathematics is personally, emotionally, and intellectually dehumanizing. It does not have to be like that."

Jannok Nutti (2013) of Sámi[8] ancestry came to the same conclusion. As a result, she conducted a Swedish research project whose main purpose was to prepare six Sámi teachers, during one school year, to be agents for transforming school mathematics. She collaborated with them in designing and implementing Sámi "culture-based school mathematics" content (p. 57). This quoted expression signifies her inclusion of Sámi worldview perspectives (i.e., Sámi ontology, epistemology, and axiology) in mathematics classes. Teachers are the ultimate implementors of any educational innovation, therefore, they should become collaborative partners in such projects. She stated her overall goal: "The intention of the culture-based mathematics activities was *to reconstruct school mathematics* by creating a learning environment grounded in both school mathematics and Sámi culture-based knowledge" (p. 63, emphasis added).

However, none of the six Sámi teachers quite reached this expectation to an extent anticipated by Jannok Nutti. Instead their Western mathematics content and *general* Sámi cultural themes (e.g., reindeer management) would appear almost independently of each other in lessons. The teachers never explicitly made connections between the two knowledge systems. Moreover, when the teachers' mathematics content was connected to a *specific* everyday Sámi activity (e.g., baking or cooking a specific Sámi dish), it was not in an authentic Sámi way. For instance, the teachers used Western ways of measuring, instead of body measures. Jannok Nutti (2013, p. 68) explained why her expectations were not met. "The teachers wished to implement culture-based mathematics teaching, but felt that they lacked the knowledge and time [away from teaching the curriculum content] to implement culture-based teaching." An overcrowded curriculum was a major deterrent to this innovation.

Research Question

With the exception of Jannok Nutti (2013) and Rickard (2005), none of the studies described in the above literature review articulated specific criteria that would help teachers, in concrete constructive ways, either (a) to develop their own mathematics teaching materials enhanced by Indigenous ways of knowing and being, or (b) to implement such lessons or modules produced by

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[8] Sámi Indigenous peoples inhabit the northern portion of Europe. Since 1200 CE, they have suffered colonization similar to North American Indigenous peoples' experiences (Aikenhead, 2017c, pp. 110-111).

others. We agree with Jannok Nutti's assessment of her teachers' two deficiencies, but there is so much more to discover about the complexities of teaching ICBSM.

Our research question was designed to help fill this void in the research literature: *What precise supports must be in place for teachers to enhance their mathematics classes in a sustainable way with Indigenous mathematizing and worldview perspectives*?

By collaborating with four non-Indigenous teachers in a mentoring way during one school year, we were able to identify: (a) what they needed to learn about Indigenous perspectives and about mathematics, and (b) what they needed to *unlearn* with respect to Indigenous perspectives and about mathematics. These results are reported in of "Indigenous Culture-Based School Mathematics in Action: Part II" (Aikenhead & Meyer, 2021). Part I focuses on key features of the professional development program the teachers experienced, and on the teachers' reactions to these features.

Research Team and School Participants

From a reader's perspective, an important political-social context of a research study involving Indigenous worldviews is knowing pertinent personal background and relationship information concerning the researchers and participants. This information is summarized here. First and foremost, we and the teachers are all Treaty 6 people[9].

Sharon Meyer was the "Research Team Leader." [10] She is of Nehiyaw (Plains Cree) ancestry, a Nehiyaw Knowledge Holder, and has earned a B.Ed. and P.G.D. She has 28 years experience in teaching/administration/consulting in provincial and reserve schools, and is currently the First Nation and Métis Consultant for the North East School Division, Saskatchewan.

Glen Aikenhead was the "Team Contact Person;" of British ancestry; 4th generation Canadian; 5 years teaching high school and lower secondary mathematics and science; and 33 years at the University of Saskatchewan preparing teacher candidates to teach science (Grades 1-12) and supervising graduate students. He is Professor Emeritus from the university's Aboriginal Education Research Centre.

At the end of the study, the four teachers and school principal unanimously decided they wanted their real names used rather than pseudonyms. These research participants are listed in Table 1. Krysta went on maternity leave for a full year, beginning December 1, 2018, after developing one set of lesson plans.

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9 In the 1800s, a series of treaties were signed between the British Crown and various First Nations in the western part of Canada. Treaties 4, 6 and 18 were established in what is known today as Saskatchewan.

10 The terms used in this subsection were designated by the project's funding agency, the Stirling McDowell Foundation, Saskatoon, Canada.

Table 1. Participants in the Carrot River study.

Participant	Education	Position	Employment
Mrs. Sari Carson	B.Ed.	Principal	25 years teaching 8 years administration
Mr. Kevin Duchscherer	B.Sc. (Mathematics), B.Ed. (Secondary Mathematics and English/History)	Teacher, Grades 7-12	19 years teaching
Mrs. Serena Palmer	B.Ed. (Reading, Mathematics)	Teacher, Grade 5	12 years teaching
Mrs. Krysta Shemrock	B.Sc. (Mathematics), B.Ed. (Mathematics, Biology)	Teacher, Grades 11-12	10 years teaching
Ms. Danielle Vankoughnett	B.Ed. (Middle Years)	Teacher, Grade 6	First year teacher

These research participants represented a diverse group. They had minimal previous experience with Indigenous ceremonies, but were acquainted with Indigenous friends. Danielle had recently studied Indigenous worldviews in her B.Ed. program. Serena had learned second hand from her sister-in-law about Indigenous ceremonies. Krysta had smudged at a science professional development session several years earlier when she taught science. All five lived the ethos of treating students equally. In fact, when we wanted to know which students had self-identified as Indigenous, some teachers were not sure.

The Study's Methods

We discovered an array of necessary teacher supports that came to our attention explicitly and implicitly during a number of events[11]:

1. Conducting a day-long introduction to the research project,
2. Holding a two-day cultural immersion,
3. Mentoring each teacher once for a half-day on Indigenous mathematizing,
4. Mentoring the development and revision of the teachers' lesson plans that included Indigenous mathematizing,
5. Collaborating with the teachers as co-researchers, and
6. Engaging in various conversations and structured interviews throughout the school year. Each conversation or interview had a different purpose, and all were audio-recorded. The

[11] The first four events comprise the four subsections that follow.

> interviews were not transcribed but were summarized and included some important quotable statements. Each participant edited their summary to ensure its accuracy.

All six events allowed us to understand the teachers' own viewpoints, feelings, challenges, and accomplishments at learning Indigenous perspectives, in the context of engaging their students in Indigenous mathematizing. We listened and watched carefully to how they learned to feel comfortable as they became an Indigenous culture-based mathematics teacher. This non-assessment approach differs from Jannok Nutti's (2013) use of a predetermined rubric.

It also differs from Beatty and Ruddy's (2019) excellent research program in Ontario that combines a town school with a close-by First Nations reserve to carry out ICBSM. They followed a cyclical framework: consult with the Indigenous community, plan collaboratively, teach cooperatively, reflect on the what occurred, and share the results with the Indigenous and town communities.[12]

As co-researchers in our project, the four teachers and principal produced most of the qualitative data that appear in a Project Report[13] prepared for our funding agency, the Stirling McDowell Foundation. The co-researchers' sizeable contribution warranted their place as first co-authors of that document (Duchscherer et al., 2019).

The teachers' development of lesson plans was simply a process that productively engaged the teachers in a collaborative effort with the researchers. By doing so, we learned in depth what they individually needed in order to succeed – answers to our research question. These answers provide professional teacher organizations, school divisions, and ministries of education with concrete constructive ways to support teachers in implementing a reconciliatory, Indigenous culture-based, school mathematics course.

Originally, we were interested in determining the reaction of Indigenous students specifically. But because so few enrolled at the Carrot River school (about 80 km – 50 miles – from the nearest reserve, typical of Saskatchewan schools), the data would not be sufficient to make any reasonable claims. In Duchscherer and colleagues (2019, pp. 41-42), a highly positive Indigenous students' focus group was based on the participation of only three students who were available the day independent interviews took place at the school; hardly sufficient to report in a journal article.

Entry to the Research Site

When contacted during the preparation of the research proposal for the Stirling McDowell Foundation, Principal Sari Carson was enthusiastically interested in her schools' participation. Sari explained, "Sharon must have felt that our teachers are open-minded enough to take on something

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[12] For mathematics instruction with/in Indigenous communities, see Nicol and colleagues (2020).

[13] Its tables and appendices contain, for instance: agendas for key meetings, interview data, questionnaire data, revised culture-based mathematics lesson plans, and videos of two culture-based lesson excerpts and a video of a collegial discussion between a teacher and Sharon. The Project Report was purposefully written for a teacher audience.

that was beyond their comfort zone" (Duchscherer et al., 2019, p. 14). All four teachers agreed to participate after learning about the project in detail at an August 31 professional development day.

During the morning of that day, the Team Leader and Contact Person explained the project's four essential components:

1. *Indigenous culture-based school mathematics* was illustrated by engaging the research participants in an Indigenous mathematizing activity;
2. *Reconciliation* was defined by the Truth and Reconciliation Commission (TRC, 2016) as being cross-cultural respect through mutual understanding;
3. *Professional development* was characterized realistically by discussing two science teachers' stories that captured the essences of a similar Indigenous culture-based professional development for school science (Aikenhead et al., 2014); and
4. Our key process of *collaboration* was immediately initiated between the researchers and participants by co-planning the combined presentation during the afternoon session, directed at the other teachers in the school.

The afternoon was devoted mostly to Nakawē (Saulteaux) Elder Albert Scott who introduced his Medicine Wheel teachings. They illustrated an overview of his perspective on the world, parts of which the mathematics teachers would pass on to their students.

In early November, the four teachers were individually interviewed to learn how they viewed their August 31 professional development day. All four had experienced mixed feelings that day (Duchscherer et al., 2019, p. 9).

On the one hand, three expressed positive feelings (e.g., "very excited," "honoured to be involved," "invigorated," and "felt they were in good hands with Sharon as Team Leader"). Most recognized that they were living in an era of reconciliation, which meant to them that the project was highly worthwhile. This national political context has strongly influenced provincial ministries of education in Canada.

On the other hand, they had begun the day feeling (Duchscherer et al., 2019, p. 18): "over whelmed" by what might lie ahead; "anxious" over feeling inadequate due to not knowing very much about First Nations culture; "uncertain" about how First Nations knowledge would fit into mathematics lessons and how the project would unfold; "worried" over how much extra time the project will take; "very concerned" about making a mistake or inadvertently offending an Elder and others; and "unease" over the extra pressure from knowing how serious and worthwhile the project was. Danielle felt understandably "petrified" as it was her first year of teaching.

The Cultural Immersion

A cultural immersion is a transformative experience organized by a group of Indigenous Elders and Knowledge Holders, which usually lasts at least two consecutive days or more. It is a foundational prerequisite for: (a) *educators* who will develop culture-based teaching lessons or modules (Chinn, 2007; Furuto, 2013; Fyhn et al., 2011; Lunney Borden, Wagner, & Johnson, 2020); (b) *teachers* who implement those materials (Aikenhead, 2017b, pp. 104-118; Aikenhead et al., 2014); (c) *curriculum writers* who compose outcomes and indicators related to Indigenous ways of knowing and being (Aikenhead, 2017b, pp. 79-80, 128-132; Belczewski, 2009); and (d) key administrators in Saskatchewan school divisions and in the Saskatchewan School Board Association.

Cultural immersions are filled with poignant learning moments, including those that help guide participants around potential linguistic pitfalls, which otherwise may cause confusion or misconceptions. These conversations are "personal heart-felt dialogues dedicated to mutual understanding" that require an exchange of fundamental perspectives (8Ways, 2012, p. 4). Vickers (2007, p. 592) of Tsm'syen ancestry called such meetings "camping spots where we can dialogue" between cultures. For instance, teachers, who fear making "a mistake" thereby upsetting an Indigenous student or parent, learn very quickly from an Elder or Knowledge Holder to feel comfortable because non-Indigenous teachers' heart-felt attempts at introducing Indigenous understandings are easily recognized by Indigenous people as being genuine, and learning by making "mistakes" is how Elders and Knowledge holders describe how they have learned.

The project's teachers and principal attended our two-day cultural immersion in early October. Nakawē Elder Albert Scott planned and led the first day's activities. Nehiyaw Knowledge Holder Sharon Meyer organized the second day, having collaborated with the teachers on ideas and questions they wanted addressed.

Elder Scott began the day in a good way by an acknowledgement prayer. Then everyone experienced and learned about smudging, the Pipe Ceremony, and a traditional Feast. Elder Scott explained the connections between what protocols are followed and his Nakawē First Nations worldview. This process of connecting an action with an aspect of a worldview was modelled by him for the teachers to follow. They were later mentored by Sharon to follow the same process when teaching Indigenous mathematizing along with Western mathematics. Making connections between the two is a fundamental process in ICBSM. The teachers also learned that these ceremonies focused on their personal spirituality and not at all on persuading anyone to adopt an Indigenous understanding of spirituality.

During the second full day of the cultural immersion, Sharon demonstrated parts of the Medicine Wheel teachings, she discussed life on a reserve, and she answered all of the teachers' questions. The teachers participated in Indigenous mathematizing, for example: playing a few Indigenous games, making a dream catcher, and learning free style looming with plastic beads. This was followed by brainstorming the connections between these activities and Western mathematics.

It soon became evident that the teachers were beginning to form their own support network to carry on such brainstorming to help each other plan ideas for mathematics lessons connected to Indigenous mathematizing. According to Sari, the spontaneous "professional learning community" (Duchscherer et al., 2019, p. 37) became a major reason for the project's success and sustainability.

Cultural immersions are indeed powerful, but not so much because the brain is stimulated. Their power lies in how a person's *heart* is moved. This was recognized by a teacher in a different professional development program dedicated to Indigenous culture-based science teaching. She captured the power in her phrase "*the brain needs the heart*" (Aikenhead et al., 2014, pp. 107-144). To become a culture-based teacher, the intellect is not nearly enough. First and foremost, teachers need their hearts engaged before the brain can develop successful lesson plans or can successfully implement culture-based lesson plans of others.

Here are the teachers' retrospective comments made a month later concerning the second day of the cultural immersion (Duchscherer et al., 2019, pp. 20-23):

Krysta: "In the afternoon, … Sharon asked us to reflect on making connections [between the Indigenous mathematizing] and our math teachings. For dream catchers, I thought about methods of counting and the fundamental counting principle. … The games linked well to probability, logic, and reasoning. … Sharon never told us what materials would produce a good lesson. Instead, she was a resource who showed us or described an Indigenous activity. Then it was up to us *to think* of connections and *to decide* what materials would work. That was a skillful process we were beginning to learn. … I found it beneficial to work with my colleagues. … Being familiar with your curriculum is important, but having Sharon guide us through activities was powerful. … She inspired and we did the follow-up thinking and creating."

Kevin: "The first day laid the foundation for the second day. I felt more at ease the second day because we discussed pedagogy and materials to incorporate in lessons. … But without the first day the second day would have been mechanical, and would not represent the spirit in what we want to accomplish. … The looming activity was personal to me. I really got involved. … I don't want students to feel the Indigenous culture is just another curriculum outcome. I want it to have *meaning* to the student.

Danielle: "The afternoon went quickly because we were *doing* activities, which had a lot to do with math content. Having thought about what I just said, I see it's important to not always be teaching *to* my students, but have them *do it*, as well. … I wrote down everything Sharon went through. As I began planning my first lesson, I used the same symbols on both documents to show when an idea in my lesson plan illustrated or followed what I had written in my notes on Sharon's ideas."

Serena: "Sharon shared some background information about living in Saskatchewan as an Indigenous person. … The more I learn about First Nations, the more I think that our understandings of First Nations people have been based on *mis*understandings and *un*truths. The wording in the treaties can lose meaning when translated. …It was an awesome afternoon. We did so many activities and games. My only complaint was I think we could have done that all day long. … When reflecting upon the sequence of events so far in the research project, there were good reasons for the August 31 meeting coming first, and then the first cultural immersion day, followed by what we did the second day. It all worked for me. I felt more prepared and equipped to create my lessons."

As fascinating and edifying as the presentations of Indigenous knowledge were for the teachers, what supported them the most were: participating in Indigenous mathematizing, reflecting on it, creating connections to the curriculum, and discussing those connections.

The Indigenous worldview information was absolutely essential, but it would have been better placed in the context of mathematizing more often than it was. Some of the worldview content could be clarified in terms of the all-important connections between Indigenous mathematizing and Western mathematics.

The teachers expressed a wish to have more opportunity to work with potential Indigenous teaching materials. Consequently, we arranged for Sharon to mentor them *individually*.

Mentoring the Collaborating Teachers

Sharon mentored each teacher once during an October half-day of released time. They worked toward the teachers' lesson planning. She followed the same approach she used in the afternoon of the cultural immersion's second day. She inspired, while the teachers did the thinking, chose creative connections to the curriculum, and made the final decisions. Sharon coached each teacher on the challenging, cross-cultural, creative process of turning an Indigenous activity or idea into an Indigenous culture-based mathematics lesson plan. She guided their thinking by asking questions and by describing Indigenous processes and content for a teacher to consider using. She encouraged each teacher to play around with it, to explore it in greater depth, and to reject it if that was their wish.

From Sharon's perspective, their half-day together caused each teacher to make great strides forward. Sharon forged stronger relationships with all the teachers; relationships that could not have evolved as much in the more public context of the cultural immersion.

During Glen's early November retrospective interviews with each teacher, he asked them to reflect on their mentoring experience with Sharon. The teachers profusely expressed their gratitude and appreciation for having the half-day experience with her. Here are some quotations (Duchscherer et al., 2019):

> "I'm privileged to be part of this project, part of the process, learning about Indigenous knowledge and my math teachings." "I feel validated now." "Sitting with her and learning specifically about the topic I would teach was crucial. There's a lot of information on the web, but having her as a resource was crucial. Working with Sharon was a pivotal moment." (p. 25)

The teachers began to develop their Indigenous culture-based lessons in October. The first lessons were taught in November.

Culture-Based Mathematics Lessons Taught and Discussed

Following Sharon's mentoring sessions, the teachers were on their own to explore ideas for their first lesson plan and for finding more resources. Each lesson would take two to four class periods to teach, as it turned out. The teachers discussed their progress with each other, thereby strengthening their support network.

When a good lesson plan draft had been written, they emailed it to Glen to offer suggestions, if any. Sharon was always called upon to check the authenticity of the Indigenous perspectives that appeared in the lesson. Her responses often became teachable moments.

Glen joined the teachers when they taught their lessons in November. Pre-lesson and post lesson conversations occurred. They were rich in teachable moments. The sessions were audio taped but not transcribed. Glen composed a synopsis of these conversations for each teacher, who then verified its contents. Editing by teachers occurred, if necessary, to reflect the teacher's personal understanding and their choice of wording. Thus, each teacher became the author of their synopsis. This collaborative mentoring process helped identify what support the teachers needed (i.e., answers to our research question).

For each teacher, these qualitative data were organized into tables (Duchscherer et al., 2019, pp. 27-37). Each table consists of four rows of data: (a) the teacher's "Planning," (b) their "Reaction to Teaching the Lesson," (c) their "Reflections on the Lesson," and (d) "Outsider's Observations" (i.e., mostly Glen's comments plus Sari's observations of what occurred outside the classroom).

These qualitative data sometimes led to mentoring a teacher on ideas to consider when revising their lesson plan for other teachers to teach. Conversations typically emerged over, for example[14]: the importance of connecting Indigenous mathematizing with curriculum content, the nature of Western mathematics, avoiding subtle appropriation, identifying instances of two-eyed seeing, and explaining students' reactions in terms of the possible degree of culture clash between a student's self-identity and their view of school mathematics or their feelings over abstract Western mathematics.

The four processes (planning, teaching the lesson, reflecting on that lesson, and listening to outsider's observations) were repeated for their second lessons taught between March and May 2019. The teachers' confidence increased dramatically with their second experience of planning, teaching, reflecting, and being mentored collaboratively during the process. By May, they had developed the capacity to continue the project with the support of their colleagues – their new found support network. Principal Sari certainly thought so (Duchscherer et al., 2019):

> I've been watching the evolution of the teachers from the beginning of the project. At first, they were nervous, anxious, and worried. Within the last five months, however, culture-based math teaching is something they have come to embrace: their comfort level is higher; and their confidence level in what they are doing is higher. This is really good for an administrator to see! (p. 37). … They have formed an informal "professional learning community" right inside the school. They support each other. They talk about successes and challenges. Together, they revisit lessons to revise for next year. This is fantastic! I sense that the project has taken on an independent feeling to continue on its own next year. That's great! That independence serves as evidence that the teachers are feeling confident. I am very proud of them. Their work has sustainability. (p. 37)

Details about the lessons themselves do not answer the study's research question. As mentioned above, it was the *process* of developing their lesson plans that revealed explicit and implicit needs required by teachers to succeed. Thus, the lesson plans are not described here, but are found in Duchscherer and colleagues (2019, Appendix E).

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[14] These examples foretell topics discussed in Part II of this two-part article series (Aikenhead & Meyer, 2021).

Due to space limitations, this article continues with "Indigenous Culture-Based School Mathematics in Action: Part II: The Study's Results: What Support Do Teachers Need?" (Aikenhead & Meyer, 2021).

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