Re(righting) Mathematics Education: Changing Students' Attitudes Towards Mathematics Through Indigenous Knowledge and Worldview

by

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A thesis submitted in the partial fulfillment of the requirements for the degree of Master of Education

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Abstract

This study explored the impacts of incorporating decolonizing, Indigenous focused lessons and pedagogies in a grade 9 (Ontario) locally developed (LD) classroom on students' attitudes towards mathematics. A reform-based mathematics lesson with Indigenous content and a decolonial approach was implemented into a grade 9 LD classroom. The goal of the study was to observe a change in student attitudes towards mathematics when this style of an indigenized lesson was implemented, as compared to typical daily curricular activities in most LD mathematics classrooms. Observations were taken of the class both before and during the indigenized lessons. One student was interviewed in a semi-structured format both before and after the lesson. The student was asked what they did and did not enjoy about the Indigenous Knowledge (IK) highlighted lesson, how they felt about the incorporation of IK in mathematics, and how they would compare the lesson to their regular daily activities in mathematics class. The teacher of the class and the student support personnel (SSP) were also interviewed for their unique points of view and to provide further observations of students during the IK lesson. Artifacts of regular classroom work were also collected to provide an accurate comparison of typical curricular activities before the implementation of a reform-based, Indigenous-focused, decolonial lesson. The analysis of the data revealed a positive change in student attitudes, engagement and enjoyment when the regular classroom pedagogies were disrupted with a reform-based, IK highlighted, decolonial lesson. A limitation of this study was the small sample size due to multiple logistical constraints. A longitudinal study with more reform-based, IK-highlighted lessons and multiple sections of LD mathematics could provide more insight into the impacts, challenges and benefits of implementing these types of lessons and pedagogies for social change and improved reconciliation in education.

Acknowledgements

First, I would like to express gratitude for my supervisor, Dr. Ann Kajander. Her support and belief in this project provided me with the drive to complete this thesis. This experience has been made a very positive one thanks to her guidance and support.

I would also like to thank my committee member, Dr. Lisa Korteweg, for her expertise and support in this project. Without her inspiring me to take an interest in this topic, I would not have completed a Master's, let alone one with a social justice lens.

Both Dr. Kajander and Dr. Korteweg inspired me to pursue research with an aim to promote reconciliation and social justice, for which I will be forever grateful. This research and the Master's program have inspired me to pursue lifelong learning and to work to promote social change in all classrooms.

To my colleagues, Kelly Sedor and Matthew Valley, this project would not have been possible without your support. You have both been very good listeners and have had the ability to ground me throughout this project. I cannot thank you enough for your encouragement.

In addition, I would like to express appreciation towards my family and friends who have supported me through this process. This journey would have been much more difficult without their support and optimism.

I would also like to thank the school where data was collected for this study as they welcomed me into their space with open arms. I would also like to acknowledge the research participants for their collaboration and cooperation in making this study possible.

Finally, I would like to acknowledge the Ministry of Education's Mathematics Knowledge Network and the Social Sciences and Humanities Research Council of Canada for financially supporting this project.

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Chapter One: Introduction

Description of Research Study

This thesis explores the impacts of decolonizing and incorporating Indigenous Knowledge (IK) highlighted mathematics on students' engagement at the grade 9 locally developed (LD) level. This research was focused on a school within a medium-sized school board in Thunder Bay, Ontario. I began with interviewing a student on their experiences in mathematics and their enjoyment of the subject. I also made observations and took thick field notes of the class's engagement in the classroom and mathematics curriculum, prior to the incorporation of a decolonized and IK-highlighted lesson. Then, I delivered a decolonized, Indigenous focused, problem-based mathematics lesson to the class and interviewed the same student afterwards on their thoughts about the lesson. This interview included questions about whether or not the student enjoyed the style of the lesson, along with prompts of why or why not, and questions specific to the IK content embedded into the lesson. The interview also sought the student's thoughts on the style of lesson, their impressions of the activities, and whether or not they would like to engage again in this type of lesson in the future. The teacher of the class and the student support personnel (SSP) in the classroom were also interviewed to better understand their thoughts and opinions on problem-based, IK-highlighted lessons. I also inquired into their observations of the class in terms of the students' attitudes, engagement and enjoyment of the lesson. One aim of this project was to bring forth the voices of students in Indigenous-focused mathematics, ideally emphasizing the voices of Indigenous students in the locally developed stream.

Little to no current research exists in this area due to many reasons including the following: low funding available for materials, curriculum development or teacher PD, and,

significant changes in the pedagogies of mathematics education (National Council of Teachers of Mathematics, 2000; Russell & Chernoff, 2013; Schoenfeld, 2004). I would like to bring more attention to the LD group of students and educate others on this particular stream and the students who enroll in it due to significant social inequities that already exist at this level of schooling. The social inequities present in LD are also exacerbated by classroom settings. I am passionate and committed to bring forth greater social equity in mathematics education, with the goal to re(right) the futures of students who enroll in this level of schooling. Inequities tend to be reproduced from generation to generation in both Indigenous and non-Indigenous populations and this social reproduction of unjust futures for the young/youth needs to be corrected or righted in education (Livingstone, 2014). I would also like to bring light to the lack of knowledge that is currently deep ignorance regarding who students are in these LD courses, as well as to develop more resources that will assist teachers in developing and improving both LD course materials and social justice teaching approaches. Research into LD mathematics helps to highlight this marginalized group of learners, particularly the over-representation of Indigenous students, and works to right the historical wrongdoings reproduced and perpetuated by education and curriculum.

Personal Background and Relational Context

Throughout my elementary and secondary education, I was always considered to be a good student, and my teachers would describe me as either average or “smart”. I always excelled in mathematics, gym, and science, and although I did not enjoy social studies, I was an average student in that subject. After elementary school, I continued on into the academic and university level streams for all of my classes except mathematics. I was determined to take the advanced placement (AP) program, and I successfully completed this specialized math program. I did

slightly better than average in my studies, however, I never put any real effort into my schoolwork as I generally found school to be easy without putting much effort in, so I justified not studying. Throughout my high school experience, I never stepped foot in any non-academic level classrooms, and had no idea what happened in locally developed or applied classes.

I continued onto post-secondary education at Lakehead University, pursuing a degree in Chemistry and a Bachelor of Education. Again, I had never stepped foot into a community college or considered doing anything but pursuing studies at the university or academic level. I completed my undergraduate degree in chemistry with a minor in mathematics, in addition to my Bachelor of Education degree, following the calendared requirements and finishing within the five-year timeframe, all without irregularities of time period, credits or content achievement.

It was not until my Bachelor of Education year that I had any experience or exposure to other levels of education – from the standpoint of an educator or teacher. The "Curriculum and Instruction in Mathematics" course opened my eyes to what applied and locally developed classes look like and what external factors may influence the students in these course levels. I also learned effective problem-based learning and other curricular approaches to help *all* students succeed in mathematics, regardless of level of ability. This course truly changed my perspective on how to teach mathematics so that all learners can enjoy and engage in the subject. Through a reformed, problem-based approach, differentiated instruction becomes much more manageable and the mathematics becomes richer and has an authentic connection to the real world. This mathematical approach was very different to what I was expecting based on my own educational experiences in the academic and university streams.

I also enrolled in a special topics class during my Bachelor of Education year called "Indigenizing Perspectives and Practices in Education" (IPPE). Through my experience in the

IPPE class, I gained a newfound interest in decolonizing and "indigenizing" my future teaching practices and developing new, more holistic ways to teach. As a white settler, this course truly changed my opinion of Indigenous peoples in Canada, and what we can do as educators to help close the education gap between Indigenous and non-Indigenous students as well as promote reconciliation in all subjects. It also caused a significant shift in my points of view through an effort to decolonize myself through this course. Throughout the course, I attended many cultural events, including a Fall Harvest and pow-wow, in addition to visiting a community health centre, where I interviewed a Two-Spirited Indigenous woman. I also had the opportunity to engage with Indigenous students in the Indigenous Student Success room in a local classroom, which included making bannock with students, working in a one-on-one setting, and listening to their stories. Finally, I participated in a traditional Sweatlodge ceremony, which I believed truly changed my point of view. Through these activities, I have worked to decolonize myself through developing a greater understanding of the history of Indigenous peoples in Canada and engaging with Indigenous people in the community. Prior to this course, and the activities that I engaged in through the course, I likely never would have considered the impacts of an Indigenous worldview and pedagogical approach in my future teaching. These two courses helped me understand how I can help marginalized students succeed with my teaching practices and the importance of relationships between teachers and students.

After taking these two courses, I was interested in how I could bring the topics of problem-based learning in mathematics and decolonizing and IK knowledge focused practices in education together, which in turn, led me to this Master's project. After reading a journal article by Russell and Chernoff (2013), it became clear that these two paradigms were far from mutually exclusive: an Indigenous knowledge (IK) worldview aligns very well with decolonial practices

and problem-based learning in mathematics. This complimentary fusion was the catalyst I needed to commit to this project.

During the first term of my Masters, I began working in a locally developed (LD) grade 9 mathematics classroom as a research assistant. The goal of this work was to research and develop tasks and resources for teachers of LD mathematics to use in their classrooms on a daily basis, as prescribed by the Ministry of Education's Mathematics Knowledge Network (MKN), the funder of this project. Through the creation of these tasks, I began to see how this work could align with my personal research goals. I could develop tasks for the Ministry/MKN that included a decolonized and IK-highlighted approach, while field testing them in the grade 9 classroom we were already observing. This work would not only align well with the MKN expectations but also for my own thesis project expectations. A double bonus of research was that I was afforded the opportunity to both evaluate the students' engagement and attitudes towards the lesson for my thesis, while producing actual curricular content for the Ministry/MKN's project.

Research Question

My research seeks to open curricular space for marginalized students enrolled in the LD level mathematics classes to voice what activities they enjoy in the classroom, as well as their opinions on the incorporation of decolonized mathematics lessons with an IK focus. The research question was formulated from literature that links engagement and attitude with both learning and achievement and will be situated within the academic literature in Chapter 2. Through this thesis, I hope to bring attention to the needs of LD mathematics students, especially Indigenous students, and how they may be met with decolonial and/or Indigenous-focused pedagogy in mathematics. This research was inspired by a Birch Bark Canoe lesson that I delivered as part of our research group's larger work as part of the MKN project. This lesson focused on making a

birch bark basket, but it did not have a focus on mathematics. The lesson was very engaging for the students who participated, and it inspired me to create more lessons like it that had a larger focus on mathematics. This led to the development of the Transportation and Mapping lesson that was delivered as part of this study (see Appendix D).

The central research question of this thesis is the following:

1. *How do student attitudes towards locally developed Grade 9 mathematics change when exposed to Indigenous focused and decolonial pedagogies?*

For this study, I am interested in learning about student attitudes as they relate to mathematics, in terms of understanding if students are displaying disinterested, excited, indifferent, or any other types of behaviours towards the subject. Attitude is defined as "a settled way of thinking or feeling about something", typically one that is reflected in a person's behavior ("Attitude," n.d.). To align the study with the concept of attitudinal change, I asked the student participant about their thoughts and opinions on mathematics and their level of enjoyment in mathematics through a semi-structured interview prior to the lesson. I asked about past experiences of mathematics lessons as well as their feelings on the current term's class. I also interviewed the same student after the lesson and again asked about their thoughts and feelings towards the IK-highlighted, decolonized lesson.

As can be seen in the conceptual framework of attitudinal change, one's attitude is then reflected in behaviours. A person's behaviour could be described through action, engagement in the activity as well as excitement with the learning. I took observations of how students approached mathematics through their behaviours, whether timid, or cautious or in disinterested, as examples. I also took observations of levels of engagement in the lesson as well as levels of excitement to participate in the lesson. Observations were taken before the IK-highlighted lesson

was facilitated in the classroom as well as during the IK-highlighted lesson. These observations as data will be illustrated and expanded upon in Chapter Four. In addition to the student interviews and longitudinal observations as data, I also interviewed the educators in the room to note their observations of the students' attitudes towards mathematics prior during and after the IK-highlighted lesson.

In terms of attitudinal changes, I am referring to any difference between students' behaviours, engagement, excitement and their own described feelings or emotions towards mathematics before the lesson (i.e. focused on daily activities) and during the IK-highlighted activities. I expected to see a range of changes that could include a continuum from low participation in daily classes to increased participation or engagement in the IK-highlighted lesson. I also stayed open to students' feelings of negativity towards the inclusion of culture in mathematics that was not felt prior, or a previous lack of interest in mathematics to an increased interest in the subject. Any changes in attitude were noted through comparison of the interviews and observations before the lesson and those that took place during and after the lesson. I hoped to see positive changes for students, in how they view and interact with mathematics in contrast to the students' regular attitudinal expression on a daily basis. I also hoped to see increased engagement and excitement towards mathematics when the IK-highlighted, decolonized approach is implemented.

Other goals for the study included engagement in activities highlighting IK and experiencing a decolonized lesson that promotes reconciling and repairing relationships between Indigenous and non-Indigenous Canadians through mathematics. Students were engaged in an IK-highlighted lesson, and any impacts on their attitude towards mathematics were explored through observations and interviews.

Chapter Two: Literature Review and Framework

Introduction

Across Canada, significant changes have been made to curriculum, including mathematics, that encourage teachers to consider Indigenous perspectives (Madden, Higgins, & Korteweg, 2013; Stavrou & Miller, 2017), Indigenous content and pedagogy (Sterenberg, 2013) and "mathematics reform" in their teaching practices. In education, decolonizing is the "process of recognizing colonialism, and making efforts to diminish and extinguish its power" and exercise of oppression against Indigenous ways of knowing (Aikenhead, 2017, p. 17). On the other hand, indigenizing is defined as respectfully and accurately incorporating IK, emphasizing Indigenous worldviews and ways of knowing in classroom content and pedagogies (Battiste & Henderson, 2009). Unfortunately, IK-highlighted content and ways of knowing have been continuously ignored, avoided or erased in curriculum, eclipsed by Eurocentric knowledge systems (Battiste & Henderson, 2009; Godlewska, Moore, & Bednasek, 2010).

All students can benefit from IK-highlighted content and decolonial pedagogies in school, including STEM subject classrooms (Aikenhead, 2017; Borden, 2013). Eurocentric education has highlighted the "math wars" debate between traditional mathematics and reformed mathematics, and there are now claims that traditional-pedagogical mathematics aligns with a Eurocentric worldview, while reformed mathematics pedagogies better align with Indigenous worldviews (Russell & Chernoff, 2013). Traditionalists endorse practices that include rote memorization and teaching by telling, whereas the reformists believe that mathematics pedagogies should be based on student investigation or inquiry in their real-world contexts or lived experiences (Russell & Chernoff, 2013). A shift towards decolonizing and incorporating IK-highlighted mathematics may provide not only a solution to the math wars (Russell &

Chernoff, 2013) but also a significant impact on all students' achievement, especially for Indigenous students who often lag behind their non-Indigenous peers in STEM subjects (Donald, Glanfield, & Sterenberg, 2011).

An emphasis on student achievement in mathematics or teacher attitudes towards decolonial pedagogies or the inclusion of IK-highlighted content has been the focus of educational research (Boaler, 2016; Stavrou & Miller, 2017; Sterenberg, 2013). The paucity in the literature on student attitudes towards mathematics demonstrates a lack of understanding on how student attitudes are connected to critical IK highlighted, problem-based lessons in LD mathematics. Moreover, it appears that students enrolled in Ontario locally developed (LD) level mathematics have not been studied to any extent regarding student achievement or attitudes. These students are also not included in the provincial government's Education Quality and Accountability Office (EQAO) testing (Education Quality and Accountability Office, 2014). One of the goals of this testing is to "inform the improvement of instructional programs and strategies to help all children succeed." However, as this group is not tested, "all" learners have not been equally assessed (Education Quality and Accountability Office, 2014, p. 3).

Theoretical Framework

The theoretical framework utilized in this study is twofold. The first part of the conceptual framework is social constructivism through the reform-based learning style of mathematics utilized in this study, and the second part of the framework is an Indigenous storywork framework developed by Archibald (2008).

The mathematics reform is grounded in a constructivist worldview. Humans constructing meaning through their engagements in the world is a key feature of social constructivism (Creswell, 2014). In the case of this research, there is a focus on reform-based teaching practices,

which emphasizes collaborative learning, problem solving and rich tasks, manipulatives and tools, the teacher as a facilitator, and hands on learning (Macaulay, 2015; Russell & Chernoff, 2013; Schoenfeld, 2004). The position of social constructivist is also linked to cognitive psychologists Vygotsky (1978) and Leont'ev (1981), who believed that social interaction promotes learning and development and that participation and engagement in activity is necessary for learning to take place. This can be interpreted as participation is necessary for learning to occur and that learning is not a passive process. Through this description, it can be seen that the concept of social constructivism is easily applicable in reform-based teaching practices. Student are able to engage in their reformed classroom environment and make meaning from these experiences. This is in line with reform-based practices where teachers are the facilitators, students learn by doing and a focus on problem solving and hands on learning through rich tasks. Constructivist approach towards mathematics place emphasis on inquiry, investigation and problem solving as active forms of learning that students can construct their own meaning in (Macaulay, 2015). The notion of constructivism is important in this paper as the National Council for Teachers of Mathematics identifies and embodies constructivist ideals in the standards for teaching mathematics (National Council of Teachers of Mathematics, 2000). These are the standards that should be upheld by mathematics educators, which relates to the implementation of a reform style lesson in the study.

The second part of the theoretical framework is an Indigenous holistic framework that guides the decolonial curriculum piece of the study. Archibald's (2008) IK-highlighted storytelling framework embodies respect, responsibility, reverence, reciprocity, holism, inter-relatedness and synergy. This framework expands upon Kirkness and Barnhardt's (1991) study

on the four R's – respect, relevance, reciprocity and responsibility and the impact they had on First Nations students achievements in higher education.

This framework has been chosen for this study as this storywork approach has already been extended to mathematics previously, through work with the Haida Gwaii in British Columbia (Nicol, Archibald, & Baker, 2013). In the context of this study, this framework is being applied in grade 9 LD mathematics, with a focus on connection to the Ojibwe people of the Robinson-Superior treaties of 1850 as the location of the research is on the traditional lands of the Fort William First Nation. Archibald's storywork curricular framework guided the development of the lesson, the delivery of the lesson, and the facilitation of the interviews. Respect and reverence for Indigenous knowledges, traditions and practices were kept at the forefront of this study, with active responsibility to re(right) mathematics education for all students, but in particular, Indigenous students. Reciprocity and synergy played a role in the trust built between the researcher and the students and educators. Relevance to the students' lives was kept in mind through the development of the lesson as well as the delivery, and holism was embedded throughout the delivery of the lesson. The notion of this Indigenous storytelling framework is critical in this study as it guides the goal of decolonizing mathematics education, and the social justice aspect of this study.

Mathematics Education in Ontario

Many organizations play key roles in the teaching and learning of mathematics in Ontario. The Ontario Ministry of Education (OME) may be the largest stakeholder as the developer of the curriculum documents, but there are other stakeholders, such as the National Council of Teachers of Mathematics (NCTM), who published the *Principles and Standards for*

School Mathematics in 2000, the Ontario Association of Mathematics Educators (OAME) and Ontario Mathematics Coordinators Association (OMCA).

Streaming in Ontario schools.

The current practice for Ontario Mathematics is to have mixed ability courses in elementary grades, and then stream students based on ability beginning in grade 9. There are three streams available to students in grade 9: academic, applied, and locally developed. The academic stream generally leads students to university level courses in the senior grades, and it has more emphasis on theoretical components of mathematics (Curtis, 2014; Ontario Ministry of Education, 2005; Smaller, 2014). The applied stream generally leads students to College level courses in the senior grades, and it has more emphasis on applied, practical components of mathematics (Ministry of Education, 2005). Finally, the locally developed (LD) level of mathematics is considered the lowest track (stream), and the curriculum that develops the basis for these courses is developed either at the district, board, or school level and is subject to approval by the OME (Ontario Ministry of Education, 2004). The LD level has been developed for students who are at least four grade levels behind (LDCC Project, 2005). The first mention of LD level courses is in 2005, through a Consortium led by the Peel District School Board (LDCC Project, 2005).

Historically, streaming in Ontario schools has been established in schools since the early nineteenth century, whether implicitly or explicitly, and varying from elementary to secondary schools (Curtis, 2014; Smaller, 2014). Streaming has been called the origin of inequality in our schooling system, based on the history of teaching certain social classes certain topics and others more practical material (Curtis, 2014). Since the beginning of education, inequalities have

existed between genders, different ethnic backgrounds, and socioeconomic classes (Curtis, 2014).

Social inequities in educational opportunities, including the opportunity to pursue post-secondary education begin in elementary and secondary schools (King, Warren, King, Brook, & Kocher, 2009; Livingstone, 2014). Based on surface data, it might seem that social inequities are improving, and are seen to a lesser extent than they were in the past, however, regarding equality of educational outcomes, inequities in education may be becoming more and more pronounced (Livingstone, 2014). Intersectionality also plays a role in amplifying inequities for many marginalized, racialized students who experience educational inequities coming from many directions, for example, a black student from a lower socioeconomic class, or a female First Nation student coming to a larger, urban city center for better secondary education while leaving behind all her school support systems of extended family and community (King et al., 2009; Livingstone, 2014; San Vicente, 2014; Smaller, 2014). Streaming has been found to increase the achievement gaps between groups of students and may lead to inequitable outcomes for students in the lower streams (applied and locally developed).

Historically, streaming has occurred in many different forms. There has been explicit streaming, where students are grouped based on academic abilities, and implicit ones where academically strong students are segregated from academically weak students in the same classroom. Until the 1990's, Ontario streamed secondary students into three different levels, advanced, general and basic. These terms were abolished in 1999, and these streams became what is now known as academic, applied and locally developed (LD) at the secondary level (Curtis, 2014; Smaller, 2014). The academic curriculum is focused on theoretical applications of concepts, the applied is more focused on practical, applied applications of concepts, and the LD

curriculum provides students with the skills to enter the workplace after secondary school (Livingstone, 2014).

The goal of these LD courses in grades 9 and 10 is to address and fill gaps in learning for students, with the outcome of the student pursuing either an academic or applied credit in the same subject afterwards, or pursuing the Workplace level credit in their senior years after completing the locally developed in grade 9 or 10. The range of learners in LD courses is extremely varied, as some students may be functioning up to three grade levels behind, while others may be almost functioning at an applied level (LDCC Project, 2005). LD course content can sometimes overlap with academic and applied level courses, with a focus on the same subject matter. However, the majority of the material is supposed to be developed to meet the needs of the students. Because the expectations in a locally developed mathematics course vary from board to board and location to location, there is no available curriculum document with a complete breakdown of expectations. The course content is up to the classroom teacher in the end, who will tailor the course to the needs in the classroom.

In Ontario, the Education Quality and Accountability Office provides provincial testing in grade 9 for "all" students, but in reality, this number is closer to 95% of all students, as students enrolled in LD mathematics courses are not evaluated (Education Quality and Accountability Office, 2014; King et al., 2009). One of the goals of this testing is to "inform the improvement of instructional programs and strategies to help all children succeed." However, as this group is not tested, "all" learners have not been equally assessed (Education Quality and Accountability Office, 2014, p. 3). Unfortunately, as there is no testing for learners at the locally developed level, there is little to no information to determine funding allocations for this unique group of learners, and no information on student progress or success. EQAO has stated that

results of their standardized testing directs research, which in turn costs money (Education Quality and Accountability Office, 2014). While standardized testing may not be the best form of assessment, at least it would lead to funding and resource development that is desperately needed for this level. And, more concerning is the fact that a lack of testing leads to a lack of research by the EQAO/Ministry of Education and a significant gap in the literature on LD mathematics curriculum development and pedagogies.

Although there is little to no research existing on LD mathematics, there is limited literature describing the issues that exist with streaming between academic and applied mathematics. Macaulay (2015) states that: "Students in academic classes are doing better than ever while their counterparts in applied classes appear to be withering on the vine – only 44% of students in applied classrooms achieve what amounts to a "B" on the provincial assessment...less than half of the students in the applied stream are achieving the provincial standard" (p. 9-10). While Macaulay's work focuses on the issues with academic and applied streaming, her comments may be applicable or relatable even at the LD level, as students are not even considered to be functioning at the applied level regarding mathematical abilities and are therefore not meeting the curriculum expectations set out by the OME.

The process of ability-grouping (also known as streaming, tracking or setting) in education is not only common to Ontario, but is also popular in the United Kingdom and United States (Boaler, Wiliam, & Brown, 2000; Hand, 2010). Research on the effects of streaming have been completed in the United States and the United Kingdom, with a focus on opposition and the construction of failure (Boaler et al., 2000; Hand, 2010; Sandholtz, Ogawa, & Scribner, 2004). A study completed in the United Kingdom looked at ability-based grouping from a student perspective, and the researchers discovered three major issues with streaming: high sets, high

expectations and high pressure; low sets, low expectations and limited opportunities; and restricted pedagogy and pace (Boaler et al., 2000). High sets and low sets in the United Kingdom are the equivalent to our high levels of courses (i.e. advanced placement and International Baccalaureate programs) and our low levels of courses (i.e. applied and locally developed). To make connections between this study and the Ontario curriculum, specifically the LD level, the focus will be on the latter two issues: low levels, low expectations and limited opportunities; and restricted pedagogy and pace (Boaler et al., 2000).

The researchers interpreted the student perspectives on being placed in a low set (low stream) to have severe and damaging implications (Boaler et al., 2000). Students reported that the work was too easy and that they were often copying mathematics directly from the board at the front of the room, rather than having the opportunity to work through the mathematics themselves (Boaler et al., 2000). Teachers frequently changed throughout the semester and they also reported that there was no sense of advancement being possible (Boaler et al., 2000). Students in the study were asked what they enjoy about their mathematics classes this term and other terms to determine whether or not teacher-student relationships were present in the LD research class. Students were asked about their opinions on the level of mathematics they are learning (i.e. is it too hard, easy, etc.). According to Boaler, William and Brown's (2000) study, 27% of the students in the low track reported that the work they were given was too easy for their mathematical ability and that teachers will not provide them with more challenging work. The students also believed that there was little hope of moving to a higher stream, as they needed good test results at the end of the year, however, the test encompassed the work taught in all streams – meaning that the low track students were not taught all of the content on the end-of-year assessment (Boaler et al., 2000). This leads to a vicious cycle where students become

trapped in a level that does not challenge their mathematical abilities, with little to no opportunity for mobility between levels.

The observations made by the researcher in this study also showed a lack of reformed practices in the streamed teaching, but rather an enhancement of procedural practices once students were streamed (Boaler et al., 2000). Courses in the United Kingdom are streamed as there is a concern that some of the ablest students are not reaching their full potential, but through streaming, it has become evident that the majority of students are achieving well below their potential (Boaler et al., 2000). 40 out of the 48 participants in this particular study indicated that they would prefer to return to the "de-streamed" or mixed ability classrooms, where instruction was differentiated (Boaler et al., 2000). The researchers observed reform-based mathematical practices to be more evident in these mixed ability classrooms, and students could tackle more challenging work if the work they had been doing was not challenging enough (Boaler et al., 2000). Based on this research, two factors were determined to be strongly associated with growth in student achievement in mathematics: an opportunity to learn and the degree of homogeneity in the classroom (Boaler et al., 2000).

This research could be evidence that streaming in an Ontario context is not allowing our students to reach their full potential at any level, negating the potential for growth in mathematical achievements because in Ontario, LD classes share similarities in curriculum and streams with the British streaming systems (Boaler et al., 2000). Further efforts to incorporate mixed ability groupings have been researched and found to be in line with reformed mathematics practices and a worthy practice to allow students to learn from one another (Hand, 2010; Jao, 2013; Sandholtz et al., 2004).

The impacts of streaming students can be further explained through Sandholtz, Ogawa and Schribner (2004) and Hand (2010). Although the goal of Sandholtz et al. (2004) was not initially to look at the impacts of streaming, it emerged as a prevalent theme throughout their research on standards gaps. The researchers found that streaming did not increase overall student achievement in schools, and it leads to discrepancies in curriculum content across the streams (Sandholtz et al., 2004). Streaming also fostered inequity and tended to produce inequitable outcomes for students in lower streams particularly (Sandholtz et al., 2004). Students in lower streams tended to receive instruction that emphasized worksheets and rote procedures rather than including opportunities to think critically (Hand, 2010; Sandholtz et al., 2004). Similarly, Hand (2010) found that the traditional pedagogical approaches to teaching low stream students can work in a negative light towards a culture of opposition in the classroom (Hand, 2010; Sandholtz et al., 2004). This can be related back to what is happening in the current Ontario streaming where traditional practices and a workbook structure are sometimes used in low stream classes, and also the achievement gap between academic and applied (and presumably between applied and LD as well).

Hand (2010) determined three key features of low-stream mathematics classrooms: reliance on the didactic classroom, polarized participation structure, and weak participation practices. Reliance on the didactic class is something touched on in the former paragraph as well. These characteristics of the low stream classroom only continued to create more and more co-constructed opposition in the classrooms, which did not lead to greater success of the students, and only frustrated the teacher further. As the semester went on, the students received more and more reprimands for not focusing on the mathematics and less opportunities to engage in their

learning. With these changes, instances of opposition increased in the classroom greatly. This provides a clear link from traditional teaching practices to opposition in the classroom.

The co-construction of opposition in the classroom was also evident in Kajander, Zuke and Walton's (2008) case study analysis of students at-risk. Although the teacher in Case B started out with a more reform-oriented teaching practice, the didactic classroom, polarized participation structure and weak participation practices continued to co-construct greater opposition in the classroom. This pushed the teacher back to a more traditional approach as he became increasingly frustrated with the students and opposition present in the classroom.

The literature reviewed in this section on LD mathematics demonstrates the many reasons that streaming and traditional teaching practices may be working against increasing student achievement, which can then be related to the concept of streaming and traditional teaching in Ontario low track schools, and the achievement gap between the different levels.

Students at-risk.

The student demographic of LD classrooms includes students from all different backgrounds, with different needs and often different external factors influencing their education. Some might use the term that students in LD are "at-risk" whether that be at-risk of not achieving academic success in high school, or whether that might mean something different. For the purposes of this study, I have identified students at-risk as those who often come from lower socioeconomic status families, less fortunate family situations, live in communities that have social issues, and may have difficulty with peers and school (Kajander et al., 2008; Schissel & Wotherspoon, 2001). In addition to the factors, students at-risk may also be impacted by their health, loneliness, boredom and their development from an early age (Kajander et al., 2008; Schissel & Wotherspoon, 2001). Kajander et al. (2008) also identified students at-risk as

including those with parents who have lower levels of education. Livingstone (2014) claims that students who have parents with lower levels of education tend to be more likely to also achieve lower levels of education. Inequalities due to social injustices such as gender, race and low socio-economic class all tend to reproduce themselves from generation to generation and in schools (Livingstone, 2014).

Many of the students enrolled in LD courses could be described as at-risk based on the above research. They often have factors influencing their education such as a lack of parental guidance or involvement, loneliness or poor peer relations, social issues and poverty. Unfortunately, these gaps tend to reproduce in a perpetual cycle from generation to generation without intervention and through curriculum and schooling (Livingstone, 2014). As educators, we have the ability to form meaningful relationships with these at-risk students, as well as the means and skills to help them overcome these barriers to higher levels of education.

Overrepresentation of Indigenous students in LD mathematics.

Canada's history with Indigenous peoples is one filled with the hard realities of assimilation, deceit and colonization (First Nations, Metis & Inuit Education Association of Ontario, n.d.). As the census data and Statistics Canada results continue to demonstrate, social inequities and injustices are the most profound and multigenerational for Indigenous peoples (Statistics Canada, 2018a, 2018b). For Indigenous youth, these social ills and intergenerational trauma from the Residential School system continues to have a profound impact on their education (Curtis, 2014; Galabuzi, 2014; Livingstone, 2014; Statistics Canada, 2018b). Ongoing intergenerational impacts of trauma include the Sixties Scoop, systemic racism by Indian Act regulations and documentation of status, and broken treaty promises that continue a cycle of colonization and assimilation in education that reproduces multiple obstacles and difficulties

including no high school education available in their own communities. Many Indigenous youth fit the description of at-risk students due to no fault of their own or their families/communities. These students often end up grade levels behind due to grade gaps in their education for the following reasons: few teachers stay more than one year in northern communities and most are very inexperienced, resources are scarce and textbooks out of date, no special education services or diagnoses, etc. It is not a surprise that Indigenous students end up in LD mathematics and are vastly over-represented as a student population in these classes.

Through the implementation of decolonizing techniques and the inclusion of IK-highlighted content in mathematics lessons, researchers have shown that we can begin to engage at-risk Indigenous youth in meaningful content that may help to prevent these gaps from continuing to the next generation (Aikenhead, 2017; Borden, 2013, 2013; Doolittle & Glanfield, 2007; Martin, 2013; Nicol et al., 2013; Sterenberg & Hogue, 2011). The implementation of IK-highlighted content and a decolonial approach also engages non-Indigenous at-risk students in the hope of preventing further reproduction of gaps for this group of learners as well (Borden, 2013). In addition, this study aims to promote reconciliation between Indigenous and non-Indigenous by demonstrating to students and teachers how decolonizing education is hopeful, positive and improves relatability between cultures.

Inequities and streaming.

In elementary schools, teachers may not explicitly stream as it is done in secondary schools, however, implicit streaming or assumptions about streaming is much more common. Teachers may assign groups based on ability rather than mixed ability groupings, or there may also be groupings between grades (i.e. the strong performing grade three students working with weak grade four students) (Smaller, 2014). This implicit streaming was demonstrated in the case

study report by Kajander, Zuke and Walton (2008), where one grade seven teacher separated three weaker students and had them work on booklets based on the grade five and six curriculum, with the aim to prepare them for a life skills class in grade eight. The researcher working in this classroom felt that with further assistance, one of the students (Brian) may have been able to complete the grade seven curriculum (Kajander et al., 2008). In a way, this would mean saving the potential this student had rather than placing him in a life skills class, which is implicit streaming. One very overt method of streaming within classes occurs when teachers group students for purposes of instruction — actions, which, unfortunately, often result in longer-term streaming effects, as can be seen in Brian's case (Kajander et al., 2008; Livingstone, 2014). Teachers also treat students in different ways, depending on various factors including a students' gender, race, ethnicity and social class, whether these actions are intentional or unintentional (Livingstone, 2014). A student who is labelled at-risk by the school or a teacher immediately probes a bias in the teacher and this student will be interacted with in different ways than the teacher would interact with a gifted student per say (Livingstone, 2014). At some point in time, labelling of students as at-risk becomes a self-fulfilling prophecy by pedagogies, teachers and curriculum in LD classrooms by focusing on deficits rather than investing in students' abilities. These less explicit streaming tactics can cause long lasting effects in students.

There are also large disparities in academic success of students who take different streams. Many researchers have provided evidence that students placed in applied level classrooms are much less likely to graduate high school with their secondary school diploma when compared to their academic counterparts (Hamlin & Cameron, 2015; Livingstone, 2014; San Vicente, 2014; Smaller, 2014). This phenomenon can be seen in the following figure:

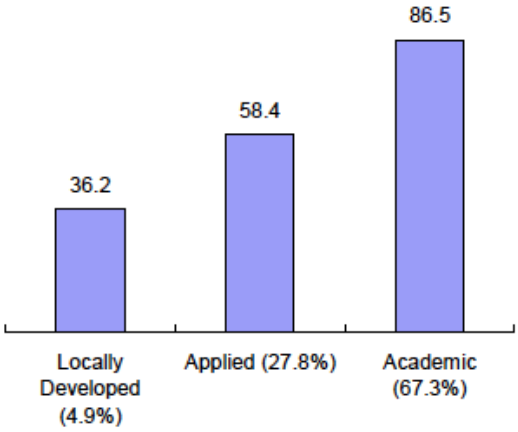


Figure 1. Demonstrates the percentage of students in each level of grade nine mathematics who successfully complete their Ontario Secondary School Diploma (OSSD) within five years (King et al., 2009). The number at the top of the bar is the percentage of students in that level that completed the diploma, and the number at the bottom is the percentage of total students who were registered in that level (King et al., 2009).

Based on this figure alone, it is clear that just over half of students in the applied level in grade nine are actually completing their diploma within five years compared to the academic students, of which 86.5% of the cohort are completing their diploma (King et al., 2009). Probing further, the LD students have even lesser chances of completing their OSSD. Only 36.2% of students in this level graduate with their OSSD, within five years (King et al., 2009). The gap between levels are increasingly large, and although students are placed in LD due to being up to four grade levels behind, the research demonstrates that by placing students in the LD stream, they are further disadvantaged in the success of achieving their OSSD (King et al., 2009; LDCC Project, 2005). This placing also negates external factors that impact their education, like race,

socioeconomic class, gender or other contributing factors. The intersectionality of many factors is to blame for lower student achievement in the lower streams.

Considering that less than half of the students enrolled in LD and just over half of the students enrolled in applied grade nine mathematics complete their OSSD, even fewer of these students are able to pursue post-secondary options. Although pursuing post-secondary is not necessarily the best option for students after secondary school, it is an option for many students who complete their OSSD. Considering so few students in the LD and applied levels actually complete their OSSD, this means that even fewer have the opportunity to pursue options like college or university. This is demonstrated in the figure shown below:

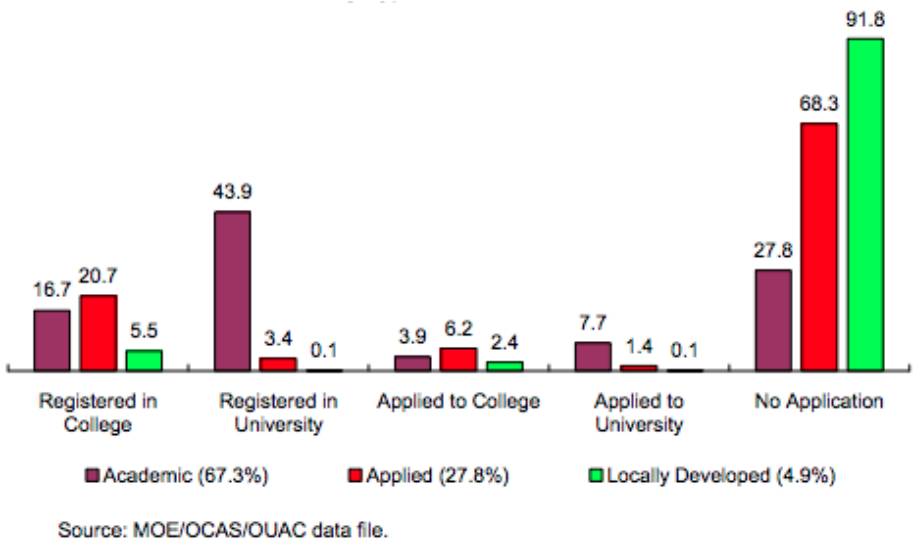


Figure 2. Demonstrates the percentage of students that apply for and register in college or university as well as the percentage of students who do not submit an application for either, divided by stream in grade 9 (King et al., 2009). The number at the top of the bar is the percentage of students in that level that either registered or applied to a university or college, or did not submit an application to either (King et al., 2009). The number at the bottom is the percentage of total students who were registered in that level (King et al., 2009).

Figure 2 reinforces the idea that streaming students takes away potential post-secondary options for students in the lower streams, despite the practical nature of the applied curriculum and the change in name in the senior grades to College stream (King et al., 2009). Only 20.7% of students who begin in the applied stream actually end up registered in college, and less than 5% are registered in university (King et al., 2009). The overwhelming majority does not even make an application to post-secondary. Again, post-secondary is neither the only nor the best option for students, the emphasis is placed on the reality of how many students are closing the door on these options due to streaming. LD students often end up in the workplace, and post-secondary does not seem to be a reality for the large majority of these students (King et al., 2009).

There are so many effects of streaming that are only seen by students later on in secondary school, or after formal schooling has been completed. However, students are expected to select a stream at the end of grade eight, which puts an immense amount of pressure on their shoulders at such a young age. This is especially the case for students who do not have family members who are equipped or encouraged to advocate for their children, especially Indigenous families who have a long history of distrust and trauma in education from the Residential School system. In line with the Truth and Reconciliation Commission's Calls to Action (2015), it should be the education system, along with teachers and revised curriculum (see Calls #62 and #63), who make the effort and promote equitable changes to advocate for culturally responsive and high quality education for Indigenous children as a core part of Canada's reconciliation effort (Truth and Reconciliation Commission of Canada, 2015). Once students enter secondary school, very few students change streams, except Indigenous students who tend to be placed in lower streams after grade 9, and even fewer students—Indigenous or non-Indigenous—have the opportunity to move to a more advanced stream (Hamlin & Cameron, 2015; Livingstone, 2014).

Beyond this, there are also barriers to switching streams like parental or guardian approval, even if the students themselves hold the belief that they can be more successful in a different stream. There are many external factors that impact a student's ability to engage in education, and these external factors can form barriers to their success based on the inequities present in our current system of streaming. In Northwestern Ontario (the setting of this study), many Indigenous students from surrounding northern communities travel to Thunder Bay for high school education. These students often have gaps in their education due to various factors (lack of qualified teachers, poor funding, cataclysmic events such as flooding, forest fires and suicides that halt the whole community including the school, etc.), so when they come to high school in the city, they are often stereotyped and placed into the LD stream as a holding place to see their abilities (Livingstone, 2014). Explicit streaming disadvantages Indigenous students to a great extent as there is unlikely to be a switch to a higher stream during their high school stay. Additionally disadvantageous is that the students' parents are often located in their home northern communities (expensive plane ride away) and are unable to advocate on behalf of their child due to the distance, language barriers, and alienation. Often, local guardians or boarding parents do not feel compelled to advocate for the students as they are not the students' parents or see this as their responsibility. The graduation rates for Indigenous students are lower than any other student demographic, including racialized groups, and we are doing a great disservice to these students by stereotyping and placing them in lower streams when we know there will be few to none who make the change to a higher stream of learning (Galabuzi, 2014). This deficit assumption that Indigenous students are assumed to not be able to learn and develop is an inequitable scenario that is perpetuating colonialism in our education systems against Indigenous students.

Socioeconomic classes and streaming.

Historically, children in poverty have fared the worse in school while those of the working class have fared better but usually worse academically than those children of the middle and upper classes (Livingstone, 2014). Working class is generally used to refer to those in trades, manual labour, or industrial worker households. Middle and upper classes refer to those in professional and managerial households and includes both state sector professional employees with modest incomes to extremely wealthy corporate executives in private sector positions (Livingstone, 2014). Children of the working class have demonstrated characteristics such as decreased reading scores, higher grade failures, greater drop-out rates and much worse employment opportunities (Livingstone, 2014). The accumulated evidence shows that Ontario's secondary school system continues to stream students based on their parents' economic class position. The under-representation of working-class students in academic programs and their overrepresentation in applied and locally developed programs continues to be an important factor in secondary school graduation rates, and access to post-secondary education (Hamlin & Cameron, 2015; King et al., 2009; Livingstone, 2014). Even if students in the applied and locally developed streams beat the odds stacked against them, and apply and are accepted to university, with increasing tuition fees, and escalating income polarization, there are many barriers to low socioeconomic class children attending universities (King et al., 2009; Livingstone, 2014). As can be seen in a quote from Livingstone (2014), "Among the 2006 Grade 9 cohort in Toronto, over 60% in academic level had confirmed university entry in 2011, compared to fewer than 10% of those at applied program and only 1% of Essentials [locally developed] program students" (p. 25). Livingstone (2014) also described a young age cohort that has had opportunities to complete a university education by 2004 (ages 25-44). Within this age cohort,

those from professional family origins are nearly four times as likely to have earned a degree in comparison to those who are from industrial family origins. A recent study also found that by the end of five years, more than three times the number of dropouts were from families in the lowest tenth of family income in comparison to those in the highest income decile (Livingstone, 2014). The same study also found that students in the top socioeconomic quartile were 40% more likely to engage in post-secondary education in comparison to those in the bottom quartile (Livingstone, 2014).

We are currently living in a “credential society” in that more and more people have become dependent on obtaining degrees, certificates or advanced diplomas in order to acquire a career (Livingstone, 2014). This creates a vicious cycle where those who come from lower socioeconomic classes are disadvantaged due to streaming, and are less likely to graduate high school, and therefore less likely to obtain post-secondary education to acquire a career that might change their socioeconomic status. There is little room for students to deviate or move to a different stream, and therefore, eventually a socioeconomic class. This produces a cycle that favours those in upper and middle classes and is stacked against those of lower socioeconomic statuses. This is well stated in a quote by Livingstone (2014), "The effects of ability grouping are the same as the effects of inflation — the rich get richer and the poor get poorer" (p. 26). Socioeconomic status is only one of the factors that could marginalize or oppress a population. When socioeconomic status is combined with race, gender or culture, the inequities associated with streaming can become greatly amplified.

Indigenous students and streaming.

Similar to socioeconomic status, discrimination based on ethnic background and race can also be seen through streaming. The most obstinate racial bias in our society is against

Indigenous peoples. A working class First Nation woman is triply oppressed in Canada's Eurocentric, White-dominated, capitalist, patriarchal society (Galabuzi, 2014; King et al., 2009; Livingstone, 2014). The intersection in this one person's lived reality of what appears to be three individualized marginalities creates a triple-oppression that is difficult to adequately describe and even harder to contend with.

From the beginning of colonialism in Canada, differential pathways for the children of racialized newcomers and Indigenous communities have led to worse educational outcomes and potentially lifelong disadvantages in socio-economic status (Galabuzi, 2014). A 2004 survey of adults who had completed schooling determined that less than 5% of those with Indigenous heritage had obtained a university degree, when compared to approximately one quarter of the general population (Livingstone, 2014). Data shows that Indigenous and racialized peoples are the fastest growing demographics of Canada's population (Galabuzi, 2014). Indigenous students often have more restricted access to quality education than their non-Indigenous peers in provincial systems, are more prone to drop out before completing secondary education, and are more likely to attend schools with other students from disadvantaged backgrounds (Galabuzi, 2014). Indigenous students are also overrepresented in the lower streams, such as applied and LD mathematics, extending the disadvantage gap though streaming (Hamlin & Cameron, 2015; King et al., 2009; Livingstone, 2014). Identity formation is significantly impacted negatively by the streaming and deficit perception processes, especially for Indigenous and racialized students (Galabuzi, 2014). The mandatory Education Quality and Accountability Office (EQAO) testing (which applies to students enrolled in academic and applied level mathematics courses) regularly reveals an achievement gap between Indigenous and non-Indigenous that can be as high as 50%, which is a grave cause for concern (Galabuzi, 2014). Provincial funding for Indigenous students

is also significantly lacking when compared to non-Indigenous students, only inflating the educational gaps and social inequities that exist and have been historically compounded between Indigenous and non-Indigenous peoples (Galabuzi, 2014).

There is also the added challenge that Indigenous students are less represented in the predominantly Eurocentric curriculum (Battiste, 2013). Many students may come from a rural or northern reserve community to an urban centre for their secondary education, and are then confronted with multiple challenges in attempting to share or access their cultural knowledge and competencies (Galabuzi, 2014; King et al., 2009). Indigenous peoples in Canada have had long-standing, negative, harmful and traumatic experiences with schooling, and the lack of representation of Indigenous knowledge and experience in the curriculum re-emphasizes this cultural harm (Galabuzi, 2014). Dion, Johnston and Rice's (2010) report argues that the curriculum needs to integrate IK and FNMI perspectives, which they call Indigenization. They also contend that curriculum and teachers need to address ongoing colonialism and Eurocentric worldviews, a term that they call decolonizing education. Many Canadians, including teachers, maintain that Canada's global reputation of a "fair and good country" is due to our colour-blindness and multi-ethnic/multiculturalism; however, our Eurocentric, oppressive education systems and the statistical evidence against Indigenous students/communities do not align with these claims (Saul, 2009). Canada/Ontario's education system is still centered on the needs of able-bodied, middle or upper class, European heritage, White youth, at the expense of Indigenous and racialized students, children with disabilities, non-English speaking (ELL) and newcomer children.

The Mathematics Reform

Historically and currently, the pedagogical approaches to teaching and learning mathematics have been quite controversial. In the 1970s, mathematics was a fairly rote, procedural practice with a focus on memorization and little focus on understanding mathematics (Russell & Chernoff, 2013; Schoenfeld, 2004). However, research was released in the 1980s that demonstrated a gap in problem solving skills of students (Schoenfeld, 2004). This led to the first talk of reformed mathematics teaching practices, and the great debacle surrounding the teaching and learning of mathematics, which was coined the "math wars". Even in recent years, although the Ontario curriculum addresses problem solving skills as a primary concern, many mathematics educators may be teaching using a more traditional mathematics approach due to the polarised nature of the war. This war has been perpetuated by misunderstandings and misinterpretations of the two different pedagogical approaches – traditional and reform.

The National Council for Teachers of Mathematics (NCTM) released their *Principles and Standards for School Mathematics* (Standards) in 2000, which focused on a pedagogical shift in the teaching and learning of mathematics. The recommendations in the NCTM's Standards are grounded in the belief that all students should learn important mathematical concepts and processes with understanding (National Council of Teachers of Mathematics, 2000). This means that students should learn the meaning behind performing a certain method, and why the method works. The guide makes an argument for the importance of such understanding and describes ways students can attain it. The guide also provides a vision for school mathematics which acknowledges the need for technology, a rich curriculum, having ambitious expectations for students and approaching problems for various perspectives (National Council of Teachers of Mathematics, 2000). The math reform evident at the basis of these standards provides teachers,

administrators and facilitators with a guide to teaching mathematics. The fact that the Standards are grounded in reformed mathematics practices allows for a comparison to the literature on effective mathematics practices.

Macaulay's (2015) doctoral thesis focused on effective practices in grade 9 applied mathematics. Her findings indicate that schools who were highly performing or rapidly improving in terms of achievement on the standardized Grade 9 EQAO mathematics testing utilized the following key elements in their schools: resources, reform-based teaching, leadership, supportive mathematics department, and professional learning. Although these elements were identified to support the growth of mathematics learners pursuing an applied credit, these same elements would probably prove useful at the LD level as well.

One recurring theme in effective practices for this mathematic curriculum was collaboration: for teachers teaching the applied credit in the same semester and for students when tackling problem-solving in the math classroom (Macaulay, 2015). The effective practices identified in this dissertation are also mirrored in Jao's (2013) thesis on teacher strategies to increase engagement in the classroom. All of the teachers in these studies discussed the use of the OME's TIPS4RM lessons and their effectiveness in the classroom for student engagement and achievement, as well as the use of technology (Jao, 2013; Macaulay, 2015). As mentioned in the former section on streaming, research has also supported the concept that traditional practices in low level math classrooms have increased student opposition and fostered greater inequity in classrooms (Hand, 2010; Sandholtz et al., 2004). It has also been demonstrated that reform-based practices increase student engagement in classrooms (Jao, 2013; Marks, 2000).

Various forms of literature have all pointed towards the conclusion that reform-based mathematics practices increase student achievement on EQAO testing, supported the growth of

mathematics learners and their conceptual understanding of mathematics, supported developing problem solving abilities, and have increased student engagement in mathematics (Hand, 2010; Jao, 2013; Macaulay, 2015; Marks, 2000; National Council of Teachers of Mathematics, 2000; Sandholtz et al., 2004). These research-based conclusions support the mathematics reform movement, and push for decreasing the use of traditional mathematics teaching practices.

Student engagement.

It has been suggested that reformed mathematics pedagogies have a strong connection to increased student engagement (Hand, 2010; Jao, 2013; Marks, 2000). Engagement in the classroom leads to academic achievement and contributes to students' development (Marks, 2000). “Students who are engaged with school are more likely to learn, to find the experience rewarding, to graduate, and to pursue higher education” (Marks, 2000, p. 154). Two aspects of engagement that are important to discuss with LD classes are social and academic engagement. Jao (2013) argues that both the social and academic needs of students need to be catered to in order to increase engagement of students in the applied level classroom. Creating places of community (“safe spaces”) as well as use of the OME’s TIPS4RM lessons, the use of technology and reform-based practices are at the center of the findings regarding increasing student engagement (Jao, 2013). Marks (2000) argues that “[rich tasks grounded in mathematics reform] attenuates the effect of personal background on engagement, eliminating the effect of prior achievement for elementary school students and the effect of [socioeconomic status] for high school students” (p.169). From a student perspective, Sullivan et al. (2009) contend that students perceive that effort equates to success in secondary schools. Some of the patterns identified as motivators for students to engage in class include parental approval, for their own feeling that they are capable, and the personal encouragement of teachers (Sullivan et al., 2009). The aspect

of personal encouragement of teachers can make a large difference in students at the LD level as they may not have a parent at home who is looking for them to succeed, and they may not have developed a growth mindset. Teachers can build those social aspects of engagement into the classroom, and lead students to an overall increase in engagement (Jao, 2013; Marks, 2000).

To complement the findings regarding practices to increase engagement in low stream classrooms, we can take a look at key elements of low stream classrooms that work towards decreased engagement and increased opposition. A focus on traditional mathematics pedagogies with little room for student-led learning leads to fewer opportunities for students to engage in mathematically rich tasks (Hand, 2010). This leads to lower student engagement in general, which is linked to lower academic success and traditional teaching practices (Hand, 2010).

Student attitudes.

The focus of this research is to determine whether or not a noticeable change in attitude towards mathematics is observed in students when they are able to engage in problem-based learning with an IK focus and decolonizing pedagogies. A students' attitude towards mathematics is directly related towards their achievement in the subject (Kajander et al., 2008). Although student achievement is not the focus of this study, it is important to note that greater student achievement in grade nine LD mathematics leads to greater success of students graduating with their OSSD (King et al., 2009). Graduation from high school with an OSSD opens the door for future post-secondary education as well, where we have a lower proportion of Indigenous peoples pursuing studies (King et al., 2009).

According to Higgins, Huscroft-D'Angelo and Crawford (2019), positive attitudes are related to increased engagement and greater persistence in students. They also point out that mathematical performance has as much to do with students' attitudes as it does their knowledge

(K. Higgins et al., 2019). Unfortunately, it has been reported that "students' attitudes towards mathematics become more negative over time" meaning that it is important to take early intervention in establishing positive attitudes (K. Higgins et al., 2019). Higgins et al. (2019) also report that student attitudes towards mathematics and their understanding of how mathematics can be applied in future careers impacts whether or not students pursue more advanced studies in mathematics, which is critical in halting the reproduction of social inequities from generation to generation.

The current literature on student attitudes does not focus on pedagogical approaches to mathematics teaching, but rather, on the connection between the clarity, conciseness and willingness to help of the teachers and how the students interpret their attitude towards the subject (Sonnert, Sadler, Sadler, & Bressoud, 2015). It was found that the students' level of understanding of the subject greatly aligned with a positive attitude towards mathematics (Sonnert et al., 2015). This can relate back to reform-based mathematics practices, which have been shown to develop a deeper conceptual understanding of mathematics (National Council of Teachers of Mathematics, 2000; Russell & Chernoff, 2013; Schoenfeld, 2004). In this study, the use of reform-based practices was selected as this positive connection between understanding and attitudes was noted in the literature.

Much of the literature on student attitudes in mathematics takes a more quantitative or mixed methods approach to the study. As I wanted to pursue a qualitative study, the methods used in the literature in many cases were not applicable. The more quantitative studies tend to focus on the Test of Mathematics Related Attitudes (TOMRA) or Mathematics Attitude Scales and analyze the data based on the numerical responses to the questions (Batchelor, Torbeyns, & Verschaffel, 2019; Deieso & Fraser, 2019). Although these studies can provide valuable

information on the students' attitudes, this approach did not seem appropriate with the efforts to create relationships and connections with students in this research study. Instead, the relationship between attitude and increased engagement was focused upon in observations and interviews as well as greater persistence or investment in mathematics among the students (K. Higgins et al., 2019).

Decolonizing to IK-highlighted Mathematics Education

Reconciliation through IK-highlighted and decolonial pedagogies.

The government of Canada as well as settlers in Canada have worked to establish and then maintain themselves in a position of colonial power over Canada's First Peoples – Indigenous peoples. Indigenous is a term that encompasses First Nations, Métis, and Inuit peoples, and literally means "originating or occurring naturally in a particular place; native [to]" ("Indigenous," n.d.). Throughout the history of Canada, the government created treaty agreements between different groups of Indigenous peoples in order to establish their power in Canada. Treaties were recognized as a sign of peaceful relationship and respectful agreement between Indigenous peoples and the government of Canada (settlers). Indigenous peoples valued the treaties as covenant and believed that they would be honoured as they were enshrined in ceremony and good faith (Gadacz, 2015). This treaty relationship can be seen in historical Indigenous art and cultural artifacts such as Wampum belts, treaty medals, and oral histories which went beyond mere contractual agreements between two distinct peoples (Gadacz, 2015). Relationships are key in most Indigenous worldviews, and treaty agreement was meant to be honoured by Canadian settlers and governments in perpetuity. Sadly, colonial governments used the treaties as a means to take control over Indigenous peoples, forcing them onto reserves with pass systems operated by Indian agents and effectively marginalizing, oppressing and colonizing

Indigenous peoples into submission and subjugation (Indigenous and Northern Affairs Canada, 2018). In the research setting of Northwestern Ontario, the most relevant treaty is the Robinson Superior Treaty of 1850, which was signed by the Ojibwe First Nations of Lake Superior and Canada (Indigenous and Northern Affairs Canada, 2018).

The creation of the Indian Act in 1876 further marginalized Indigenous peoples and limited their rights greatly. First Nation reserves were containments of First Nations peoples, and any movement in or out of the communities had to be pre-approved by the government agent (Indigenous and Northern Affairs Canada, 2018). The creation of the Indian Act combined with the lack of honouring the treaty promises led to harsher oppressions and assimilation in Canada by limiting access to health care, taking away land and the rights associated with it (hunting and fishing), outlawing ceremonies and cultural practices, and deceiving Indigenous peoples (First Nations, Metis & Inuit Education Association of Ontario, n.d.).

Many historical events like the Sixties Scoop, where children were removed from their homes and placed into adoption or foster care, have continued a long tumultuous and traumatic history of bad relations between Canada (the government) and Indigenous peoples (N. J. Sinclair & Dainard, 2017). Over time, First Nations peoples have been not only been marginalized but the Canadian government has also attempted to assimilate Indigenous peoples into “Canadian” or more pointedly, settler culture. Education through the Residential School system has been the most damaging because it set our history for a traumatic, untrustworthy relationship between settlers and Indigenous peoples. Education was the colonizer’s tool of choice, or, as Senator Murray Sinclair (2016) has stated, “Education is what got us into this mess and it is education that will get us out” (para. 10). Indigenous peoples have been systemically marginalized and

colonized over 500 years to the point where they still do not have the same civil and human rights as (non-Indigenous) settler Canadians.

Recently, the Canadian government has begun to acknowledge the many historical wrongdoings that have taken place and were intentional in effort to colonize and assimilate Indigenous peoples. To guide Canadians to advance reconciliation between Indigenous and non-Indigenous peoples, the Truth and Reconciliation Commission of Canada (2015) created a document of Calls to Action, rather than recommendations, in order to explicitly state what institutional stakeholders need to address for reconciling the great harms and wrongs in child welfare, language and culture, health and education (Truth and Reconciliation Commission of Canada, 2015). My study focuses on making real changes in LD math classrooms to address the educational injustices of implicit streaming for Indigenous students, the lack of IK in math curriculum, and the over-representation of Indigenous students and the attitudinal or self-esteem harms in math education.

There are numerous TRC Calls to Action that will be addressed in this research, including:

- 10. We call on the federal government to draft new Aboriginal education legislation with the full participation and informed consent of Aboriginal peoples. The new legislation would include a commitment to sufficient funding and would incorporate the following principles:
    - ii. Improving education attainment levels and success rates.
    - iii. Developing culturally appropriate curricula.
- 62: We call upon the federal, provincial, and territorial governments, in consultation and collaboration with Survivors, Aboriginal peoples, and educators, to:

    - i. Make age-appropriate curriculum on residential schools, Treaties, and Aboriginal peoples' historical and contemporary contributions to Canada a mandatory education requirement for Kindergarten to Grade Twelve students.
    - ii. Provide the necessary funding to post-secondary institutions to educate teachers on how to integrate Indigenous knowledge and teaching methods into classrooms.
- 63: We call upon the Council of Ministers of Education, Canada to maintain an annual commitment to Aboriginal education issues, including:
    - i. Developing and implementing Kindergarten to Grade Twelve curriculum and learning resources on Aboriginal peoples in Canadian history, and the history and legacy of residential schools.
    - ii. Sharing information and best practices on teaching curriculum related to residential schools and Aboriginal history.
    - iii. Building student capacity for intercultural understanding, empathy, and mutual respect.

My thesis study aims to address these Calls by implementing a decolonial math pedagogy with the curricular integration of Indigenous perspectives and highlighting IK as vital math knowledge in order to:

- Improve student attitudes towards mathematics
- Increase graduation and success rates among all students
- Build capacity for intercultural understanding through teaching mathematics through Indigenous culture, and

- Develop and implement these types of lessons and activities in high school LD or applied math classrooms.

Through this research I hope to address some of the needs of teachers of these groups of students as well as how the needs of the students can be met through IK-highlighted lessons and decolonized teaching practices in an effort to advance reconciliation.

In education, decolonizing is the "process of recognizing colonialism, and making efforts to diminish and extinguish its power" (Aikenhead, 2017, p. 17) while indigenizing is defined as incorporating IK, worldviews, and teachings in the classroom (Battiste & Henderson, 2009). Both decolonized and IK-highlighted content have been systematically excluded in schools and curriculum, eclipsed by Eurocentric knowledge systems (Battiste & Henderson, 2009; Godlewska et al., 2010). Decolonizing and incorporating IK-highlighted mathematics are considered processes in relation with Indigenous peoples/community through education. Systemically, it is difficult for non-Indigenous teachers to do this type of teaching without guidance from local Indigenous educators, knowledge holders and community when mainstream non-Indigenous schooling has been and continues to be settler-stream and Eurocentric (Battiste, 2013; Belczewski, 2009; Munroe, Lunney Borden, Murray Orr, Toney, & Meader, 2013; Stavrou & Miller, 2017). All students, including both Indigenous and non-Indigenous can benefit from decolonial and IK-highlighted pedagogies in STEM classrooms, including math (Aikenhead, 2017; Borden, 2013).

As an educator, my own grappling with my personal implications in colonialism must be part of my understanding of decolonizing the Western, Euorcentric curriculum. And this reckoning and awareness must take place before or in tandem with the incorporation of IK-highlighted content in lessons and activities. Personal decolonization is critical to one's position

in the reconciliation process and involves taking the time and effort to educate oneself on the history of Indigenous peoples, cultures, content and issues, as well as making the effort to build relationships with Indigenous community to seek guidance on IK and cultural protocols so that educators can work to move forward in reconciliation. Moving forward does not mean forgetting the past, but acknowledging it and pledging to do better through educating others, listening to the guidance of local Indigenous knowledge holders, and working to reverse the long colonial impacts on Indigenous peoples in education. Decolonization of oneself is a difficult, lengthy process that requires deep introspective thought and recognizing of one's actions and thoughts. However, as an educator, the process of decolonization needs to be recognized at a larger, institutional level. Although one can consider themselves to have undergone a decolonization process on a personal level, the way we have structured our education system in Ontario only perpetuates Eurowestern worldviews. A total epistemological reorientation to education and the rethinking of relationships between schooling and capitalism are required to effectively decolonize education in Ontario.

Decolonizing perspectives grounded in Indigenous knowledges are a way to bring about more success for both Indigenous and non-Indigenous students (Munroe et al., 2013). Unfortunately, these ideas are not widespread at this point. This research aims to increase awareness of decolonial curriculum and the need to decolonize oneself in order to address the Truth and Reconciliation Commission's (2015) Calls to Action and meet the needs of systemically marginalized, discriminated and colonized Indigenous youth. Indigenous education for Indigenous students needs to be a decolonial, culturally safe and IK-honouring curriculum and educational experience (Munroe et al., 2013). As Munroe et al. (2013) state,

> Decolonization can be seen as a process of "deconstruction and reconstruction" that "engages with imperialism and colonialism at multiple levels". This demands the critical examination of the hegemonic structures of mainstream education that continue to perpetuate the values of colonialism (p. 320).

This process of decolonization or critically examining the curriculum and pedagogies of mainstream/settlerstream education is imperative prior to the incorporation of Indigenous traditions, knowledge and practices in the classroom. In Belczewski's (2009) work, she describes her own (settler) educator experiences of incorporating what she thought to be culturally appropriate or relevant activities, but still felt that she was behaving colonially. She underwent a critical self-study of who she is as a White educator for First Nations students and what she brings to the classroom that is "relevant and inclusive without being culturally tokenistic" (Belczewski, 2009, p. 194). Without engaging in this critical, decolonial self-examination, any effort to include Indigenous knowledges or cultural approaches in curriculum runs the risk of coming across as tokenistic or ignorant without Indigenous community participation (Belczewski, 2009). In my thesis project, decolonization of myself as math teacher and researcher included a process of cultural humility by examining who I am as a White settler educator and verifying the accuracy and validity of the IK at the core of my math lessons. The lesson at the centre of this project was an adaptation of a lesson developed by the First Nations Education Steering Committee in British Columbia, which is a reliable source of culturally relevant and IK highlighted lessons (First Nations Education Steering Committee, 2011). The adaptations made to the lesson were authenticated through the use of a local video of birch bark canoe making on Fort William First Nation in addition to knowledge I have learned through immersing myself in First Nations cultural practices with Elders.

The relationship to the math wars.

Eurocentric or mainstream education is consumed with highlighting the "math wars" debate between traditional mathematics and reformed mathematics. Now, there are claims that traditional-pedagogical mathematics aligns more with a Eurocentric worldview, while reformed mathematics pedagogies that pay attention to place/Land, student inquiry, and collaborative learning, better align with Indigenous worldviews (Russell & Chernoff, 2013). Traditionalists endorse practices that include rote memorization and teaching by telling, whereas the reformists believe that mathematics pedagogies should be based on student driven investigation or inquiry (Russell & Chernoff, 2013). A shift towards decolonizing and IK-highlighted mathematics may not only provide a solution to the math wars (Russell & Chernoff, 2013) but also a significant impact on all students' achievement, especially for Indigenous students (Donald et al., 2011).

First Nations, Métis and Inuit connections to mathematics education.

Mathematics has been traditionally known for rote memorization, lecturing and textbook questions. This traditional pedagogical approach is not aligned with IK-highlighted or decolonized teaching methods but it aligns well with a more Eurocentric worldview and provides a disservice to all students learning mathematics (Russell & Chernoff, 2013). A more reform-based practice of teaching and learning mathematics aligns much more with Indigenous worldview and decolonization. Based on personal experiences in academic and university level mathematics, and as mentioned in the literature, fewer Indigenous students reach post-secondary levels of excellence in mathematics education in comparison to non-Indigenous students, which may be in part due to the pedagogical approaches traditionally used to teach mathematics (King et al., 2009; Livingstone, 2014). Research has shown that reformed methods of mathematics education create higher engagement rates and academic success rates for students (Boaler, 2016;

Boaler & Staples, 2008; Russell & Chernoff, 2013). Traditional mathematics pedagogy aligns easily with Eurocentric worldviews, whereas reformed styles of teaching align more with Indigenous worldviews through the practical, hands on aspects that take into consideration a more holistic approach to learning (Nicol et al., 2013; Russell & Chernoff, 2013). Choosing reformed mathematics methodologies to teach Indigenous focused and decolonial content may create the ideal learning environment for all students, particularly those in locally developed level courses that tend to be overrepresented by Indigenous students.

Doolittle (2006) has also touched on the subject of mathematics as medicine through decolonizing and incorporating IK-highlighted mathematics – but with a conscious effort in the direction of the underlying Indigenous knowledge in content (Enyedy, Danish, & Fields, 2011). Edward identifies as a Mohawk man, and he has a Doctor of Philosophy in Mathematics, awarded from the University of Toronto (Doolittle, 2006). Early on in his life, he did not identify specifically as a Mohawk man, but always felt as though something was missing (Doolittle, 2006). It was not until he attended university that he felt a true connection to his Mohawk culture (Doolittle, 2006). His plenary talk focuses on how to appropriately connect Indigenous culture to mathematics, his struggles bringing together two separate identities, and how these can lead to math as medicine (Doolittle, 2006).

Doolittle (2006) suggests asking the question “What are the Indigenous analogues to mathematics” rather than asking “What is Indigenous mathematics?” (p. 23). This is a critical question as it puts into perspective how we look at the incorporation of IK-highlighted knowledge mathematics pedagogy. Using traditional Indigenous objects to teach mathematics, for example, using traditional Eastern Woodlands Wampum belts to teach patterning without context around what a Wampum belt is or why it was used does not necessarily align with the

history or heritage of the Indigenous peoples. In this case, it might be better to ask how the tradition of these belts fits into mathematics rather than trying to fit the traditional piece into a specific topic in mathematics. Doolittle's ideas on mathematics align with decolonizing and IK-highlighted strategies shown in other research (Enyedy et al., 2011; Russell & Chernoff, 2013; Sterenberg et al., 2010). Near the end of his talk, Doolittle (2006) asks if mathematics can be thought of as medicine, and who the fortunate individuals are that get to access its benefits.

Educators have also indicated that actually implementing decolonizing and IK-highlighted strategies into the classroom is intimidating due to various reasons including: lack of experience, understanding and contact with Indigenous community and culture and worry that they will offend students in the classroom (M. Higgins, Madden, & Korteweg, 2015; Primavesi, 2015). Prior to my engagement in the Indigenizing Perspectives and Practices in Education course that I enrolled in during my Bachelor of Education year, I would have also found the implementation of Indigenous knowledge and perspectives very intimidating. The research in this thesis and resources developed for use in the classroom have the goal of removing some of these barriers, and help educators focus on implementing these decolonized and IK-highlighted pedagogies into the classroom, with the goal of changing students' attitudes towards mathematics. Developing an effective, culturally responsive curriculum may seem daunting, but it is the full responsibility of educators to work towards a place of social justice, rather than ignore or perpetuate social injustices (Higgins et al., 2015; Primavesi, 2015). Without embracing a social justice perspective, White educators can take on the role of the "perfect stranger", where traditional teaching practices with grounding in Eurocentrism are common as they are comfortable and reflects what the educator wants to know or wants to express. The role is deemed as "perfect stranger", as the White educator is acting in a place where they are removing

themselves from the history of Canada and excluding culturally relevant material for the reason that it makes them uncomfortable (Higgins et al., 2015). The issue with taking on the role of the "perfect stranger" is that inaction is perpetuating social injustices in society and is working against reconciliation in Canada. Decolonizing and incorporating IK-highlighted mathematics are strategies that can be used to make content more culturally relevant and work towards a place of equity (Enyedy et al., 2011; Higgins et al., 2015; Primavesi, 2015).

It is not only important to decolonize mathematics pedagogies utilized in the classroom, as well as perform self-reflexive decolonization as an educator in the process in order to recognize how one's actions contribute to colonialism and what can be done to prevent that cycle of damage and exclusion from reproducing and then perpetuating systemic racism and neo-colonialism in schools (Primavesi, 2015). By interrupting the cycle of oppression and assimilation of Indigenous peoples into Western society, we can make space for Indigenous perspectives and practices to be at the forefront of our education. Eurocentric views continue to perpetuate the superiority of non-Indigenous White Canadians, and it is teachers' and educators' responsibility as Canadian educators to break the cycle of colonial violence (exclusions, deficits, dehumanizing students) and the history of residential schools from continuing in our schools, as mandated by the Truth & Reconciliation Commission's report and the Government of Canada (2015).

Race and racism.

Indigenous youth report being misunderstood and targeted by racism regularly, which leads to a lower school performance and loss of interest in schooling (Hare & Pidgeon, 2011). Race and racism of and towards Indigenous peoples can be addressed through the incorporation of IK-highlighted mathematics and decolonizing mathematics education. Research states that

schools are places where youth can connect with their sense of self and construct identities (Fine, Burns, Payne & Torre, 2004). If an Indigenous student does not feel adequately represented in their education or school, and is subject to individual and systemic racism, then how can we expect them to construct their own sense of self and develop the capacities to build relationships and forge change? Indigenous youth experience frustration trying to navigate settlerstream schools while struggling to communicate perspectives and cultural strengths in our Eurocentric classrooms (Bissell & Korteweg, 2016). A settlerstream school is a school that is primarily composed of students who identify as non-Indigenous settlers in Canada. Settlerstream schools are schools that are Eurocentric in nature. The high school that I attended would be considered a settlerstream school. As educators, using decolonizing and IK-highlighted strategies and pedagogies ensures that we are not only educating all students, but giving Indigenous students a chance to see themselves reflected in their education and to develop the critical thinking skills that education has to offer. By incorporating IK-highlighted mathematics and decolonizing, we have the ability to reduce racism towards Indigenous peoples, improve engagement and learning for all students, and even greater, we have the ability to promote reconciliation with Indigenous peoples (Borden, 2013).

Through the incorporation of Indigenous knowledges, traditions and practices in mathematics and decolonizing, we can put Indigenous students at the center of the curriculum rather than our current practice of systematic ignorance of Indigenous perspectives. By educating both the dominant race (White Canadians) and the oppressed race (Indigenous peoples) on accurate, evidence-based Canadian history, we can begin to close the gap between races and promote reconciliation with Indigenous peoples. A critical problem is that many White settlers do not want to face this difficult history or engage in troubling conversations with peers of

students. Unfortunately, specifically ignoring or "white-washing" history perpetuates the cycle of oppression and marginalization of Indigenous peoples. Without critical changes in pedagogy, true Canadian history is often systematically disregarded or ignored, and not taught in classrooms, and the dominant race does not learn about the genocidal past of the oppressed. This only contributes to the cyclical racism that occurs by White people to Indigenous peoples, and promotes a larger gap between races and the notion of nonconformity and assimilation rather than reconciliation (Donald, 2009).

Although the notion of addressing racism towards Indigenous peoples has not been specifically addressed through a mathematics pedagogical approach, an IK focus and decolonizing can be implemented in any subject area. One example of IK-highlighted content could be to invite in an elder to discuss traditional Anishinaabe circle teachings (appropriate for Treaty 3, 9 and Robinson-Superior Treaty areas), or in mathematics specifically to take a Land-based approach to teaching and learning. This can relate back to mathematics through circles, circumference, bearings, angles and many other mathematical concepts. It is imperative that while working towards IK-highlighted mathematics and decolonizing, one must also watch out for westernizing thinking models of Indigenous peoples through Eurocentric concepts.

Research at the Locally Developed Level

As previously mentioned, emphasis on student achievement in mathematics or teacher attitudes towards teaching IK-highlighted teaching or decolonizing content has been the focus of educational research, demonstrating a lack of understanding of student attitudes towards mathematics (Boaler, 2016; Stavrou & Miller, 2017; Sterenberg, 2013).

Although student achievement and teacher attitudes have been explored, little research has taken place on student attitudes and their connection to IK-highlighted content and

decolonizing classroom practices. Moreover, it appears that students enrolled in Ontario locally developed (LD) level mathematics have not been studied to any extent regarding student achievement or attitudes. These students are also not included in the provincial government's Education Quality and Accountability Office testing (Education Quality and Accountability Office, 2014). One of the goals of this testing is to "inform the improvement of instructional programs and strategies to help all children succeed" (Education Quality and Accountability Office, 2014, p. 3). However, as this group is not tested, "all" learners have not been equally assessed. In a sense, these students have been excluded from the Ontario education system, which allows the OME to ignore their needs, and not take responsibility for LD learners and teachers. This is important to note as Indigenous students may be overrepresented in this level of education due to lower engagement and lower school performance of these particular groups. As students who self-identify as Indigenous may be overrepresented at the LD level, this also means unequal testing of these students, and therefore no funding to generate research at this level, leading to less professional development in this area. This cyclical progression demonstrates no means to an end for students in the LD level, especially for the marginalized populations that are overrepresented in these courses, like Indigenous students.

In a sense, the OME has "given up" on these students, but the school boards and the Ministry can claim that EQAO is not appropriate for these learners. This demonstrates that the OME and school boards are not investing in these students as there are no funds available to them, given that the data from the EQAO tests for LD students does not exist. While by definition, the more open curriculum of the LD courses cannot be evaluated by a set or standardized test, some other means of assessment and support is needed.

Summary

In summary, the current mandate of mathematics education in Ontario relies on three issues: destreaming of curriculum and students in school mathematics, reform-based approaches to teaching/learning of mathematics, and increasing students' authentic engagement in learning mathematics. These are three key pieces of the re/righting puzzle that could fit together to increase growth in mathematical competency and numeracy by disengaged learners in Ontario schools. Streaming currently reproduces and perpetuates inequities of marginalized student groups, including racialized, low socioeconomic class, or students contending with exceptionalities (Galabuzi, 2014; Hamlin & Cameron, 2015; Livingstone, 2014; San Vicente, 2014). By placing a student in an applied or LD grade 9 mathematics class, the student becomes doubly disadvantaged in terms of the "forced out" (dropout) rate, the chances of graduating with an OSSD, or continuing on to pursue post-secondary education (King et al., 2009).

Disparities that exist through streaming begin in elementary school and are extended further through explicit streaming in secondary education. The impacts of streaming are long lasting and reproducing. Reform-based mathematics teaching is linked to increased engagement, as is mixed-ability grouping rather than ability-based streaming. There are also many avenues of social justice education that can be addressed through IK-highlighted and decolonizing pedagogies, particularly in mathematics classrooms. Adopting strategies of decolonial and Indigenous focused teaching practices may steer away from the many social injustices that continue to systematically oppress Indigenous peoples while moving towards an improved relationship for greater reconciliation with Indigenous peoples. Eurocentric perspectives and practices are ubiquitous in Canadian curriculum and teachers are primarily White settlers (Kanu, 2005). To end this social reproduction of inequities through mathematics education propagating

gap, all educators need to come together and face our collective responsibilities for education-as-reconciliation across multiple historic and current divides (Donald et al., 2011). Decolonial and IK-highlighted pedagogies can be adopted into every subject area. Mathematics pedagogy is a critically important part of reconciliation education because it has been traditionally taught from a Eurocentric perspective, an approach that has not served the needs of most students enrolled in LD or applied courses. Social injustices in education can be addressed through the inclusion of IK-highlighted content and decolonizing pedagogies in the classroom, which can help close the gap between Indigenous Canadians and non-Indigenous Canadians to lead to a point of reconciliation. By implementing strategies that work towards a place of collaboration and reconciliation between educators, students, policy makers, community members and administrators, we can begin to rewrite mathematics education for at-risk mathematics learners in Ontario schools.

Chapter Three: Methodology and Methods

Introduction

The research for this thesis aims to work towards greater equity for students enrolled in LD mathematics, with special attention provided to Indigenous knowledges in the curriculum in order to better support both Indigenous students who are over-represented in LD as well as improve math education for all students. As an educator, I need to recognize my social position in order to reduce reproducing cultural harms and more inequities for students in LD, specifically those of Indigenous heritage. This study was a test case to determine what changes can be made by myself, other educators, school boards and administrative levels in order to positively impact students' attitudes towards mathematics and provide space and opportunity in the curriculum for students to voice their ideas, thinking and perspectives on what they enjoy in mathematics. The research aims to bring attention to the needs of LD mathematics students, especially Indigenous students, and how they may be met with reform-based pedagogies and IK highlighted, decolonial curriculum in mathematics.

The research question that was addressed in this thesis is:

1. *How do student attitudes towards locally developed grade 9 mathematics change when exposed to reform-based pedagogies and Indigenous Knowledge highlighted, decolonial curriculum?*

Methodology

This research was conducted qualitatively, and the design that was employed was critical action research. Qualitative research is focused on "understanding the meaning people have constructed" (Merriam & Tisdell, 2016, p. 15). As the goal of this thesis is to understand and deconstruct how students and educators interpret their experiences with (and without) IK-

highlighted, reform-based mathematics, and what meaning they attribute to these experiences, a qualitative approach to research is appropriate. Qualitative research is grounded in social constructivism and aims to attain an understanding of how people make sense of their experiences and their lives (Merriam & Tisdell, 2016). In qualitative research, the researcher is the primary instrument for data collection and data analysis (Merriam & Tisdell, 2016). With the researcher being the primary instrument for data collection and analysis, this means that biases and assumptions of the researcher should be monitored through the theoretical lens of the study to check how they are impacting or not impacting the data analysis and whether or not that is the intended outcome (Merriam & Tisdell, 2016). I adhere to decolonial theories in education , so throughout the process of interaction with participants, data collection and data analysis, I reflected on how my position as a White, female, middle class, well educated, recent Bachelor of Education graduate would play a role in the project. This self-reflexivity will be further expanded upon further in this chapter.

The mission of critical action research is to promote social justice among the marginalized, oppressed, disenfranchised or disadvantaged populations (Given, 2008). Researchers in critical action question the "social implications and moral issues of action and seek shared understanding of the social action" (Given, 2008, para. 8). The goal of critical action research is to: develop an "improved understanding of a social phenomenon and create a social transformation at a community or organizational level resulting from reflexivity and self-reflection about the hegemony in the research relationship and in the community or organization" (Given, 2008, para. 9). In the case of this thesis project, the goal was to develop an improved understanding of the impacts of implementing a reform-based IK-highlighted lesson

with a decolonial approach into a grade 9 LD mathematics classroom and to observe students' attitudes towards LD math in this new context.

One of the main aspirations of this research was to bring forward student responses and views on the incorporation of Indigenous perspectives, practices and traditions into their regular math classroom activities and content. The students' own interpretations of their experiences with IK-highlighted curriculum was analyzed as it related to their attitudes and engagement in mathematics. As Indigenous groups have a long history of marginalization and face systemic injustices in education, the incorporation of IK-highlighted lessons and my conscious efforts to decolonize my mathematics teaching all work towards reconciliation and greater equality for Indigenous students. With the implementation of IK-highlighted curriculum in the classroom, one of the goals of the study was to observe a transformation of students' attitudes in a positive way, meaning to increase attitudes of willingness to take risks in mathematics and curiosity and investment in the lesson.

This social change study was focused at a LD level mathematics course for two pivotal reasons: students in LD mathematics often have large gaps in their math education and their needs cannot be met with the applied and academic level provincial curricula. These students also tend to have more external factors impacting their education, such as poverty, substance abuse, lack of familial stability and support, mental and physical health issues and a history of distrust in education (Kajander et al., 2008). Another reason the LD class was selected as an ideal group to research was because of the larger numbers of Indigenous students being placed into LD classrooms. Indigenous peoples have been consistently marginalized, oppressed and disrespected throughout Canada's history. Education and Indigenous peoples have a poor

relationship due to historical wrongdoings like residential schools, but also due to lower amounts of funding in federally funded schools for First Nations youth.

Critical action research as the methodology is a logical choice due to the hope for social change and a focus on equity, equality and a move towards reconciliation between Indigenous and non-Indigenous peoples in Canada. The goal of seeking out inequalities in education through this study with active self-reflection throughout the research process were employed. In critical action research, it is often common for participants to act in a capacity of co-researchers, where they help to guide the study based on the findings. This element of critical action research was employed to a certain degree for the educators in the classroom but was not implemented with the student participant. This was in part due to the age of the student as well as the lack of knowledge in the area of the research, but also due to the self-identified cultural heritage of the student. During the data collection process, there were also many setbacks which created a very tight timeline for data collection and analysis to occur in order to guide the research, so I unfortunately did not have much opportunity to involve the participants as collaborators as much as I would have liked. However, the student participant and both educators were asked to contribute their thoughts to future applications of the IK-highlighted lesson as well as changes that should be made in the future.

Throughout the study, the data was collected and analyzed using a postcolonial lens as the goal of the study was to create social change to promote reconciliation through IK-highlighted mathematics and a decolonial approach to teaching. This means that through the data collection process, I was cognizant of the ways in which inequalities are perpetuated in the classroom and I made every effort to stop them from reproducing. I also ensured not to appropriate First Nations culture through the delivery of my lesson in the classroom, and

acknowledged to the students my positionality at the beginning of the lesson. I also made every effort to observe all students in the classroom to see if the IK and practices had impacts on their attitudes and engagement. I was specifically looking for students who were actively participating in the lesson, talking with other students about the lesson, who were not using mobile devices and those who completed the worksheet. In an interview setting, I also made efforts to analyze the responses from the student participant in this study with a decolonial lens. Through data analysis, I was looking for items that sparked interest with a decolonial viewpoint in mind as well as keeping the research question at the centre of my research.

Method

Research setting and sample selection.

The classroom selected for the study was within a medium-sized public school district in a medium-sized city in Northwestern Ontario. The LD class had one teacher and one SSP. There were 16 students enrolled in the course, and it was a grade 9/10 split LD class. 2 students in this course had worked with our research group last year through the Ministry of Education project in some capacity. None were previously interviewed for either the Ministry of Education project or another research group members' personal research. Based on students asking to work in the Indigenous work room, the class appeared to be fifty percent Indigenous (primarily of First Nation heritage) students. Note that these students did not self-identify as Indigenous or First Nation, however, the Indigenous work room is a safe space for Indigenous students exclusively. I interpreted students leaving to work in that room as a sign of the student's self-identification of Indigenous heritage. I received one ethics permission form for a student participant for this study, who identified as White. I did not receive any signed permission forms from any other

students. The SSP that was interviewed identified as White and the teacher did not disclose his heritage.

The sample size for this study largely depended on how many students in the class were able to return signed permission forms. There was an implicit likelihood that the sample would be biased towards those students who attend on a regular basis and are already succeeding in the course (Kajander, Flessa, Lampo & Sedor, 2018). I received two signed permission forms from students in the course, and the student I interviewed attended class on a very regular basis. Unfortunately, I did not get a chance to interview the second student, as his attendance became very irregular, to the point that I did not see the student after the fifth week of the full semester (4 month long) course. Many other students asked me for a second set of ethics forms as they were very interested in participating, however, none returned the forms signed. This may have been due to many factors, such as: lack of regular access to a parent/relative, poor communication with a boarding parent/guardian to sign a form, lack of a backpack to bring the form home, external factors impacting the students' mental states or mental health, absenteeism, physical health issues, as well as an overall lack of trust or confidence in the school system. I had many comments from students, including "Who should I get to sign this form in the group home?" and "I'll never get this form signed", despite wanting to participate in the study. The lack of signed ethics permission forms will be expanded upon in the "Limitations" section of the thesis conclusion.

The students in the sample were all enrolled in the same grade 9/10 LD course at the same high school. The student in the sample was also present for both lesson facilitation days so that they could best reflect on the full lesson's experience during the research interview. These were the only criteria that were considered when selecting students for the sample, as the pool of

student participants who returned the signed permission forms was minimal. As mentioned previously, only two students returned the signed permission forms, but one was not present for the first day of the lesson. I attempted to set up an interview with this student for their experience, but he never returned to class again.

Due to the lack of student permission forms and participation, an interview with the SSP and the teacher were also arranged. The SSP was asked the questions in Appendix C regarding the LD class in general and then questions specific to the lesson I delivered in the class. The teacher was also interviewed about the lesson students participated in regarding their level of engagement, as well as general questions pertaining to the class as a whole and the number of Indigenous students present in the class. These participants were chosen as they were both present for the lesson and could comment on perceived student engagement, reactions, emotions, attitudes and opinions of the lesson.

Data collection.

Research occurred in the classroom setting with my role as a participant-observer or teacher-researcher fully immersed in the classroom culture on a regular basis. This participant observation is an ethnographic technique that is often applied over long periods of time, ideally 6 months or longer (Fetterman, 2008). As I was not fully immersed in the classroom for an extensive length of time, I applied this technique to the study as a method of developing relationships and rapport with students and the educators, however, I did not conduct an ethnography (Fetterman, 2008). I took thick observations every day of regular classroom practices and teaching pedagogies as well as student interactions with myself and the educators in the room. The goal of these observations was to determine student attitudes, engagement and enjoyment in the regular, daily activities of the classroom. As a university researcher with some

teaching experience in a high school, I found myself struggling to determine my position as the researcher while teaching or assisting the students. I vacillated between identifying primarily as the outside researcher as well as a member of the classroom community as a teacher. I had to wrestle with this identification because in critical research your identification and role will impact how the participants view you and the information that they may share with you. After much deliberation, I determined that I am both an insider and outsider in the classroom. I am an insider in the manner that I am an occasional teacher and the research participants were aware of this fact. This may have had an impact on the terminology and the information that the educators disclosed to me during their interviews. I determined that I am also an outsider to the classroom as I am a university representative and not a regular presence in the school. In the sense of the research, I also took on a participant-observer stance in the classroom (Kajander et al., 2008). This stance is defined as more than just an observer, but an observer who engages with students in the classroom (Kajander et al., 2008). On a regular classroom visit, I would observe the classroom environment, but also talk with students about the lesson and about their lives in general. The combination of the insider/outsider status as well as the stance as a participant-observer may have had an impact on the information that the student participant felt comfortable sharing with me as well as the educators.

After building rapport with the students in the class, I set out to acquire permission forms to interview two to three students (ideally at least one Indigenous and one non-Indigenous). Board permissions had already been acquired through the longitudinal study with the Ministry of Education, however, parental approval was needed for every student participant in the study. Unfortunately, only two permission forms were obtained, with one being a possible participant. After obtaining permission, but prior to the facilitation of the decolonized, IK-highlighted lesson,

the researcher interviewed the student participant about their current classroom experience. The student interview guide can be found in Appendix A. The interview style was semi-structured, and additional questions were added as necessary throughout the interview. The interviews all took place in a room designated by the office that was private and quiet, but still within the comfort of the school.

Once the interviews were complete, I conducted one lesson that incorporated IK-highlighted content and decolonized pedagogies grounded in problem-based learning (see Appendix D).

The Mapping and Transportation lesson was focused on practical applications of measurement. In the "Minds On" or "Hook", students learned about the traditional practices of the Indigenous peoples in the traditional territory of the Fort William First Nation regarding travel. In the "Action" portion, students completed an activity determining canoe travel across the Kaministiquia River, and they used appropriate measuring tools and units to measure how far the canoe travelled (the hypotenuse of a triangle). In the consolidation phase, the length of the hypotenuse was compared to the anticipated horizontal distance and different impacts on the canoe's travel were discussed (for example, current or wind). Through this lesson, current practices of travel were also explored. The Mapping and Transportation lesson took two periods to complete as anticipated.

After taking part in the Mapping and Transportation activity, the student was interviewed again in a similar semi-structured style in the same room (See Appendices A and E). The student was asked about their experiences in mathematics and asked to share their thoughts on what would make mathematics class more enjoyable for them, and what motivates them to attend class, whether that be meaningful relationships with educators, friendships, or support from

resources at the school. The students' thoughts on Indigenous content being included in the mathematics classroom (contrary to a history classroom) was also explored through the post-lesson interview.

Throughout the classroom observation period, and the lesson facilitation, the researcher also took general notes on the level of engagement of students in the class during regular classroom activities and the IK-highlighted lesson with a decolonial pedagogical approach. No particular format or checklist was used, but information that stood out to the researcher was recorded. This included quotations from students, information on attendance, programming for the day, interactions with students and general notes on engagement, attitude and excitement around mathematics.

Documents were also a source of data in this project. Artifacts of student work were collected as evidence along with general classroom observations to provide multiple data sources in order to triangulate the data and make connections between the different sources. Student work was purposefully selected to show the broad range of students and abilities present in LD math, in order to highlight some of the challenges that must be considered when teaching these students. Images of students' canoes for the Mapping and Transportation lesson along with images of students measuring the distances for this lesson were also included in the documents to be analyzed.

Data analysis.

The collected data, through interviews, observations and documents was analyzed to determine whether an increase in engagement or enjoyment was noted when the IK-highlighted and decolonized lesson is included along with problem-based, reformed mathematics pedagogies.

Throughout the data collection process, mini data analyses were occurring concurrently. Although the data collection period was fairly short, collected data was quickly analyzed in order to guide the next round of data collection. The logistics of the data collection in this study did not allow for full analyses in between rounds of data collection, however, I analyzed as much as I was able to. Generally, this meant making notes on my observations in the classroom and identifying important characteristics of the data. To determine important characteristics of the data, it was looked at it through a postcolonial lens with the basis of critical action research in mind. The concept of social change and the central research question were also kept in mind throughout this study.

Throughout the data collection and data analysis phases of this project, I was also consistently self reflexive on my positionality, how it was guiding my analyses and what information was being disclosed (or not disclosed) to me due to my insider-outsider perspective. Throughout each stage of the study, I considered the social justice impacts of the study and how my interactions with the participants impacted their wellbeing and thoughts towards education. I reflected in a personal journal throughout the study and looked at the data through a decolonial lens in order to select interesting quotations or selections of the data that seemed critical. Decolonization is a process, and requires a break in the settler colonial triad (Tuck & Yang, 2012). Decolonization is connected to anti-imperialism elsewhere, and in relation to this study, education (Tuck & Yang, 2012). I worked to develop a lesson that would help disrupt and break the settler colonial triad, and made significant efforts in the development of the lesson, interviews and my personal reflexivity to keep the goal of decolonization at the centre of the research (Tuck & Yang, 2012). I made note of interesting or critical selections of data to either come back to in the next round of data collection or in the organization of themes. Throughout

the data analysis process, I also kept the research question in mind when selecting passages and pieces of transcripts, observations and documents.

To analyze the data, Atlas.ti as a qualitative coding program was used. Interviews were transcribed and imported into Atlas.ti, written observations were typed and images of documents were imported into the software. Researcher reflection on the purpose of the study and theoretical lens took place many times throughout the analysis. Data was looked at through a postcolonial lens, keeping the research question in mind, and meaningful passages or images were selected. In Atlas.ti, these are called quotations. From there, these meaningful passages were organized into groupings, called codes. Passages were assigned these codes, of which there were many. At this point in the data analysis, I pulled back from the project and again looked at the whole picture and the overall goal of the research project – to understand how student attitudes towards mathematics are impacted or changed when they are able to meaningfully interact in problem-based lessons with an IK focus. Between the codes, I started looking for patterns, and adjusted the code groupings that the quotations belonged to. From these codes, I was able to create groups of codes that were better related. Again, I went back and forth with inductive and eventually deductive analysis in order to finally organize them into themes. Then, emergent themes were determined through inductive, deductive and comparative reasoning of the various codes (Merriam & Tisdell, 2016). The emergent themes that evolved through the data analysis process were:

- Locally developed profiles
- Typical student experiences in LD mathematics
- Effective pedagogies in mathematics education
- Student attitude, engagement and enjoyment in mathematics

- Cultural connections to education
- Supporting LD mathematics

After these themes were formed, I again ensured that the individual quotations within in each code and code group and eventually theme fit well within the category as well as fit with the goal of the research project – to answer the research question.

The creation of the themes listed above was in response to students' attitudes before the lesson and after the lesson. Some of the themes are more relevant to the interviews and data collected prior to the lesson delivery and some are more relevant after, however, they are all critical themes to answering the research question in this thesis.

Ethics.

Ethical permission from relevant organizations was obtained through our research group's project with the Ministry of Education's Mathematics Knowledge Network. Protocols were slightly modified to fit the scope of this thesis project. Student and parent/guardian permission to participate in this thesis was required by both the Lakehead University Research Ethics Board (REB) and the review board of the public school board where the study took place.

Participants and guardians of participants were made fully aware that they could withdraw their permission or their child's permission from the study anytime. To date, no participants have been asked to be withdrawn from the research study. Participants were also reminded as active and ongoing consent that they were not under any pressure or requirement to answer any questions they wished not to. I had one participant choose to skip a question, which demonstrates that this participant was aware of their choice to not respond. Finally, I made certain to help all participants understand that they could request a copy of the study results. Respect throughout the data collection and analysis was actively taken into account with all

research participants, and confidentiality was maintained. All participants were given pseudonyms to protect anonymity. As a researcher in the classroom, it was my responsibility to ensure that the class understood my intentions of the research and that they were involved throughout the process.

Data was collected through face to face interviews, which caused no physical or psychological harm or potential risk for participants in this study. The interview questions for each participant can be found in the Appendices. Deception did not play a role in this study and the utmost respect was shown for participants by ensuring that participants were aware of their rights in the study, ensuring that participants were in comfortable location for their interviews, ensuring that they were aware they could ask for a copy of the research findings and answering any questions about the research study to the best of my ability. Original copies of transcripts of interviews are stored in a secure, locked location at the Faculty of Education for five years, after which time they can be destroyed. The findings of the study will be shared with participants who request to view the findings, as well as members of the school board and the Critical Transitions Community of Practice, of the Mathematics Knowledge Network, upon their request.

Researcher beliefs and assumptions.

As the researcher, I bring forth various beliefs based on my personal experiences and connection to the topic. I am aware that I hold the belief that the addition of IK-highlighted and decolonial content in any subject area is critical to Canada reconciling with Indigenous peoples. I also believe that its inclusion in mathematics will allow Indigenous students to see their culture in the Science, Technology, Engineering and Mathematics (STEM) fields, with the implication that more Indigenous peoples will go into these fields. My personal view is that students will be

more successful (specifically Indigenous students) with the inclusion of this content across all subject areas.

Regarding mathematics pedagogies, I also hold the predisposition that reform-based or problem-based learning is the most appropriate way for students to learn mathematics. With these approaches to teaching and learning mathematics, I believe that more students can understand and relate to mathematics and more students enjoy the subject. If this is widely implemented in all classrooms province-wide it is my view that students will be more successful in mathematics, EQAO testing and will be able to apply mathematics more easily in real-life situations. I also believe that problem-based learning gives a chance for spatial learners to succeed, which I believe traditional mathematics does not.

The combination of decolonial curriculum and IK-highlighted content with problem-based learning in the mathematics classroom is one that can be very powerful. I believe with this approach to teaching and learning, students will be more engaged in mathematics and will generally be more successful as they are invested in their learning. With this combination, I also have faith that success levels for both Indigenous and non-Indigenous students will increase and more knowledge on Indigenous cultures and practices will be shared, allowing for reconciliation between Indigenous and non-Indigenous peoples.

Although I hold these very strong beliefs, they are also proven to be true in the literature. I know these theoretical orientations have influenced this research; however, I have tried to put the socially constructed realities of the participants at the forefront of this research. I looked at these realities with the beliefs that I bring to the project. I do not think my personal beliefs have impacted this project in a negative way, and that they are very much in line with the critical action research that I intended to pursue. Throughout the process of engaging in this research, I

have attempted to bring forth the true authentic thoughts of the participants in the study, but knowing that my own beliefs influenced passages that I considered to be critical in the data analysis section.

Throughout this research, I also consider myself to have acted as both an insider and an outside in the classroom. For the student participant, I held an outsider role as I was a student researcher from the university, however, for the educator participants, I was more of an insider as I am also an educator in high schools. My status as an outsider allowed the student participant to open up to me a bit more as he did not consider me a teacher, but more of a person who could enact change in his school. In terms of the educators, my status as an insider possibly closed off the teacher participant as it seems to be more difficult to disclose areas you need to work on to your colleagues. This may not have been the case, however, this is the feeling I got when I interviewed the teacher. In the case of the SSP, my status as an insider did not impact the depth of information that was shared with me. I believe the SSP would have shared similar stories had I been an outsider.

In terms of my positionality, I identify as a White, middle class, well educated, female student researcher. In a study with a postcolonial lens, my race can be viewed as possibly a barrier to quality research as I am considered to be part of a group that is not oppressed or marginalized in any way, yet I am studying a race that is oppressed and marginalized. I believe my race might have had a larger impact on the study had I acquired a participant that identified as Indigenous, however, I had White participants and one of an undisclosed heritage. Sometimes being a member of the dominant race can come across as having a “saviour” attitude when attempting to create social justice for oppressed races. Through my interview questions and personal decolonization, I believe that I managed to avoid my research as being interpreted this

way. I also positioned myself within the class at the beginning of the lesson, identifying myself as White, but explaining that it was important to bring more First Nations perspectives and practices into the classroom in order to promote reconciliation, recognize the contributions of IK in mathematics and to seek social justice for marginalized groups. Through the interviews I conducted I also clarified my personal heritage to the participants. I also played a video with a first person First Nations perspective rather than taking on this role myself, which helped bring forward authenticity (Ontario Travel, 2017).

Limitations.

Throughout the observation and data collection phases of this project, I encountered many limitations. One limitation of this study was the difficulty in receiving signed consent forms from students. This resulted in a skewed student representation with input from only one White student. Despite building relationships and connections with many of the students in the class, and many students asking for ethics forms, I still only received two forms, which demonstrates how much of an obstacle the formalized REB-university ethics approach is for Indigenous students. At the school board level, communication was made with staff who were responsible for ensuring Indigenous students' success to aid in obtaining signed permission forms. The staff had connections with parents of many Indigenous students, but still was unable to assist in obtaining signed permission forms. There was no way around this process of received written consent to participate in the study. There were also many systemic obstacles to gaining Indigenous student consent, such as: Indigenous family/community distance, lack of adult advocates in the students' schooling, unfamiliarity with 'research', distrust in high schools and the school board, racism in the city as well as chronic absenteeism, grade gaps, physical and mental health issues, trauma, etc. Given these axes of obstacles, I was unable to obtain

permission forms from any Indigenous students, which meant that their participation was formally undocumented. These issues in ethics procedures demonstrate how decolonizing education efforts can only go so far before the forces of settler-colonialism assert themselves. It was my goal to include first person Indigenous perspectives in the study, however, the rigid difficulties and multiple obstacles for obtaining signed permission forms signed made this basic goal unattainable.

Due to the inability to obtain signed permission forms from Indigenous students, the study had to change its focus towards LD student needs, systemic issues, low-level streaming and the self-esteem of students as regular conditions of LD mathematics. The IK highlighted lesson was employed as an opportunity to disrupt the obstacles that were faced to create a space in the curriculum for a hopeful social change intervention and to emphasize to Indigenous students that they are worth it and that IK is important and vital to education, university research and for improving LD mathematics.

Students enrolled in LD level classes often have external factors that impact their education, and many do not attend on a regular basis for many other issues than just academic (Kajander, Flessa, Lampo & Sedor, 2018). Students who do not regularly attend class or are missing 2-3 days per week are considered chronically absent in this study. This can make it difficult to retrieve the signed forms from students. To increase chances of retrieving signed permission forms, I attempted to build strong connections with students, however, thus proved to not be enough. To supplement the lack of student data I received in the study, both the teacher in the classroom and the SSP were interviewed to describe their experiences in the classroom and their observations of student experiences. This is one of the numerous struggles when conducting research with students who may be considered at-risk population.

Another limitation that I experienced in this study was time. As this is a Master's level research project, there was not a large amount of time to conduct the study. If the time were available, this could be tested on multiple LD classes, as no two classes are the same. Perhaps that would widen the scope of the project and allow more connections to be made that educators could relate to.

Data collection was also limited to a very short period of time, which made it quite intense and did not allow for very thorough concurrent analysis. The teacher for the LD class changed at the last minute, which demonstrates another obstacle that impacts LD student progress and engagement. Teacher turnover (especially at the last minute) demonstrates to LD students that they are not worth the effort or preference of full time, permanent teachers.

I then began with the observation days and ended up facilitating the lesson just prior to March break. Unfortunately, throughout the data collection period, there were numerous serious external factors influencing anyone's ability to enter the school, so there are days where I have no data on the class. These external factors may have also had an impact on the students and their willingness to attend school and added to the LD students' regular difficulties in attending school. To maintain confidentiality of the school and school board, details on the external factors that caused these critical gaps in the research and the students' schooling will not be divulged. It is important to note though that the second student participant (Dean, whom I did not interview), stopped attending school after these external factors started impacting the school community on a regular basis. Also due to these external serious factors, I was unable to interview Tom (the SSP) until significant time had passed; therefore, his memory of the lesson may not have been as great or with much detail for the data. Finally, after the lesson facilitation, Mr. M left the school for unknown reasons. Due to this leave, I was unable to interview him until after a significant

amount of time had passed and again, the details were of the lesson and the students' responses were not fresh in his mind at the time of the interview.

Although the external factors influenced the ability to collect data, I still believe the data that I have collected to be valid. These external factors had just started impacting the school community when I finished Harry's second interview, so I believe the data I collected from him to be influenced very little by the factors. While the factors may have also influenced the length of time that had passed between the lesson and interviews of the educators, I still believe that what they mentioned in the interview was relevant information to the study.

Chapter Four: Findings and Discussion

Findings

The purpose of this research project was to determine whether or not students enrolled in grade 9 Locally Developed mathematics demonstrated a change in attitude towards mathematics with the intervention of a culturally responsive lesson for social change in LD mathematics. In order to determine whether or not attitudes had changed, students' attitudes towards mathematics prior to the addition of cultural content had to be determined. Throughout the course of this project, seven key themes emerged:

- Locally developed profiles
- Typical student experiences in locally developed classrooms
- Effective pedagogies in reform-based mathematics
- Student attitudes, engagement and enjoyment in mathematics
- Culturally responsive connections in mathematics education (for student representation in LD classrooms)
- Supporting locally developed classrooms

Each of these themes was arrived at through initially inductive and eventually deductive reasoning. Initially, as data was collected, it was analyzed to see where further analysis might be required, who else should be considered for interviews, and what supporting documents would assist in data triangulation. These initial analyses concurrently with data collection allowed me to adjust the research process as appropriate.

Throughout the data collection process, there were many cataclysmic setbacks that were external to the project. The setbacks led to a disjointed and condensed data collection process, which required immediate analyses of each piece to quickly determine how to continue. The

lesson was implemented between the student's two interviews, but there were also many days when all students were unable to attend school, therefore, there may have been limitations with the memory retention of all the interview participants, including the one student. And, it should also be noted that the teacher and SSP interviews took place approximately two months after the decolonized and IK-highlighted lesson was facilitated in their classroom due to factors external to the project causing school closures and the teacher's leave of absence. These limiting factors should be kept in mind while reading the data analysis as they likely had a significant impact on the findings.

In order to determine a change in student attitudes, I first compiled the profiles of the students and educators in the LD classroom.

Locally Developed Educator Profiles

Data regarding the teacher of the LD class as well as the SSP present in the room were collected in order to create a picture of what this specific class looked like. The educators' education, cultural heritage, history with the school board, their classroom arrangement, collaboration and personal characteristics were looked at. Semi-structured, transcribed interviews, sample classroom artifacts and field notes of classroom observations were used as the methods to collect this data. Mr. M's and Tom's interview transcripts can be found in Appendix E. Each educators' section will describe the elements that they bring to the classroom, including their educational background, as well as their personality characteristics and teaching preferences, in order to provide enough detail to picture a typical day in this LD classroom.

Mr. M: The teacher profile.

Mr. M, the teacher of the LD class had been working as a teacher for approximately 15 years, with 11 or 12 being full time. However, Mr. M has had a lack of stability in class and

school assignments each year since he became full time. The term prior to this one, Mr. M had been working at more than one school to be full time; using his lunch break to travel to the second school. As this one class is a small part of a much larger project with the Ministry of Education, I was able to compare it to our previous class profiles, which we had prior ethical clearance for through the larger project. The class that was studied in the previous year had a teacher who also lacked stability. In her career, she had never had a consistent school or stable timetable. Mr. M mentioned that he and the other teacher, Mrs. W, were at about the same level of seniority and had been going through the same treatment for the last 11 or 12 years. It is interesting, but possibly not surprising to note that through my classroom observations, Mr. M appeared quite tired and burnt out on a daily basis. Perhaps some of this burnout could be attributed to the lack of stability in his teaching position. Mrs. W was not tired and/or burnt out during the research groups' observation days the previous term, however, she was a teacher that demonstrated very strong resilience and had a very strong bond with the students. On the contrary, Mr. M did not appear to have a strong relationship with the students, according to my observations, as will be further discussed.

Mr. M had never taught the grade nine LD mathematics course, but he had taught the grade ten LD mathematics course once before. Mr. M's formal teachable subject is in a science discipline while mathematics is his second teachable subject. His timetable during the observation term of this study was composed of mostly science classes with this one section of LD mathematics.

As for personal characteristics, my observations and conversations suggest that Mr. M came across as having little energy for the LD class and seemed mostly focused on covering the content, rather than placing value on the students' actual understanding of mathematics. It is

possible that he did value the students' understanding of the subject, but he was too burnt out to plan more engaging, reform-based activities. The samples of worksheets given out by Mr. M represent typical days and his expectations of the students (see Figures 3 & 4). In the interview, Mr. M told me about a typical day in his classroom – which consisted of some kind of warm up or review, a teacher-directed lesson, and then finally something to be "worked through" like a worksheet (Mr. M, personal communication, June 13, 2019). My classroom observations were also consistent with this description. I observed lecture-style lessons as long as 50 minutes and as short as 30 minutes in the LD class. The lessons were a traditional-style presentation with the teacher at the front of the room giving lecture style delivery of content to the group of students, who were all expected to sit silently at their desks.

Throughout my observations, I noted that Mr. M did not enjoy being interrupted during his lessons and that he did not enjoy unpredictability in students' responses to his questions. An example of this was when Mr. M asked the students what the total would be on a specific item, including taxes. The class calculated the amount of money and he put it on the board, down to the nearest cent. Harry, a student who loved to argue with Mr. M, mentioned that you would not actually pay that amount of money if you were paying cash as we no longer have pennies in Canada. Mr. M ignored his comment entirely, when it was a completely logical response that could have been discussed with the class. Valuable teaching moments like the scenario above were often ignored. After learning that this was Mr. M's first time teaching this course, his lack of flexibility may partly stem from his idea of teaching mathematics. To be flexible in lessons and teach in a knowledgeable manner, you have to be comfortable and hold a level of confidence in the subject you are teaching, and it was easy to observe that there was a lack of comfort for Mr. M in mathematics. Mathematics education literature has clearly demonstrated that there is a

connection between confidence and competence in this specific subject of mathematics teaching (Maclellan, 2014; Maher, Morley, Fimusanmi, & Ogilvie, 2019; Russo & Hopkins, 2019).

Also, after observing and conversing with Mr. M for a good portion of the term, I found that I hardly knew anything about him as an individual. By the end of the term, I was unaware of what he did outside of the classroom. Although it is not a requirement for a teacher to disclose personal activities to their students or other adults in the classroom, it can be a valuable starting point for finding common ground between educator and student and developing a meaningful relationship (Jao, 2013).

Although I have painted a picture of Mr. M's classroom to be a very traditional one, I did observe some actions that Mr. M took to ensure that his students would be successful. Mr. M would walk around and work with students one-on-one and at their level daily. He would work through some questions with them, and he tended to carry pencils in his back pocket in case students needed one. He also checked in with every student daily to see how they were understanding the mathematics. In our interview, he expressed frustration in that he could not get the students to buy into his lesson and activities and did not understand why (Mr. M, personal communication, June 13, 2019). I trust that Mr. M believes he had his students' best interests at heart, but that he does not have enough knowledge on teaching LD students, teaching mathematics, and recent research on the best pedagogies. I also attribute some of his traditional style to the lack of stability he has experienced as continuing labour conditions with the school board over the last twelve years and the level of burnout he was experiencing. To overcome the obstacles and impediments that LD students face on a regular basis, teacher stability, confidence and competence are required. The hiring process for LD classes is the same as that of any other course, which means that the unique needs of the students are not taken into account. The

instability and assigning of these courses to staff who are able to fill only the academic role of the teacher, but not other obstacles only reinforces to LD students that they are not worth it. I do not believe that Mr. M is intentionally disserving students in their education, but rather that he is the product of a system with instability. The lack of professional development for both full time and contractual teachers of LD students is also perpetuating Mr. M's traditional teaching style. Throughout the course of the semester, I noted that he became more open to new ideas the longer I was in the classroom. After my IK-highlighted lesson, he indicated to me that he would use that lesson if he was assigned to teach LD mathematics again, however. The facilitated lesson served as an intervention and opportunity to show students in LD mathematics that they are worth it.

Tom: The student support personnel profile.

Despite a class enrollment of only 16 students, the school assigned an SSP to Mr. M's grade 9 LD class. Tom had been working as an SSP for the school board for about six years. Prior to this, he worked in children's mental health for approximately seven years. Tom is typically placed in LD and applied level classes. He mentioned that he had not been in an academic level class for years (Tom, personal communication, May 2, 2019). Tom received his training and certification in the Child and Youth Worker program at a community college. He mentioned that the last time he took mathematics was in grade twelve (Tom, personal communication, May 2, 2019) and he did not indicate any professional development in mathematics or specialized training to be in a mathematics classroom.

On a daily basis, Tom made every effort to talk to the students in the class and ask them how they were doing in both the mathematics and generally in life. In addition to his work with the students, he also worked to support Mr. M in the classroom. In an interview, Tom mentioned a few times that he and Mr. M would work in collaboration (Tom, personal communication, May

2, 2019). Tom would joke with the students in the class very frequently and would help them work through the worksheets Mr. M handed out. My classroom observations of Tom noted that he seemed to have a deep conceptual understanding of mathematics, based on the way he was describing questions to the students. He also had a comfortable way of interacting with and relating to all the students who referred to him only by his first name. I only learned of Tom's last name when he signed the ethics forms for this study. And I intentionally assigned Tom a first-name pseudonym in this thesis to reflect the fact that Tom's teaching style was one of caring for the students first, placing value on relating to them as people and finding common ground. The strength of the relationships that Tom had with the students meant that he knew many of them from other classes and was an asset to help motivate them. Tom tended to work with students one-on-one and worked with all students, rather than just support a single student. Another beneficial characteristic was that Tom had a good relationship with Mr. M as well the majority of the students.

Contrary to the lack of personal connection I noted with Mr. M, I felt that I knew quite a bit about Tom before the end of the semester. We would often talk about what he liked to do in his spare time and what activities he engaged in outside of the classroom. This relatability helped Tom form meaningful bonds with some of the harder to reach students as well as Mr. M. Tom came across as someone who enjoys being an educator and working with LD students because he always came in the room with a positive attitude and a smile, regardless of the plan for the day. Tom was also a consistent presence in the classroom, with no absences throughout the data collection. Tom gave a similar impression on the classroom as to what Jao (2013) described in the case of Mathieu, where the classroom environment created through a focus on the social domain became more relaxed and casual. Tom tended to focus on the social domain rather than

the academic, which may make more sense as he is a classroom support. This focus on social domain allows for more student independence and classroom engagement overall (Jao, 2013). Tom took a very active, hands on approach with the students and I would rarely see him sitting in his designated desk. Tom's connections with the LD learners, especially those with at-risk students and Indigenous students in the class demonstrates a lack of caring and reinforces the sense that the students are worth it. The relationships that Tom formed with students worked to ward of some of the detrimental effects of many LD classrooms, like implicit streaming and the level of distrust in education.

Typical Student Experiences in Locally Developed Mathematics

In this section, a typical day in the life of a locally developed student will be described, including the classroom environment, typical activities and interactions with students and educators in the classroom. This section also seeks to answer how student attitudes change when students experience a culturally relevant, decolonized lesson plan as it provides information on their attitude and engagement on a regular basis in the classroom. Although this information is specific to this class, similarities might be found between this class and other LD classes throughout Ontario.

The class observed for the purposes of this thesis was a grade 9/10 split LD level mathematics course. There were sixteen students on the class roster and on a regular basis, about eight or nine students would attend class on average.

Classroom environment.

On my first day of observation in Mr. M's classroom, I noted the classroom configuration. All desks were in single rows, spaced out so that there were no groups of desks together. As students filed in, there was a group of students who sat at the front, with the

majority of students choosing to sit at the very back or along the sides of the classroom. Students were able to sit wherever they chose, and few students chose to sit in the middle of the classroom. There was also a physical divide between two groups; those who sat at the back and those who sat at the front. I also noted that there were no anchor charts on the walls of the classroom. Mr. M was assigned to this class at the very last minute, so even though I noted the above classroom characteristics, which are not in line with current, reform-based practices in mathematics, I thought it was logical given the very late assignment of this course. Throughout the course of the semester, however, the desk configuration did not change nor did the lack of anchor charts on the walls. Mr. M's desk was at the front of the classroom, and the SSP also sat near the front of the classroom at a student desk. There was a smartboard at the front of the classroom, which the teacher used on a daily basis for his lesson.

Classroom activities.

A typical day in the classroom included a brain teaser, a lecture style lesson and a worksheet. On about a weekly basis, Mr. M also took the students down to the foods room to participate in a cooking lesson. This was an activity that he decided to incorporate into the class based on a recommendation from Mrs. W. On a typical day in the foods room, students would be in there with another class, working on cooking together. Usually, the other class was a foods class, but the odd time it would be another mathematics class.

Within the traditional, lecture style lessons were also decontextualized questions, like "Shade in 1/5 of the circle below" rather than a more "real life" approach like "You and your four friends ordered a pizza from Little Caesars and you want to split the pizza evenly. Shade in the amount that one friend would eat in order for each of you to have the same amount." Even a slight difference like in the example above could work to make the lesson more interesting for

the students despite the lecture style of the lesson (Kajander et al., 2008). The question I posed above can potentially lead to a much richer conversation, especially with the student profiles in the room. Harry, the student I interviewed, loved cooking and food and shopping for food. A student like him could have taken the question posed above a step further and divided the circle into the number of pieces that a Little Caesar's pizza normally has, and then shading in 1/5 of those pieces. This could mean a pizza with 8 slices being divided into fifths, which is a much richer question. It would be interesting to go through this question with the entire class, or if a student did not come up with the scenario that Harry might have, you could always use this as an extension activity or one with a higher ceiling for students who find the initial question fairly easy. I noted that a scenario like the ones posed above actually happened once, in the tax unit.

Harry had counted up his personal collection of Pokémon cards at home and looked online to find out how much they were worth. He then went ahead and added the tax on top of that value to determine how much a store could sell them for. Harry told Mr. M about his calculations in the middle of the next lesson on taxes. Harry was told to be quiet until the end of the lesson. Harry was a student who liked to argue with Mr. M if at all possible, so Harry did not like this, and mentioned that the work he did related to taxes. Mr. M continued to tell him to be quiet until the end of the lesson. You could tell that Harry was shut down. It was not discussed again that day.

If I had been the educator in that room, I would have embraced that scenario for the following reform-math principles and needs of all students in mathematics. Harry took the self-directed initiative to take the previous day's math content from the lesson and apply it to something he was interested in, on his own time, and related to relevant lived experiences and his own daily life. This is a student learning moment to be celebrated and held up as a mode for

engagement for other students. It is difficult to get engagement from students in the classroom, and Harry had done all this work on his own time! Mr. M had not provided a real-life situation where taxes were needed that related to the students' personal lives at this point, but Harry found one, which was incredible.

When asked at any given time what Harry would like to see more of in class, or where he uses mathematics at home, cooking and shopping were always his two responses. At one point, he expressed frustration in the post-lesson interview, stating that he would like to see more shopping activities in the classroom, "if we ever do that" (Harry, personal communication, March 6, 2019). He also indicated throughout that he felt they were given too much work in class and that the work was too difficult. He mentioned that he liked activities that involved shopping, cooking, counting (his Pokémon cards), and hands-on activities the best (Harry, personal communication, March 6, 2019). Perhaps if there were more real-life connections on a regular basis in his mathematics class, Harry would be able to make some more connections to mathematics besides cooking and shopping.

Locally Developed Student Profiles

To be able to understand any change in the attitude of students towards the subject of mathematics after the IK-highlighted lesson I would facilitate, I felt it necessary to learn more about the students in the LD class and their characteristics, engagement, excitement and attitude towards mathematics on a daily basis. Through interviews with one student, classroom observations, samples of student work and the interviews with the educators, I have attempted to describe some characteristics that represent these students enrolled in the LD class as accurately as possible.

Although only one student was interviewed (Harry), in the context of the research classroom, I would not consider this student to be an anomaly in most ways. An overall description of the class as well as Harry will be discussed in this section.

Overall, one surprising piece of information that I had not considered prior to data analysis was a perceived mathematical ability that appeared even less than actual mathematical ability of the students in the class. This was a theme between different data sources that emerged through the analysis and it was deduced that it could be a part of the student profile. Harry, the student I interviewed, exhibited this characteristic when he mentioned to me that the work was "too difficult", which disagrees with my classroom observations of Harry (Harry, personal communication, March 4, 2019). I helped Harry one on one on numerous occasions and found that he was able to do the mathematical work with little to no help. So why then does he believe that he cannot do it and that the work is too difficult? It is a question that could be answered with further study, however, the students in the classroom are fully aware that they are in the "lowest" stream (based on academic ability), and I believe it is clear that this is impacting their perceived abilities (Kajander et al., 2008). Boaler, William and Brown's (2000) article mentioned deficit perceptions that are often displayed through LD students' self-esteem, and in the case of this study these perceptions are being expressed through this deficit mindset displayed by Harry. Harry was not the only student I observed that exhibited this feature.

Class demographics.

The demographics of this class were consistent with the literature on alternative and LD mathematics education. There was one newcomer in the class, who spoke very little English, while there was a disproportionately higher number of Indigenous students compared to the Applied and Academic math courses (Galabuzi, 2014; Livingstone, 2014). What this means is

that a larger portion of the LD classes identify as Indigenous in comparison to Academic or Applied classes where a smaller proportion of the class would identify as Indigenous (Galabuzi, 2014; Livingstone, 2014). Research indicates that this may be for various factors and in Northwestern Ontario, these factors include gaps in education due to lack of qualified teachers on reserve schools, intergenerational trauma from residential schools, less funding per student for federally funded schools, a history of various forms of abuse in families, etc. (Government of Canada; Indigenous and Northern Affairs Canada, 2017). Racism also plays a role in streaming students where a students' perceived abilities by administration are lower than the students' actual abilities, and they are placed in a lower stream like Applied or LD (Galabuzi, 2014). In Northwestern Ontario, if students are coming from reserves for high school education, they are often staying with either members of their extended family or local, often non-Indigenous families who are paid as boarding parents/homes. Indigenous parents must often remain home in their northern communities which results in poor or little regular communication between parents and the school. This is often a reason why more Indigenous students are placed in the LD classrooms in disproportion to those streamed into Applied or Academic courses. Another contributing factor is the problem of paperwork when Indigenous students from northern communities register in urban high schools. Students often appear without a school record or transcript and the school has little to no information on their credits, success or challenges in basic subjects such as literacy and numeracy.

In this LD class, Mr. M and Tom were both asked in an interview whether or not they believed that there was a disproportionate number of Indigenous students in their LD class compared to their Academic and Applied counterparts. Mr. M agreed that there is a greater proportion of Indigenous students in the LD classes at the local high school where the study was

conducted in comparison to Academic classes. However, Tom has not been in an Academic classroom for a number of years, so he did not feel he could comment. Both Mr. M and Tom were not sure if the proportion of Indigenous students in LD relative to the Applied level was greater or not. They both expressed that both levels have high proportions of Indigenous students in this particular high school. For the research term, I was only present in the LD classes, so I do not have observations of other levels of classes.

From my researcher perspective without access to student files, I speculated that the approximately 8 students who would regularly go to the Indigenous work room to work on the assigned math worksheets were probably Indigenous students. The high school and school board has made efforts to provide Indigenous students with a designated Indigenous work room as a safe space for homework, to access a tutor, food and peers, as well as engage in Indigenous community in the school setting. Being that the Indigenous work room is a space for Indigenous students, I feel confident in stating that the students who use the room are generally Indigenous. This would suggest that approximately 8 students in the class are of Indigenous heritage. As the class roster has 16 students on it, this would mean that at least half of the students enrolled in the class are Indigenous. Many Indigenous students in the class also proudly talked about being First Nation. I observed a student wearing a hoodie adorned with “Anishinaabe” on it and often heard students talking about cultural activities. When I chatted with the students in the class, many of those who used the Indigenous work room told me that they were not from Thunder Bay. There were many students from northern communities, with some communities as far away as eight hundred kilometres.

It is interesting to note that this class had two distinct groups of students that were also based on race or culture: those who sat at the front of the class were non-Indigenous or White

whereas those who sat at the back were the Indigenous students. This physical divide was obvious from my first observation day where I observed Indigenous students who used the Indigenous work room all sitting together at the back of the classroom, whereas the students at the front did not use the Indigenous work room, and included Harry, the student I interviewed who identified as White, all sat together as a group. The students at the front of the room were much louder than those at the back of the room, and they generally participated in lessons delivered by Mr. M. The students at the back of the room tended to be more withdrawn from the class and rarely seemed engaged with the lessons. Mr. M rarely called on the students at the back of the room to answer any questions throughout the lesson, and he consistently called on those at the front of the room. When I interviewed Tom, he also noted the two distinct groups in the class and that the group at the back was withdrawn from the course content, whereas the group at the front was generally engaged (Tom, personal communication, May 2, 2019).

Attendance.

Low attendance is also a part of the student profile in this LD class. Many students struggled with attendance on a regular basis. As previously mentioned, a little over half of the students on the roster would regularly attend class. There were two students on the roster that I had never met. The low attendance has a major impact on the students' education as it only perpetuates gaps in learning and causes teachers to rely on worksheets or workbooks in many cases as they cannot replicate a problem-based lesson for the students on a day to day basis when they are absent. I also had one student complete the ethics permission form to participate in the study, but then I never saw him again for the remainder of the term. This meant that I did not have sufficient data on this student and was unable to interview him about the IK-highlighted lesson I delivered in his class. Harry – the other student that brought back signed permission

forms – was a bit of an anomaly in the class in regard to attendance. Harry had almost perfect attendance. With generally low attendance also comes a lot of late students. On a regular basis, anywhere from 1-5 students would come to class late. Sometimes, students would also leave early. This meant a difference in planning for Mr. M as he would never start the class off with a lesson on the board otherwise late students would miss parts of it (Mr. M, personal communication, June 13, 2019). He would usually start with some sort of warm up, whether that be a review of material covered previously or a brain teaser to ensure that no one missed the lesson. Although students were consistently late, Mr. M never penalized students for being late. He would tend to be very neutral when students would come in late; not acknowledging their presence nor bringing attention to the fact that they were late.

Readiness.

In their respective interviews, Mr. M and Tom described typical LD students. Mr. M described most LD students to be less mature than students enrolled in the applied and academic streams, and that many also struggle socially (Mr. M, personal communication, June 13, 2019). Mr. M identified these as reasons why students may be placed in this stream as opposed to other streams. Both Mr. M and Tom mentioned that the LD class moves at a much slower pace and is for those students whose mathematical skills are lacking or are behind their grade level. This is supported in the literature, which states that students may be up to four grade levels behind (LDCC Project, 2005). Tom also mentioned that some students who have a lack of educational history in their Ontario Student Record (OSR) are sometimes also placed in the LD level due to the fact that the school is not confident of where their abilities are at (Tom, personal communication, May 2, 2019). As can be seen in the streaming section in Chapter two, just placing students in the LD level is putting them at a huge disadvantage in the journey to get their

OSSD. To place students in LD just due to a lack of educational history without checking in with the student, the last school they attended or maybe doing a small assessment of their abilities seems inappropriate, especially given that placing a student in LD has such detrimental impacts on the students' success rate (King et al., 2009; Macaulay, 2018).

External factors.

Finally, students in LD also have many external factors influencing their education. Based on my conversations with students in this class, external issues were abundant in the student body. Some of the conversations I heard from students were on topics like the foster care system (including how to get the ethics forms signed for those in foster care), drug and alcohol abuse, pregnancy, medical issues, and lack of parental guidance. Many students were not living with their parents for various reasons and lacked some form of parental or guardian guidance, likely impacting their support in making good decisions. Some students came to class injured and when I asked what happened, the response was that they couldn't remember. These external factors combined with the usual pressures of high school, like relationships, friendships, bullying, etc. can help educators understand why students' priorities are not aimed towards their academic success.

Summary.

In sum, the students enrolled in the LD class in this study can be described as being from a diverse range of cultural backgrounds, having poor attendance, exhibiting lack of readiness for high school and having external factors impacting their education. Through observation of the class, and interactions with students, it is also clear that many of the students also hold a self-belief of their abilities that is lower than their mathematical abilities. On a regular basis, from many students in the classroom, I would hear things like "I can't do it, I'm too stupid" and "Why

do you think I'm in LD". These kinds of statements impacted me as the researcher in the classroom and even more as an educator myself. It is comments like these that shift my thoughts towards the idea that current streaming practices are not best for student self-confidence and wellbeing and it also makes me want to find a way to change students' lives for the better through education.

In terms of external factors, many seemed to be at play in the research setting. When I asked Mr. M about external factors, he indicated that it is hard to tell what is going on with a student unless they are talking to you about it. Although this may be true, as educators it is our responsibility to educate students to have mathematical literacy skills that will benefit them in their everyday life. It is hard to do that without first understanding where your students are coming from and how you can help them. There are more facets to an individual other than academics, and relationship has been shown to transcend curriculum for students enrolled in streams like LD (Kajander et al., 2019).

As educators, we cannot only cater to a small portion of the mental section in order to help our students grow. Without physical, emotional and spiritual connections, we are not helping or educating students to the best of our ability. As previously mentioned, there is also an emotional relationship aspect that may need to come before academic curricula can come into play with students, especially such as those in LD (Jao, 2013). Taking a more holistic approach to education rather than sweeping things under the rug will help students become more well rounded individuals who are able to contribute meaningfully to society.

Discussion

Effective Pedagogies in Reform-Based Mathematics

While the previous section focuses on typical day to day activities, this section focuses on how these typical activities align with or misalign with current literature on best practices in mathematics. As can be seen in Chapter Two of this thesis, current literature points towards taking a more problem-based approach to mathematics teaching and learning, with the educator taking on a facilitator role in the classroom. Recent literature also calls for more hands-on learning with an emphasis on real life aspects of mathematics. These strategies have been shown to benefit the majority of learners and develop a deeper, more conceptual understanding of mathematics (Russell & Chernoff, 2013; Schoenfeld, 2004).

Reform-based mathematics is a term that can be used to describe this method of teaching. Literature also demonstrates that reform-based teaching can assist with classroom management as it increases engagement among students, as they are doing hands-on learning with real life applications. With learners who have lower confidence in mathematics, or who have lower skill levels, creating problems that have a low entry point (i.e. something that anyone can try) can to create an environment with high participation and a more positive attitude towards the subject being taught, as it feels more accessible. Learners who have lower confidence and skill levels are often placed in LD mathematics, due to gaps in their education, lack of social maturity, inabilities to succeed with a more rigorous curriculum, etc. Therefore, using traditional teaching methods, like lecture-based learning, with the teacher as the only knowledge holder in the room, rote memorization and rules-based approaches to mathematics would be not only inappropriate for this group of learners, but could be detrimental to their academic success and understanding of mathematics (Russell & Chernoff, 2013).

Considering the recent literature and previous observations of more reform-based classes through the Ministry of Education's Mathematics Knowledge Network's project, I hoped to see a similar approach to teaching the LD mathematics during the research term for this thesis. Unfortunately, what I observed was aligned more with traditional pedagogies in mathematics education as well as the deficit perspectives and implicit streaming present in the literature. Culturally responsive approaches to teaching and reform-based pedagogies were implemented to try and disrupt this approach and make a positive difference in the students' lives.

Observed pedagogies compared to best practices.

The majority of my observation days in the classroom focused on a traditional lesson at the front of the room for more than half of the 70 minute period. There was usually a worksheet to follow with decontextualized mathematics question. During the lesson, there was a significant mention of rules as an approach to learning mathematics. I observed Mr. M teaching a lesson on percentages and decimals and he said, "We are multiplying by 100, so we move the decimal place two to the right". Although this might not seem like a major issue, it is a statement that perpetuates rote memorization and rules-based learning approaches rather than a conceptual understanding of what multiplying by 100 really means. With a group of LD students who have likely not thrived in a traditional classroom environment, this approach can be detrimental to their learning and understanding of mathematics and how it can be used outside of the classroom. An important purpose of locally developed mathematics is to teach students practical skills that they would need to use to thrive in a workplace environment (LDCC Project, 2005). Teaching decimals and place value as arbitrary, memorization style learning with no context is impractical and sets the students up for unsuccessfulness in the workplace.

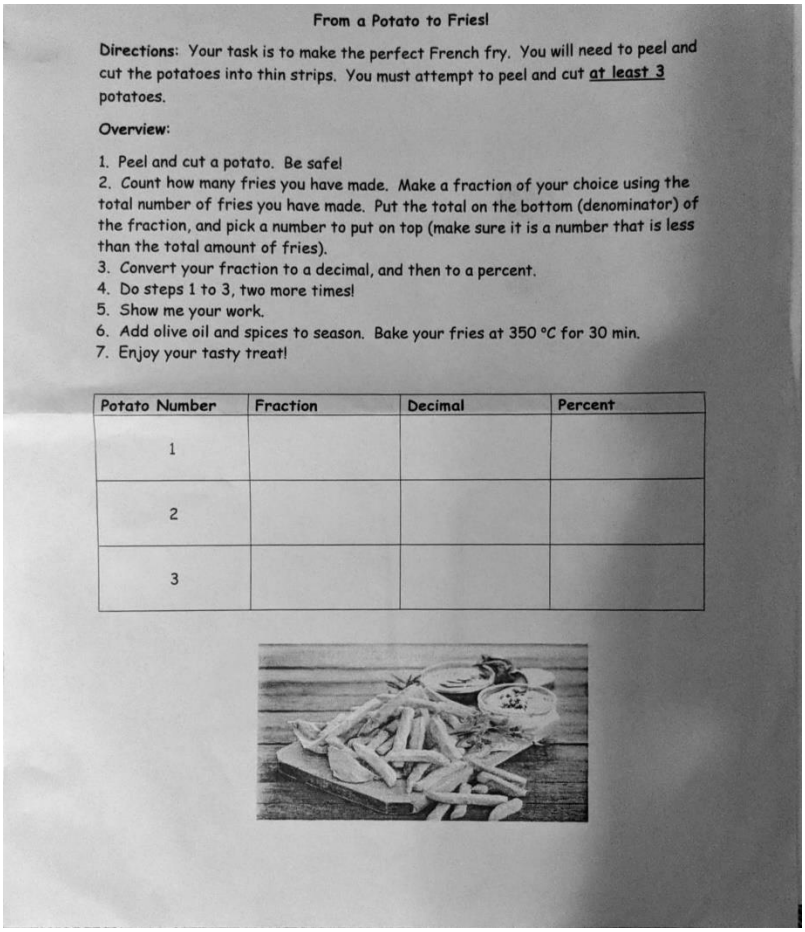
Other worrisome quotes that I heard from Mr. M were “It’s really quiet in here – how it should be” and to a student, “this worksheet will help you in the future”. These quotes support traditional pedagogies in mathematics and a Western worldview where the teacher is the holder of knowledge in the classroom and the students should be quiet and listen to the teacher (Russell & Chernoff, 2013). It also supports the notion that decontextualized worksheets and lecture style lessons will best help students learn and understand knowledge that is useful in the future, when there is literature disputing this perspective (Belczewski, 2009; Boaler, 2016; Doolittle & Glanfield, 2007; First Nations Education Steering Committee, 2011; Government of Ontario, 2018; Nicol et al., 2013; Wright, 2012).

After interviewing Harry, Mr. M and Tom, they all mentioned the same thing: that hands on learning promotes engagement and enjoyment among students in LD mathematics. Mr. M even noted that although typical activities in his room included worksheets, hands on learning would provide a better conceptual and memorable experience in mathematics for students. Harry listed specific activities that he enjoys most in the classroom, which were all hands-on learning opportunities with ties to real life. Despite the discrepancy between Mr. M’s observed pedagogies and what he believed to be best for the students, he mentioned how difficult it can be to find good resources for LD mathematics, which will be expanded on in the “Supporting LD Classrooms section”.

As mentioned previously, the student interviewee, Harry, indicated to me that hands-on activities – particularly cooking activities – were his favourite. Harry even identified where he sees mathematics in cooking, which he said was the measuring aspect of it (Harry, personal communication, March 4, 2019). Harry’s responses are consistent with the literature, which

states that hands on activities help students more deeply understand mathematics and that lessons with real life contexts help students make connections to mathematics in their everyday lives.

Unfortunately, on my observation days in the foods room, students indicated to me that they felt uncomfortable going into the foods room with another class in there as they did not know the other students in the room. One student waited outside of the classroom as she did not even want to go in. Mr. M would ask the class regularly what they wanted to cook next and always showed frustration whenever the students did not respond with things to cook. He would mention on a regular basis that if no one had ideas to contribute then they would not go at all. The threat to take away one of the few hands-on learning opportunities that the students had hard to watch. After my interviews with Harry, I could tell that the elimination of these cooking days could be detrimental to him. Mr. M even asked me why I thought the students were hesitant to participate in the cooking activities and I mentioned that the other group of students in the room was making some students uncomfortable. After this conversation, this did not change as far as I am aware. Another reason I think the cooking was not a huge success in this class is because of the worksheets that went along with the cooking days. A sample can be seen below:



From a Potato to Fries!

Directions: Your task is to make the perfect French fry. You will need to peel and cut the potatoes into thin strips. You must attempt to peel and cut <u>at least 3</u> potatoes.

Overview:

1. Peel and cut a potato. Be safe!
2. Count how many fries you have made. Make a fraction of your choice using the total number of fries you have made. Put the total on the bottom (denominator) of the fraction, and pick a number to put on top (make sure it is a number that is less than the total amount of fries).
3. Convert your fraction to a decimal, and then to a percent.
4. Do steps 1 to 3, two more times!
5. Show me your work.
6. Add olive oil and spices to season. Bake your fries at 350 °C for 30 min.
7. Enjoy your tasty treat!

Potato Number	Fraction	Decimal	Percent
1			
2			
3			

Figure 3. A sample cooking activity that was implemented in the LD class.

This worksheet is an example of a typical activity that Mr. M would implement during more hands-on activity days There are a few worrisome elements on this sheet. The steps to cook the fries seem reasonable, but the issues are in the data students are expected to record. Recent literature in mathematics focuses on a real-life aspect and hands on activities. Although cooking fries is a real life scenario, and is hands on, the questions asked are atypical in real life cooking. The worksheet asks students to take one potato and split it into pieces (fries), and then make up a fraction of their choice. This is not something that a cook would do for fun while cooking. They may be interested in how many fries one potato makes, and then use ratios to scale that up, but it is unlikely that they would need to make up a random fraction with a numerator smaller than a

denominator that somehow related to their potatoes. Also, there is a comment on the sheet to make sure that the number on the top is smaller than the number on the bottom. Why? Improper fractions exist. In this scenario, it would actually make sense to have an improper fraction when talking about more than one potato. It could be possible to have 25 pieces of size 1/20 of a potato, which would be a 25/20 fraction, or 1 5/20. This could be interpreted as needing to have 1 potato and ¼ of the next one in order to get 25 fries (which could presumably feed a specific number of people). However, according to the sheet, these types of fractions are unacceptable.

The purpose of providing this sample worksheet is to put into perspective what daily life was like in this classroom. I am glad that the teacher was attempting to use hands on activities as a way to teach mathematics, however, the methods and pedagogies used to teach these concepts are not in line with the activities themselves. This is like doing traditional lessons, but then assessing students' ability to perform hands on tasks. The teaching and assessment have to match one another in order to provide students with effective descriptive feedback and an opportunity to improve before a summative assessment (Government of Ontario, 2010).

Relationships in LD mathematics.

From an outsider (teacher-researcher) perspective, I was not able to find any evidence that Mr. M had developed a relationship with any students in the classroom. Throughout our research in the Mathematics Knowledge Network project, we have found that relationships in the LD classroom transcend the curriculum (Kajander, Flessa, Lampo & Sedor, 2018). In order to get students to buy into what you are doing curriculum-wise; it is critical that you have the relationship piece set first (Jao, 2013). This model has been expanded upon Jao's (2013) original model where relationship and curriculum were mutually exclusive. Our belief after working in LD classrooms over the past four terms is that curriculum cannot take place until a relationship

had been established. In the case of a previously observed classroom, particularly Mrs. W's room, it was clear in the student interviews conducted that they were attending class on a regular basis because of the relationship they had with their teacher. The students in Mrs. W's classroom mentioned her name numerous times in their interviews and had even mentioned that their favourite class was mathematics, for the sole reason that she was the teacher. When one of her previous students moved up to grade ten and they found out they did not have her as their mathematics teacher, they went down to the office and requested that he be switched to her class. This shows how strong the bond was between the students and Mrs. W and how powerful relationships can be in LD.

Unfortunately for Mr. M, this was not the case when I interviewed Harry. Harry did not mention Mr. M in either a positive or a negative light, and called his class this year "fine" (Harry, personal communication, March 4, 2019). He said that he liked the people in the class (referring to the other students), but that he found the work to be difficult (Harry, personal communication, March 4, 2019). It appeared that the relationship piece between Mr. M and the students enrolled in his course was missing.

Student Attitude, Engagement, and Enjoyment in Mathematics

This section seeks to interpret students' attitudes towards mathematics both before and after the Indigenous centred, decolonized lesson I delivered in the LD research class. Harry was interviewed about his experience in the lesson and the educators were asked their opinions on the lesson and how the students responded. The data collected from the educators fills in some of the gaps in the study due to the small student population that returned completed ethics forms and were present for the lesson and interviews. The research question posed in this thesis is: *How do*

student attitudes towards locally developed Grade 9 mathematics change when exposed to Indigenous focused and decolonial pedagogies?

This section aims to answer this question, keeping in mind the regular day to day activities in the classroom, the educator and student profiles and effective pedagogies in mathematics.

Before implementing the Indigenous knowledge focused and decolonized activities.

Before the implementation of the Mapping and Transportation lesson (see Appendix D) in the LD classroom, I interviewed Harry about his experiences in mathematics, his favourite activities and what he liked or did not like about his current and past mathematics classes. I also took classroom observations of the students and made notes on their level of engagement, whether or not they seemed excited to do the work assigned by the teacher and what attitudes they displayed towards mathematics. I also interviewed both educators (Mr. M and Tom) regarding the students' attitude, engagement and excitement on a regular basis in the classroom.

Upon initial observation, it seemed that a small portion of the class (notably, those who sat at the front with Harry) seemed to be fairly engaged for the entire duration of the mathematics class. They would sometimes fall off task and discuss things other than mathematics, but nothing I would consider to be irregular among teenagers. The other portion of the class, about half, seemed to either be on their phones, had headphones in or were drawing almost the entire period. Most of the students who were completely disengaged sat at the back of the classroom. In this specific class, I also observed one student who always sat alone at the back of the classroom, but on the opposite side of the room from where the other students at the back sat. I took observations from the desk right next to this student on many observation days. This student was constantly on their phone. I did not observe a single day where this particular student

was not on their phone for any longer than about 2 minutes at a time. Tom also mentioned this student in his interview, and identified cell phones as a major distractor for students in this class. The volume of phone usage of this particular student struck me as very odd as it was almost never addressed by Mr. M. This particular student often told me that the work provided was easy, so he felt like he did not need to do it. I saw evidence of this whenever I sat to work with him one on one as he breezed through the material fairly quickly and returned to his cell phone. This student was identified in casual conversation with the educators as being lazy and uninterested in school in general.

It could be possible that this situation is similar to what Boaler et al. (2000) observed in their study on streaming, where 27% of the students in the low track reported that the work they were given was too easy. Getting him to complete a worksheet for marks was rare. I find it interesting that Mr. M did not try and find out what made the cell phone so attractive to this student. After talking to the student for a very brief moment in time, it became increasingly clear that he enjoyed video games. There are so many mathematical concepts in video games, which is a concept that could have been used in a lesson that would have gotten this students' attention, and likely many others. Harry indicated to me during a conversation in class that he enjoyed playing video games, so there may have been other students who would have enjoyed a similar activity. Overall, this student was unengaged, unimpressed with the course material and had an apathetic attitude towards school in general. This was not an atypical behaviour in this class, although this students' behaviour was a bit more extreme than the others. This was a student who was present in one of our previous observation classes, but the cell phone usage was not as extreme at that point in time. This was also a student that I had a fairly strong bond with and encouraged to try some hands-on activities in mathematics. Despite a strong bond, I

unfortunately did not receive signed permission forms even though the student indicated on numerous occasions that they wanted to participate in the study.

The second student I will describe was able to return a signed permission form, but unfortunately was never present after that point in time. This meant that I could not interview the student, nor was the student present for the lesson that I facilitated. However, I have general observations about this student. Dean was a fairly quiet student and was another student that I had originally met in a previous class our research group observed. Before Dean stopped attending the course, his attendance was very poor. I would maybe see him once a week when observing the class almost daily. Mr. M told me in conversation that he had only met him a couple of times when we were about three weeks into the term. Whenever Dean was present in the classroom, he would attempt whatever was presented to him. Although he was not an active participant in any of Mr. M's lessons, he would listen almost the entire time. Dean also seemed to have very low skill levels in mathematics in general. Working with him one on one during every class he was present, it was clear that there were large gaps in his education. Dean often needed one on one assistance before he would try something on his own as his self confidence was quite low. Unlike the student described in the previous paragraph, Dean would attempt almost anything Mr. M put in front of him, once he got assistance. He had a positive attitude in class, and had a strong work ethic. Although he did not appear to be excited to try what Mr. M would assign, he would always try. Dean is one of those students that hurts my heart as an educator. Dean and I had built a strong connection, and we would often chat about his favourite hockey team, the Montreal Canadiens. During my observation period in the class, the Stanley Cup playoffs were happening and you would often find Tom and myself chatting with him about how his team was performing. He enjoyed chatting with us about hockey and let me know that

he also played in his spare time. Dean was a student who I believe would have benefited greatly from a more hands-on, applicable approach to learning, especially in mathematics. He did not thrive in a rules-based, memorization environment, especially with his frequent absences. Although he was not present for the first day of the two-day mapping and transportation lesson I facilitated, he was present on the second day and was able to catch up to the rest of the class without any issues. Unfortunately, Dean was not able to experience the initial video that I played to start off the lesson, however, I chatted with him about the premise behind the lesson on day two, when the rest of the class was finishing up. He designed his canoe and had what appeared to be a good time pushing it through the water to the other side of the "river". I had planned on interviewing Dean the day following the lesson, however, he never showed up to class again after that point in time. When I asked Mr. M about this, he said that he was not aware of anything external to the school that would prevent him from attending class. It is my understanding that he did not receive the credit for this course.

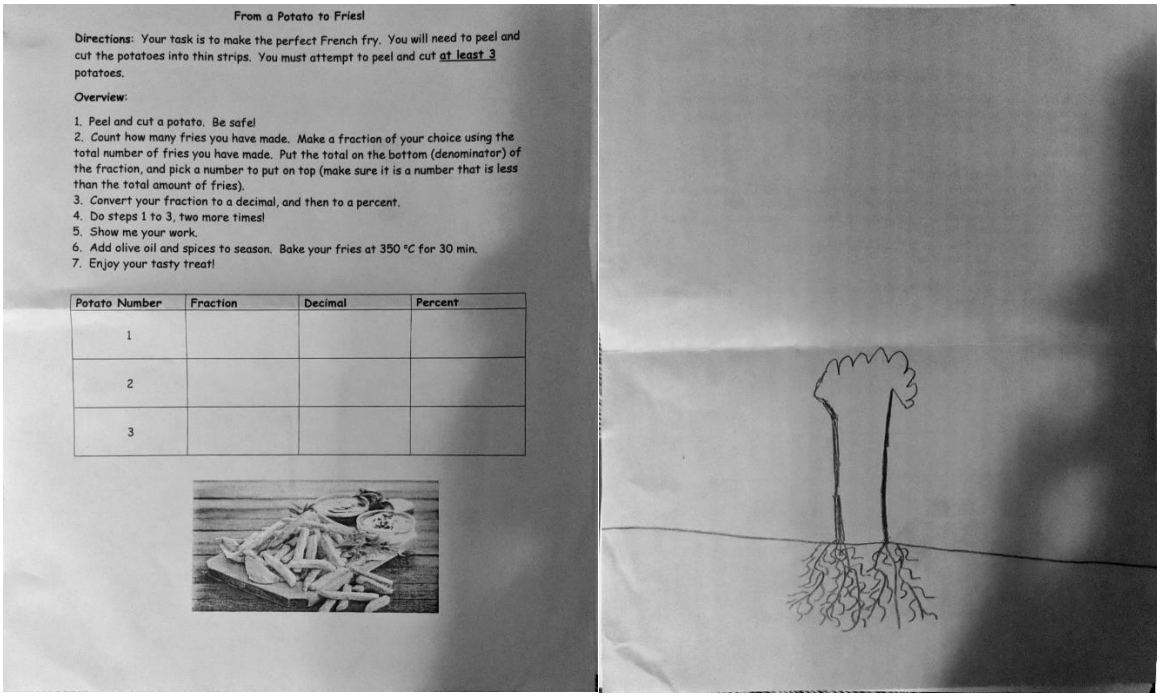
Harry, the student who I interviewed, is the next student that I will describe. My classroom observations of Harry suggest a student that is very energetic, creative, generally engaged in the classroom environment, but who is also off task and who loves to challenge Mr. M in any way that he can. Harry is a very loud and boisterous student. He makes his presence known and you can tell when he is absent. During Mr. M's typical lessons, Harry would answer his questions as they related to the lessons, only if he thought he was getting a "more correct" or better answer than Mr. M or had something more to add to the question. Harry would not ever just provide the answer to one of Mr. M's questions without adding something extra. When Harry did not have something extra to add, he would be generally trying to engage in conversation with his friends at the front of the room during the lesson. The topic of conversation

would be typically unrelated to mathematics. It was not easy to tell whether or not Harry enjoyed coming to mathematics class based on my observations alone. He seemed to enjoy being in the classroom and chatting with his friends, but I was unsure whether or not he actually enjoyed mathematics. When I chatted with Harry in the pre-lesson interview, it became clear that he did not enjoy the mathematics that they did on a regular basis, and particularly did not enjoy worksheets. Harry said on multiple occasions that he enjoyed learning through hands-on activities and felt that he learnt best that way. As Harry had so much energy, I would also think that sitting in a desk for up to a fifty-minute long lesson would be hard for him. Despite being somewhat engaged in the content, he did not enjoy it and had an attitude of opposition towards Mr. M. He almost wanted to prove Mr. M wrong very frequently or show that there was an alternate way to arrive at solutions, which is interesting. This culture of opposition was also found in Hand's (2010) study and is discussed further in Chapter Two. I had not anticipated seeing this in the classroom, as it is not something we have seen in the other LD classes through our research with the MKN, but it was definitely present in this case. Similar to the case in the literature, the teacher reverted back to more traditional teaching styles and the researcher noted that it created a culture of opposition in the classroom (Hand, 2010; Kajander et al., 2008). Although Harry is only one student who was opposing the teacher, parallels can definitely be made between Hand's (2010) and Kajander et al.'s (2008) studies and the observed LD class.

Overall, the majority of the class was consistently and chronically disengaged. On any given day, I observed 2-4 students actively engaged at various points in the lesson. Of the remaining 5-6 students typically attending, none were focused on the lesson, nor did Mr. M make efforts to engage them. He focused his attention on those who were engaged. After the lesson, I would walk around and help students one on one with the worksheets that Mr. M would hand

out. I would often attempt to work with the students who were so disengaged in the lesson, but it was not very often that they accepted my help. Through working with them, I found that their self esteem and self confidence in their mathematical abilities were so low that it was impacting their abilities to attempt mathematics problems. This is not something that I found uncommon, but something that I expected to work through with many of these students based on my previous experiences in LD classrooms. The attitude shown towards mathematics by the majority was more negative than positive, as many voiced that they could not do the work, or that they were not smart enough, or did not know how. One might describe this attitude as guarded or untrusting. In general, students were not excited about any of the worksheets presented by Mr. M on a regular basis.

On a weekly basis, when cooking classes were taking place, students seemed to be generally more excited to cook whatever item that was planned. However, I think the excitement may have stemmed from students having access to a snack and getting up out of their chairs. Students did not appear excited to complete the worksheets that went along with the cooking classes, as can be seen in Figure 4.



From a Potato to Fries!

Directions: Your task is to make the perfect French fry. You will need to peel and cut the potatoes into thin strips. You must attempt to peel and cut at least 3 potatoes.

Overview:

1. Peel and cut a potato. Be safe!
2. Count how many fries you have made. Make a fraction of your choice using the total number of fries you have made. Put the total on the bottom (denominator) of the fraction, and pick a number to put on top (make sure it is a number that is less than the total amount of fries).
3. Convert your fraction to a decimal, and then to a percent.
4. Do steps 1 to 3, two more times!
5. Show me your work.
6. Add olive oil and spices to season. Bake your fries at 350 °C for 30 min.
7. Enjoy your tasty treat!

Potato Number	Fraction	Decimal	Percent
1			
2			
3			

Figure 4. The front and back sides of a students' completed worksheet on a cooking day.

The worksheet shown in Figure 4 is a typical representation of the majority of the students in the class. A couple of students completed a few cells in the table; however, the majority did not attempt to fill in anything on the table. It is clear from the worksheet that engagement in the work to be handed in was low, but in general, engagement in making the fries was high. As previously mentioned, there were a few students who did not want to participate due to anxiety about others in the classroom, but those who were in the room were engaged in the cooking. In terms of attitude, students generally had a positive, enthusiastic attitude on cooking days.

Overall, before the facilitation of the IK-highlighted, decolonized lesson, I would describe the majority of the class's attitude towards mathematics on a daily basis as apathetic, skeptical and pessimistic. Although some students exhibited engagement in the daily activities, the greater majority of the class was consistently disengaged, which was exhibited through their cell phone use, lack of participation in classroom activities and noncompletion of worksheets that

were handed out. With regard to excitement, the class was hardly ever excited to do mathematics unless it involved cooking or a hands on aspect.

After implementing the Indigenous knowledge highlighted lesson.

After the implementation of the two-day Mapping and Transportation lesson (see Appendix D) in the LD classroom, I interviewed Harry about his thoughts on the lesson, whether he would like to see more lessons like it and whether or not he thought the class enjoyed the lesson. I also took classroom observations of the students throughout the lesson and made notes on their level of engagement, whether or not they seemed excited to assemble and design the canoe or place it in the river to travel, and what kind of attitude they displayed towards the lesson. I also interviewed both educators (Mr. M and Tom) regarding the students' attitude, engagement and excitement during the lesson.

The first portion of my lesson, also known as the "Hook" or "Minds On" portion focused on showing students a local video on building a birch bark canoe. This video showed one facilitator and some teenagers from Fort William First Nation planning, constructing and finally using the canoe. It also discussed the meaning behind the canoe, the loss of culture and knowledge around canoe making in Thunder Bay and the emotional connection between the facilitator and the canoe. This video was just over five minutes in length and what I observed while the video was played was the total opposite of typical class behaviour (Mr. M, personal communication, June 13, 2019) because there were no students on their phones for the duration of the entire video, all students were facing the board and looking at the screen, no one was talking out loud about something unrelated, and, I did not have to ask for everyone's attention or use classroom management skills to keep students on task. Mr. M added in his interview that this observation I made was atypical behaviour of the class (Mr. M, personal communication, June

13, 2019). This was an observation that I also had not seen in this class before during my regular visits. Although there are many factors to keep in mind, such as that I am not the regular educator in this room, the style of the lesson was very different than the standard, and that I had built rapport with a large number of the students in the class, I believe that the content of this video was what was keeping students engaged. The students at the back of the room that were chronically engaged were listening with interest. Mr. M and Tom also noted in their interviews that engagement on the first day of the lesson was quite high (Mr. M, personal communication, June 13, 2019; Tom, personal communication, May 2, 2019). After the video had finished, I asked the students some questions, like "Do you recognize any landmarks?", "What are they making in the video?", etc. Throughout this questioning period, I observed many students with their hands up, both at the front and the back of the room. I observed one student that I did not have a strong bond with – in fact, I experienced a negative interaction with this student earlier on in the term – who was the first person with their hand up each time a question was posed. Up until this point in time, I had not ever observed his hand being raised for anything other than asking to use the restroom or grab a drink. From my perspective, the student seemed very interested in the topic of the video – traditional birch bark canoe making. After the video and questions, I showed the students a sample paper canoe, and explained the activity at hand, which formed the "Action" portion of the lesson.

Students assembled and designed their own canoes to get them ready to travel across the Kaministiquia river (i.e. a bucket of water). Something Tom noted in his interview is that *every single student* in the class assembled the canoe and put it to the test on the "river". This was not behaviour that I typically observed in the classroom prior to this lesson. No matter the lesson Mr. M had prepared, he had yet to achieve 100% engagement or "buy in" as he referred to it in our

interview (Mr. M, personal communication, June 13, 2019). Tom also noted that he still saw canoes floating around the classroom at the end of the term, which I thought demonstrated the level of engagement students displayed in this activity quite well (Tom, personal communication, May 2, 2019). One by one, students came up to the front with their assembled canoes and pushed them across the river to see what happened. There were two settings on the fan – low and high, so they would run at least two attempts to see how far the canoe travelled each time. The students recorded how wide the "river" was, how far their canoe actually travelled across the river (diagonally) and also how far they travelled downstream. The students all pushed off their canoes themselves and had lots of fun playing with the canoes in the water. The student I mentioned that raised his hand first to answer every single question during the video was also the first person who assembled their canoe and came up to try pushing it down the river. He ended up being the first person to complete the activity and helped his friends assemble their canoes.

At this point, I would like to emphasize the fact that *at-risk youth in LD mathematics* got up out of their chairs and formed a *line* to push a paper boat across a container of water (Tom, personal communication, May 2, 2019). This is something that I noted while facilitating the lesson, and this is also something that Tom noted in our interview (Tom, personal communication, May 2, 2019). Students formed a *line* to *wait* to do a *mathematics activity*. These were students who I had not observed even attempting an activity or worksheet when it was placed in front of them alongside a completed note that had the answers written in bold! Frankly, I was really impressed. I remember the emotions I felt throughout the facilitation of this lesson and becoming so excited and optimistic in observing Indigenous students taking initiative, wanting to engage in a mathematics activity and investing their energy and efforts in their canoes.

The measurement of the canoes in the river continued into the second day of the lesson. Due to the short class timelines to facilitate this lesson, the second day of the lesson overlapped with a day in the foods room. We had students in the class who had not put their canoes to the test the prior day so they stayed behind in the classroom with me while the rest of the class headed to the foods room to make pizza bagels. The rest of the class was to return in time to consolidate the lesson.

The consolidation phase of the lesson was a bit overshadowed by the cooking of the pizza bagels, but it focused on myself posing questions like “What did the fans represent?”, “Why is the distance that the canoe travelled longer than the width of the river?” and “How would you make adjustments for this when travelling today?”. Throughout the consolidation phase, students were working on the second page of the student handout that asked them to apply their findings and communicate them. I observed students coming up to ask questions about the worksheet, which again was not a typical action that I observed for students in this class. On a typical day, if students did not understand a question on a worksheet, I would observe them generally not attempting it and pulling out their phones until an educator or myself came by to assist them. I had never observed any initiative taken by students to work through a question on their own.

When I interviewed Harry about this lesson, he indicated that he enjoyed it (Harry, personal communication, March 6, 2019). He particularly liked the water aspect of it and said that it reminded him of the video game Minecraft (Harry, personal communication, March 6, 2019). He mentioned that he enjoyed building things in class and that this was not something they normally do (Harry, personal communication, March 6, 2019). When I asked him if he thought the lesson involved mathematics, he was able to identify measuring and the use of shapes as part of the mathematical aspects in the activity. Harry thought that the lesson I

facilitated was definitely different than their regular day to day activities and that he would like to see more lessons like it. He also said that he would be more motivated to come to class if they regularly did more activities similar to the lesson I facilitated. This is powerful to me as attendance can be quite a substantial barrier to education for some of the students in the LD level, and other students may feel the same as Harry.

Based on the observations I noted throughout the lesson facilitation, and interview responses from Tom, Mr. M and Harry, it is clear that there was a substantial, marked positive change in students' attitudes towards mathematics and towards participating in this part of the class. Student attitudes changed during the lesson from ones of indifference and skepticism to ones of curiosity and lightheartedness. I was anticipating a shift in attitudes based on the literature, but I did not believe that a change could be so immediate. The video that I played at the beginning of the lesson served as a true "hook" and set the tone for the rest of the lesson to follow. Although this is just one lesson, it is clear that there was a significant change, although a future study could research whether or not this change is sustained in future lessons, and what style of learning best sustains the shift in attitude.

In the interview that I had with Mr. M, he noted an increase in engagement during this lesson as compared to day to day activities in his classroom (Mr. M, personal communication, June 13, 2019). Mr. M thought that this increase in engagement could be due to a change in the format of the lesson, from the typical worksheets to a more hands-on activity and he thought that the cultural topic of Indigenous birch bark canoes might have touched home with some students in the classroom (Mr. M, personal communication, June 13, 2019). Mr. M also thought that the lesson had multiple learning modalities that allowed different types of learners to engage with the activities, such as hands-on or kinesthetic engagement with building the canoes, multisensory

inputs or variables such as audio, visual, and sensory factors for the canoe races, etc. Both Mr. M and Tom noted that the students were very engaged in the lesson, and Harry himself identified that he was more engaged in the lesson along with his peers.

In regard to excitement of the students, I think the fact that they formed a line up at the front of the room to actually do the activity shows how excited they were to test their canoes. They were interested in seeing how far down the river the canoe would end up and how fast it might travel. Working one on one with students at the front of the room with the river setup also allowed me to take students' learning a step further. For example, I asked Dean why side B (the width of the river) would not change each time. It took Dean quite a while, but eventually he realized that it was because the width of the container was not changing. Making connections like these allow students to conceptually understand and connect mathematics to real world applications. I think my own personal excitement as a teacher helped to inspire authentic excitement in the students. They could tell that I was genuinely excited to be doing this activity with them and boosted their own engagement. Mr. M is usually a low energy person, so his teaching energy could set the mood for student participation in his lessons.

Overall, both Mr. M and Tom considered the lesson as a success. I asked both what they would change in the lesson the next time around and Mr. M could not come up with anything he would change. He even indicated that he would be interested in trying the lesson out in a future LD mathematics class. After the interview, in a casual conversation, Mr. M also noted that he played the video from my lesson for one of his science classes this term. The only suggestion I received from Tom was regarding scaling it up to a larger sized bucket with a bigger fan and bigger canoes. This is an idea that could be considered in the future. Mr. M did not think that

scaling it up would be a good idea for the teacher as the water is very heavy, but if the correct facilities were in place, it could be something to consider.

Culturally Responsive Connections in Mathematics Education

In this section, the theme of how Indigenous culture, traditions and practices relevant to Northwestern Ontario connect to student attitudes, engagement and enjoyment in grade nine LD mathematics is explored. As mentioned in the previous section, students' engagement and enjoyment of the IK-highlighted lesson was increased in comparison to regular day to day activities. Both Indigenous and non-Indigenous students exhibited positive, excited attitudes towards mathematics during the lesson compared to their regular disinterested or disengaged attitudes that were dominant in the class during the employment of traditional mathematics pedagogies.

Through Harry's post-lesson interview, I asked him what he thought about Indigenous content being present in his mathematics class (in comparison to other classes), he indicated that the cultural content "didn't really matter to him" and that it impacted his learning in neither a positive nor a negative way. However, he mentioned that this cultural connection could be good for "other people" (Harry, personal communication, March 6, 2019). This neutral response was not necessarily surprising as Harry had previously identified as White. The literature indicates that all students, not just Indigenous students, benefit from Indigenous cultures, traditions and practices in their classrooms, so it is still possible that Harry benefited from the lesson due to the connection to culture. Interestingly, Harry also indicated that he doesn't see culture in math, he just sees "math" (Harry, personal communication, March 6, 2019). This shows the disconnect between cultures and their involvement in the mathematics curriculum. When I asked Harry if he thought his classmates enjoyed the lesson and if so, how he could tell, he said that he thought

they enjoyed the lesson as they were participating in it. He also said that he found himself to be more interested in the lesson because it was fun. Mr. M also mentioned in his interview that non-Indigenous students learning about other cultures is never a bad thing. This comment is interesting as it almost has the more nonchalant idea that new pedagogies 'cannot hurt' the students, rather than the idea that it is critical to educate all students on Canada's colonial history in order to re(right) some of the social injustices of the past.

Worldviews and connections to mathematics pedagogies.

In addition to mathematics researchers praising reformed mathematics pedagogies, research has also been published regarding best practices in the incorporation of Indigenous knowledges and decolonization in the STEM (Science, Technology, Engineering and Mathematics) areas (Aikenhead, 2017; Belczewski, 2009; Sterenberg, 2013; Sterenberg & Hogue, 2011; Sutherland & Swayze, 2012). As can be seen in Chapter two of this thesis, a more reformed mathematics approach aligns greatly with Indigenous worldviews, whereas the traditional mathematics pedagogies alight more with a Western worldview. Considering the profiles of the students in the LD class, as well as the typical student profile seen in Northwestern Ontario where students are coming from small, rural, reserve communities to pursue high school education, taking a more reform-based approach to teaching mathematics is critical to students' success in mathematics. As seen previously, not achieving a grade nine mathematics credit is one of the biggest predictors for a students' success in graduating high school with their OSSD.

Students who come from northern communities to pursue high school education face many external changes that impact their education. One could be living in a boarding home to attend high school. I have heard stories from teachers who mentioned that some students from

boarding homes were frequently hungry, and they learned this was due to boarding homes locking the fridge at night. Some individuals want the subsidy they receive to house students coming from northern communities, but some do not care about the welfare of the children. There are also students who come from dry communities that do not have access to alcohol or drugs, to Thunder Bay, which is a community that has access to these items. There are some communities that do not have traffic lights, so even that is a shift for these students, regardless of their school. While these external factors are not directly related to education, they have an impact on students' abilities to participate, enjoy and attend classes. Having access to something familiar – whether that be a cultural room at school or a teacher who decolonizes themselves before teaching, or lessons with relevant cultural content can be life changing for a student. Also, having a teacher who is invested in reconciliation and who respects Indigenous culture can make a large difference in a students' life (Government of Canada; Indigenous and Northern Affairs Canada, 2017; Truth and Reconciliation Commission of Canada, 2015).

Regardless of the situation of the student, this research appears to support the literature that non-Indigenous students also benefit from Indigenous ways of learning and learning about cultural practices (Aikenhead, 2017; Borden, 2013).

Supporting Locally Developed Classrooms

This theme came about through conversations with Mr. M as well as observations I had noted in his class. As mentioned previously, Mr. M has experienced a significant amount of instability within the board he is employed with and he appears to suffer from teacher burnout. Mr. M indicated in an interview that he enjoys teaching LD classes, but also commented on the lack of quality resources for educators.

After observing the classroom, it also appears that there is more support needed for students in LD who may have external factors impacting their education, like food security, lack of access to adequate housing, substance abuse, domestic abuse and other contributing factors.

Educator support.

As Mr. M mentioned, there are very few resources for teachers of LD classes. Part of this stems from the fact that LD is meant to be locally developed to fit the needs of the students in the course. This makes it hard to create resources that are generalizable from school to school and even city to city within Ontario. Another reason why resources for teachers may be few and far between is due to reduced funding in LD classrooms. EQAO states that results of the test may direct research, meaning funding being allocated to certain levels of classes. As LD students do not write EQAO tests as they have no standardized curriculum, they will not be on the receiving end of the results directed funds. While it is not necessarily a bad thing overall that LD students are not participating in a standardized test, from a funds perspective it means that there will be disadvantages for this group of already disadvantaged students. Lack of research means lack of resources, including lessons, unit plans, strategies in connecting with the students, etc. This is why the Mathematics Knowledge Network project that we are a part of is critical in Ontario. We are working to develop a set of tasks, lesson plans and activities that LD teachers could find and adapt to the students in their classrooms. Teachers of LD classes should also be able to engage in professional development in meeting the needs of the learners to ensure that they have the resources and knowledge to be able to best assist students in their courses. It would also be beneficial for educators to have time set aside to engage in conversations with other teachers of LD mathematics to collaborate on new ideas, or share ideas that worked well in their respective classes with one another.

In addition to curricular resources for teachers, it can be mentally and emotionally draining teaching and assisting students who come from often broken backgrounds (Kajander et al., 2008). As Mr. M may have already been suffering from teacher burnout, having access to a form of support for himself may have been beneficial in his case. Although many schoolboards offer confidential counselling programs, check ins should be made with teachers of LD students on a regular basis. It is difficult to teach a group of at-risk students with external baggage if you as the educator are not in the best space mentally or emotionally. This resource was not necessarily identified as lacking by Mr. M or Tom, however, after being in the classroom in an observer/researcher role, I found it mentally taxing trying to meet the needs of the students in the best way I could. As an educator, you tend to develop relationships with your students and care for them. Although this happens in all classes, additional and often surprising external factors make this instinct of care more mentally taxing in some cases.

Student support.

As previously mentioned, students in LD often come from low socioeconomic status background, have been away from home, or have faced abuse whether than be physical, mental, sexual, or substance based. These students require quite a bit of support in order to allow them to consider academics. In the case of the research class, there were students in foster homes, who were pregnant, who encountered substance abuse issues or relationship issues, had a low socioeconomic status, lived below the poverty line and were of a marginalized or oppressed race. The intersectionality of these issues along with the educational issues like streaming, traditional lecture style learning and lack of cultural content can perpetuate gaps in education for generations to come (Crenshaw, 1989). This group of high-risk students appeared to benefit from having Tom in the classroom to support them academically, however, it appears they truly need

more than that. Some students do not have access to adequate food or clothing, so having snacks and drinks available for students should be a priority (Kajander, Flessa, Lampo, & Sedor, 2018). In addition, a clothing bin or assortment of donated clothing could be available in a safe space for students when or if they need it. School supplies are also few and far between so access to supplies should be considered as well. Often, educators provide food and supplies out of their own pocket, which becomes a burden that low-level substitute teachers have to take on or ignore which could lead to greater cynicism and burn-out.

Other supports.

Besides physical needs, there are emotional, spiritual and mental needs that students have that should be met. They should have access to a counsellor or social worker who makes the consistent and regular effort to reach out to all students enrolled in LD classes, in addition to other identified at-risk students in other levels. This social worker or counsellor should be knowledgeable and respectful of Indigenous traditions and practices in order to provide appropriate support to Indigenous students. It is interesting to note that Mr. M did not make any comments on needing more student support in LD mathematics, but instead, focused his comments on the large number of special or additional supports available in the school. Perhaps this is a result of my insider status as a teacher (refer to Data Collection in Chapter 3), and Mr. M's perception that I was criticizing the school as lacking in this area of student supports whereas my comments were directed at the province as a whole in lacking the will or means to support LD students. A reasonable effort should also be made to schedule videoconference or telephone meetings between students' parents who are not living in Thunder Bay and the student as well as the students' guidance counsellor or support person. This would provide an open line of communication between the student, parents and the board and would help the board

understand parents' needs and help parents understand how the student is doing. Ideally, students would be able to complete their OSSD in their home communities, however, for the time being a local needs-driven solution by high schools should be considered.

Chapter Five: Conclusion

Through this study, I have determined the impact that reform-based mathematics practices and the incorporation of culturally responsive or IK-highlighted pedagogies can have on a class of vulnerable, at-risk LD students. Through the initial phase of developing researcher-student relationships as well as the incorporation of hands-on learning opportunities consistent with reform-based approaches and including cultural knowledge connections to mathematics, it has become clear that student attitudes can shift positively to lead to greater engagement and higher-level thinking in mathematics. Students in the study who initially started off as disinterested and apathetic became more curious and invested in mathematics as they saw real-life or lived experience connections with the content of the math lesson.

The IK-highlighted lesson that I facilitated in the LD classroom appeared to have a significant impact on the students' levels of engagement in the mathematics. All students present for the canoe building lesson attempted the math content to some degree. All students constructed their canoes and tried to push them down the river, which is a great first step of engagement. This was a substantial learning shift from the day to day activities in the classroom that had a more traditional pedagogical approach. On most observation days, engagement in the activities and lesson for the day was between 2-4 students out of a total of 7-10 students in attendance. The increase in participation and engagement in this LD mathematics class was due to the reform-based mathematical approach to the lesson, the hands-on accessibility or experiential engagement of the lesson for low level learners, in combination with the IK focus

that was relevant to northern Ontario and respectful of the Indigenous students' heritage while honouring the vital contributions that Indigenous peoples have made to Canada such as the invention of the canoe.

It is important to note that the stance of decolonial teaching in combination with one IK-highlighted lesson that is hands-on and reform-based is not a "cure all" for the deep systemic injustices in education, specifically in LD classes and for Indigenous students. Although these strategies have led to a positive result in this study, there are still many more significant social, psychological, physical and cognitive needs that need to be addressed and much work remains to promote cultural safety and reconciliation through education for Indigenous students. Each class is unique and finding what works best for the students to increase engagement and joy in education as well as a sense of self-esteem, self-determination and resilience in school contexts for learning is the most critical. The results of this study can help guide teachers of LD mathematics in best pedagogical approaches in addition to advising the Ministry of Education on supports that would be beneficial in this level of secondary schooling. The needs of students may be met with the strategies outlined in this thesis, however, this form of teaching is just the start or tip of the iceberg in addressing student needs, social justices and greater equity in education.

Implications for LD Education

This study has many implications on future LD mathematics courses and how school boards and the Ministry of Education can best support the students and the teachers of these courses. The current LD "curriculum" can almost be described as a "skeleton" document in comparison to the very structured applied and academic curriculum expectations published by the OME. The LD "curriculum" discusses the use of hands on manipulatives and technology in the classroom in addition to a focus on "[Promoting] students' understanding of the role of

mathematics in daily life and its relation to career opportunities by exploring applications of concepts, providing opportunities for career-related project work, and promoting independent investigations" (LDCC Project, 2005, p. 11). The method of teaching that I observed in the research class did not appear to promote students' understanding of the role of mathematics in daily life on a regular basis. This disconnect between mathematics and real world uses of the skills they were learning in class took a toll on engagement and interest in the subject. Through incorporating an IK-highlighted lesson and hands-on activity with relevance to real world contexts, I was able to increase engagement and interest. This shift should be reflected in Ministry sanctioned resources developed for LD teachers. Teachers have access to "workbooks" for LD, which is similar to the workbooks used for credit recovery. These books often have no context in the questions and do not require a teacher to teach mathematical content; the information is provided to them in the booklet. These are often facilitated through self-directed learning, which is also mentioned in the LD "curriculum".

Instead of the Ontario College of Teachers and school boards sanctioning the use of these workbooks, this MEd study indicates how much more is needed. Resources that include reform-based teaching practices and the inclusion of IK-highlighted lessons, where mathematics is taught through Indigenous content and holistic practices would be more appropriate replacements to the current available workbooks. There is also no textbook currently sanctioned for this course, so the creation of a resource book for teachers with various reform-based and IK centred lessons and activities based on the results of this research could prove to be very useful to teachers (Mr. M, personal communication, June 13, 2019).

This research should also inform funding in the OME to allocate a certain amount to professional development for educators assigned to teach LD. The unique challenges of the

"curriculum" and the student population warrant conversations and collaboration between educators of these courses.

This study also aims to fill in some of the gaps in the literature on LD mathematics. Through research in this study, I have developed student profiles as well as educator profiles for this particular class. This study offers a view into one LD classroom where the pattern of instruction was shifted and improved to increase student attitudes and engagement towards mathematics through reform-based, IK highlighted pedagogies. It is my hope that others can find similarities between the findings of this project and make efforts to disrupt traditional, Eurocentric patterns of instruction in their classrooms.

Personal Reflection

Of course, at the heart of this research is the students and the call for social change. Students are the reason that I chose this study; in order to try and change the paradigm in LD mathematics and make education a better experience for our youth in Northwestern Ontario, particularly those who have external factors influencing their success in education. Inclusion of Indigenous practices, traditions, and IK content along with a demonstrable shift towards reform-based pedagogies were the inspiration behind the project. A passion for equity and justice in our education system through these ways of thinking and knowing were what drove this research. At the conclusion of the research, I discovered that students are more interested, invested and curious about mathematics through the Indigenous cultural content and placing value on the students' abilities and conceptual understandings of mathematics.

What I gained from the research was the observation of a much larger shift in the students' attitudes and perspectives towards mathematics than I anticipated, and yet also a feeling of helplessness. I was surprised to see just how engaged they were in a lesson that they

were intrigued by. This sense of curiosity is a very powerful one in mathematics and it gets students up out of their seats and more willing to learn. The feeling of helplessness stems from knowing that when I left the class, the promise of hands on, real life mathematics learning went with me. The students knew what the day to day work was like in their mathematics class, and they were not interested. They had more engaging activities on their phones or tablets and did not want to listen to a lecture and then complete a worksheet. I feel sad knowing that students are being underserved in an education system that is reluctant to change. We as educators can do better. We can bring excitement and culturally relevant education and visual applications of mathematics to the classroom. We can move away from lecture-based learning to hands on learning. School boards can do better. They can treat their staff with value and respect and work to improve stability and same school assignments. They can work to build a team of teachers who collaborate and share their successes and failures with one another, and they can provide resources and support to teachers of these courses. The Ministry of Education can do better in providing schools with sanctioned resources that reflect the diverse population of students in LD mathematics, and involve new, research-based methods of teaching like reform-based and IK-highlighted and decolonial pedagogies. If we can put students at the forefront of education and aim for the greatest outcomes, we will see changes in student success, literacy skills and mathematical literacy as re-righted education.

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Appendices

Appendix A: Student Interview Guide

Pre-Lesson Interview Questions

1. Do you use math outside of the classroom?
2. Is mathematics a part of your life? How? Why or why not?
3. Do you use math when doing cultural or land activities with your family or in your community (i.e. hunting, beading, sewing, painting, baking, travel times, buying items)?
4. Tell me about your life as it relates to education.
5. How do you feel about your mathematics class this year? What about previous years?
6. Have you enjoyed mathematics as a subject in previous grades or classes? Why or why not?
7. How do you self-identify?
8. Do you feel a connection between your cultural heritage and your experience in school? How?
9. Do you notice a connection between your cultural heritage and your everyday life? How?
10. What mathematics learning works best for you as a student?
11. Are the strategies you selected in the previous question used in your current mathematics classroom? How frequently?
12. What do you see Indigenous/culture content in the activities of your mathematics classroom? What about in your other classes?

13. What do you think would help you to become more interested in learning mathematics or more math efficient or numerate in your life?
14. What would you think of activities with Indigenous content in your mathematics lessons?
15. What do you think would make math more interesting, engaging or fun for your learning style or your life?
16. Do you have anything else you would like to share?

Post-Lesson Interview Questions

1. What types of activities are your favourite in your mathematics class?
2. What did you think of the lesson that we just did?
3. What did you learn or how did you do mathematics differently than other activities?
4. Was the lesson similar or different to your regular activities in math class?
5. Would you enjoy more activities similar to what we did today?
6. Would you attend class more often (or would it be more motivating to come to class) if there were more activities like what we did today or with some type of Indigenous content?
7. Do you have any suggestions of what Indigenous content you would like to study in mathematics class? Or how you would like to learn mathematics?
8. Do you think the class generally enjoyed the lesson (based on observation)?
9. Did you notice any students participating that usually don't participate?
10. Did you find yourself to be more interested in the lesson than usual? Why or why not?

Appendix B: Teacher Interview Guide (Post-Lesson)

1. Tell me a bit about your background. What experience do you have in mathematics education (i.e. professional development, courses, high school math, post-secondary math, etc.)?
2. How long have you been working as a full time teacher? Do you have a typical timetable year to year? How many times have you taught the 9 or 10 LD mathematics?
3. Tell me about your experiences working with Locally Developed students. What kinds of things have you encountered? What are the students typically like? What are some common problems you encounter? Etc.
4. Do you find that students in LD math have a positive attitude towards mathematics? Why or why not? How can you tell?
5. Do you ever attempt to change students' attitude towards mathematics? If so, how do you go about doing that?
6. Do you notice a difference in students' attitudes towards mathematics depending on the type of learning that is being facilitated (i.e. more positive or excited to do math when outdoors, etc.)?
7. What kinds of roles do you take on in the classroom (i.e. facilitator, social worker, parent, etc.)? How do you go about supporting these students?
8. How do these classes compare to the applied and academic streams?
9. In your opinion, is this Locally Developed math class a typical Locally Developed classroom? How or how not?
10. Can you please describe a typical day in the mathematics classroom for these students?
11. On a regular basis, how engaged are the students in the content being taught?

12. What kinds of teaching methods do you use regularly in the classroom (i.e hands on learning, self-directed learning, lecture style teaching, worksheets, etc.)?
13. What kinds of activities are the students doing when they seem the most engaged?
14. The focus of my research is based on the incorporation of Indigenous content and knowledge into the Locally Developed mathematics classroom. Research has shown that Indigenous students tend to be disproportionately present in lower level classrooms (like Applied and Locally Developed) relative to their Academic counterparts. Do you find this to be true in the Locally Developed courses you have taught?

Questions Specific to Mapping and Transportation Lesson

1. Overall, how did you think the students responded to the Birch Bark Canoe lesson? Is this typical behaviour for the students in this course? Did you notice any excitement among the students to do the lesson?
2. During the video that was played at the beginning of the lesson, did you observe a difference in engagement or attitude towards math (as compared to regular day to day activities in the classroom)?
3. Do you believe the students enjoyed the lesson? Why or why not? How could you tell?
4. This lesson was focused on Indigenous content. Did you notice any changes in the behaviour, attitude or engagement of Indigenous students in the class (in comparison to their day to day behaviour and engagement)? How about non-Indigenous students?
5. Would you consider the activity a success? Why or why not?
6. From your perspective as a teacher, what could be improved in this lesson to make it better for next time?

7. Do you think the incorporation of cultural content is important in Locally Developed classrooms? How about Locally Developed mathematics classrooms? How or how not and why or why not?
8. How do you think teachers can be better supported to deliver lessons with Indigenous knowledge and worldview in mathematics?
9. How do you believe teachers can support students better in the Grade 9 Locally Developed mathematics classroom?
10. Is there anything else you would like to add?

Appendix C: Student Support Personnel Interview Guide

1. Tell me a bit about your background. Do you have experience in mathematics education (i.e. professional development, courses, high school math, post-secondary math, etc.)?
2. How long have you been working in this role?
3. Tell us about your experiences working with Locally Developed students. What kinds of things have you encountered? What are the students typically like? What are some common problems you encounter? Etc.
4. What us your role in the classroom? How do you go about supporting these students?
5. How do these classes compare to the applied and academic streams?
6. In your opinion, is this Locally Developed math class a typical Locally Developed classroom? How or how not?
7. Can you please describe a typical day in the mathematics classroom for these students?
8. On a regular basis, how engaged are the students in the content being taught?
9. What kinds of teaching methods have you observed being used regularly in the classroom (i.e hands on learning, self-directed learning, lecture style teaching, worksheets, etc.)?
10. What kinds of activities are the students doing when they seem the most engaged?
11. The focus of my research is based on the incorporation of Indigenous content and knowledge into the Locally Developed mathematics classroom. Research has shown that Indigenous students tend to be disproportionately present in lower level classrooms (like Applied and Locally Developed) relative to their Academic counterparts. Do you find this to be true in the Locally Developed courses you have supported?

Questions Specific to Mapping and Transportation Lesson

1. Overall, how did you think the students responded to the Birch Bark Canoe lesson? Is this typical behaviour for the students in this course?
2. During the video that was played at the beginning of the lesson, did you observe a difference in engagement (as compared to regular day to day activities in the classroom)?
3. Do you believe the students enjoyed the lesson? Why or why not?
4. This lesson was focused on Indigenous content. Did you notice any changes in the behaviour or engagement of Indigenous students in the class (in comparison to their day to day behaviour and engagement)? How about non-Indigenous students?
5. Would you consider the activity a success? Why or why not?
6. From your perspective as an SSP, what could be improved in this lesson to make it better for next time?
7. Do you think the incorporation of cultural content is important in Locally Developed classrooms? How about Locally Developed mathematics classrooms? How or how not and why or why not?
8. How do you believe teachers can support students better in the Grade 9 Locally Developed mathematics classroom?
9. Is there anything else you would like to add?

Appendix D: Mapping and Transportation Lesson

This lesson is on mapping and transportation in Mathematics. This lesson was developed by the First Nations Education Steering Committee (FNESC) and was developed with a grade 8 audience in mind, however, it would fit the scope of the LD level mathematics as they can be up to four grade levels behind (First Nations Education Steering Committee, 2011; LDCC Project, 2005). I made edits to the original lesson to make it more relevant to a Northwestern Ontario audience on the traditional territory of the Anishinabek and Métis. I selected this lesson as a cross curricular hands on approach fits the definition of decolonized content. It also incorporates Indigenous content through the history of transportation in Anishinabek culture, which effectively embeds Indigenous knowledge into the lesson. Modern forms of transportation will also be discussed throughout the lesson.

It is also very functional as the measurement is an integral piece of mathematics and can be difficult for students to grasp, especially in the LD level. We have seen throughout our work through the Mathematics Knowledge Network thus far that students have difficult grasping different forms of measurement, like the example that adding two half cups of sometimes equates to a fill cup. Using real life scenarios with Indigenous content to model measurement makes it more relevant to students, and makes this concept seem more applicable in daily life.

Title: Mapping & Transportation Subject: Mathematics (Grade 9)
Time: 2 x 75 minutes Strand: Developing and Consolidating Concepts in Measurement

Desired Results

Lesson Description
This lesson is focused on practical applications of measurement. Students will first learn about the traditional practices of the Indigenous peoples in the traditional territory of the Fort William First Nation regarding travel. Students will then complete an activity determining canoe travel across the Kaministiquia River, and they will use appropriate measuring tools and units to measure how far the canoe travelled (the hypotenuse of a triangle). In the consolidation phase, the length of the hypotenuse will be compared to the anticipated horizontal distance and different impacts on the canoe's travel will be discussed (for example, current or wind), and current practices of travel will also be explored.

Ontario Curricular Overall Expectations

- DCMV.01 – estimate, and measure length, capacity, and mass, in order to consolidate understanding of the metric system.
- DCMV.04 - communicate

Ontario Curricular Specific Expectations

- DCM1.01 – investigate, discuss, and describe applications from everyday life and the workplace that would involve the measurement of length in commonly used metric units.
- DCM1.06 – demonstrate accuracy in measuring length, capacity and mass in everyday applications, using teacher-selected tools, and record the measurements using the correct abbreviations for metric units.
- DCM1.08 – estimate and use the measurements of length, capacity, and mass in everyday applications
- DCM4.01 – organize measurement information, using a simple framework, draw conclusions from this data, and make decisions based on it
- DCM4.02 – verbalize their observations and reflections regarding measurements and ask questions to clarify their understanding
- DCM4.04 – communicate, orally and in writing, the solutions to measurement problems and the results of investigation, using appropriate terminology, symbols and form.

Lesson Goals (clearly identify what students are expected to know and be able to do, as if asked the purpose by a principal)
I can...

- Measure the distance a canoe travels using appropriate tools and units
- Describe some of the historic ways that the Indigenous peoples in this traditional territory travelled
- Make connections between what factors impact the travel across a waterway

Success Criteria (teachers will identify the criteria they will use to assess student's learning, as well as what evidence of learning students will provide to demonstrate their knowledge and skills; in student language)

- Creating a labelled, complete diagram of the canoe's travel
- Demonstrating how to measure the canoe's travelled distance
- Completing the worksheet in full detail and in full sentences

Assessment

Assessment Mode: **oral**/ **performance**/ **written**
Assessment Strategy: formative, listening to students talking in groups, observing, looking at written work
Assessment Tool: completed worksheet, talk among groups

Materials

- Poster board
- Pencils
- Pens
- Large plastic bin
- Water
- Rulers
- Fan
- Erasable marker
- Canoe pattern
- Handout for students
- Glue or tape

Prior to the lesson, the teacher should set up a bin of water with a fan at an appropriate distance away

Lesson Format: What Teachers Do/Say

Motivational Hook/engagement /introduction (Minds On)

- Explain that each community has its special stories of travel and that the next two days would be focused on travel and how it relates to mathematics
- Show FWFN Canoe video: http://bit.ly/FWFNCanoe
- Ask students (historically) how people would travel in our area (either by land or water) and via what method? (canoe, walking, etc.)
- Ask students (historically) why people travelled (hunting, collecting food, visiting family, feasts, celebrations, warfare, sports, etc.)
- Bring forward the idea of water travel and how rivers flow with a current
- Ask students to brainstorm what would happen to the canoe when travelling from one side of the river to another and how we could find out how far the canoe travels

During /working on it/action (Hands On) What the students are doing

- Introduce the Canoe Model Activity
- Have students demonstrate the effect of current on a model canoe as it travels across a model of the Kaministiquia river.
- Student will construct their own canoes from poster board and tape and have them "travel" across the river.

Steps for students:

1. Cut out the canoe figure.
2. Assemble the cardstock canoe.
3. Measure the length and width of the container filled with water and record it on the diagram on their worksheet.
4. Without the fan running, determine how much of a push will make the canoe drift to the other side.
5. Run the fan and give the canoe a steady push across the river (container)
6. Mark with erasable marker where the canoe gets to the other shore and measure the distance along the container from the starting end to where the canoe touched the other shore (side A).
7. Measure the distance across the river, the width of the container (side B)

- Ask students how they could find how far the canoe actually travelled?

8. Have the students measure Side C (the hypotenuse)

After: Consolidation: Reflect and Connect

1. Discuss how this is applicable in the real world when travelling across a river in a boat when a strong current is present
2. Discuss students' findings and what they mean in terms of a real canoe or real boat
3. Discuss implications of different factors for travelers when crossing waterways
4. Discuss the relationship between the hypotenuse and the other sides of the triangle they created.
5. Discuss various scenarios where they want to end up at a specific point on the opposite river bank and how they should approach their travel.
6. Connect back to the Indigenous peoples in this area – why might they have been crossing the river? Why might we cross a river today?
7. Throughout the discussion have students completing the worksheet based on these questions

Extension Activities/Next Steps

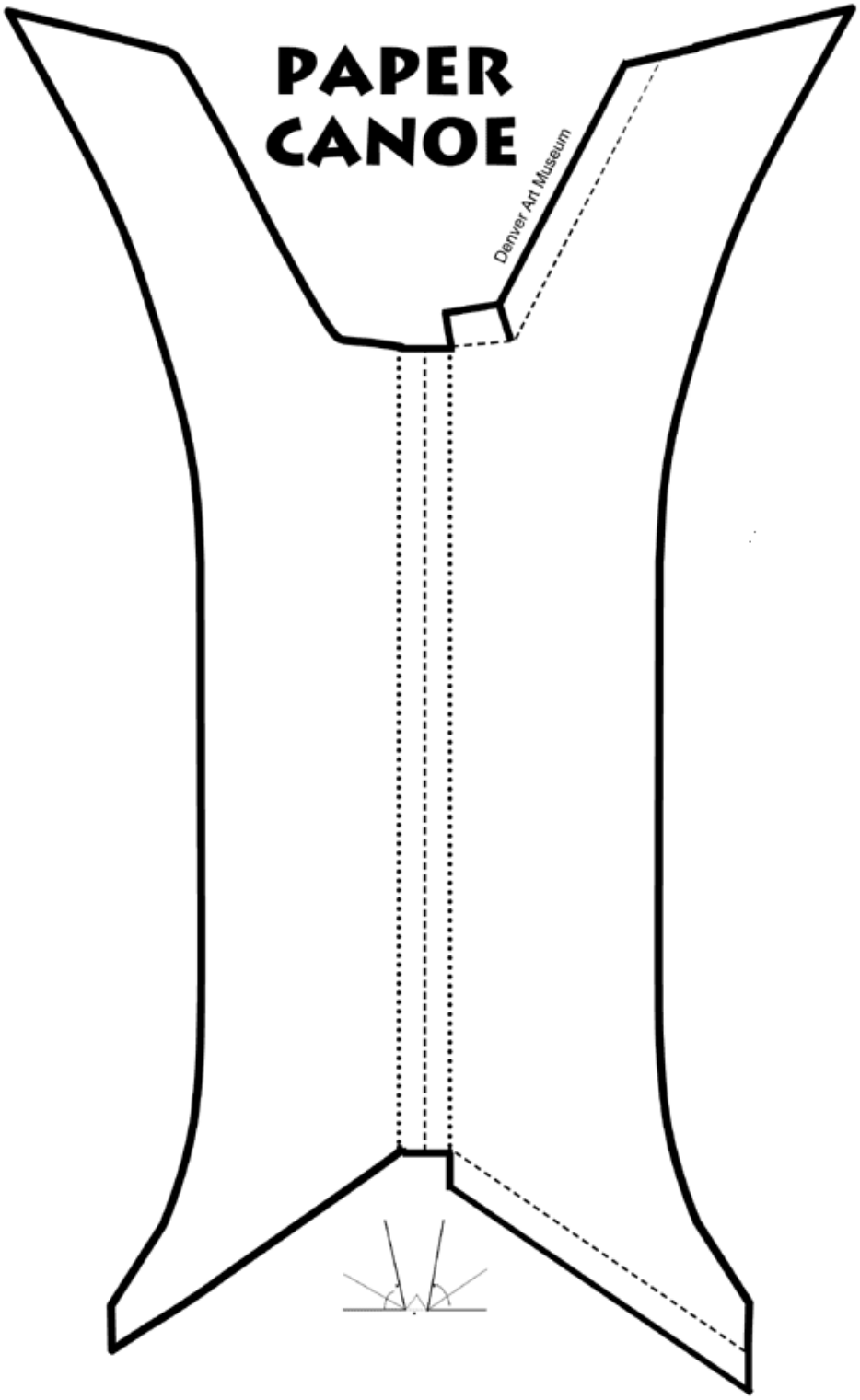
- Discussing angles and other properties of triangles

Special Education Notes: Differentiated Instruction considerations/accommodations/ assessment

- The instruction is differentiated for all learners as all students are able to help build the model canoe and measure the dimensions needed for this activity.

• The lesson has a hands-on, practical approach which helps engage more students in the lesson.
Cross Curricular Links: Oral, reading, Writing, Media, Social Studies, Science, Math, Visual Arts, Drama, Music, PE&H, (circle)
• History • Geography • Science • Health & Physical Education

Canoe Template



Worksheet

Crossing the River

British Columbia is laced with rivers. First Peoples often used canoes on rivers and lakes for travel. Crossing a river is tricky business. If you want to get to the opposite side across from where you start, you can't just head straight across. The river's current will be pushing you downstream while you are trying to get across. It's the same idea when you are crossing a lake: you have to consider the effect the wind will have on your path.

Materials

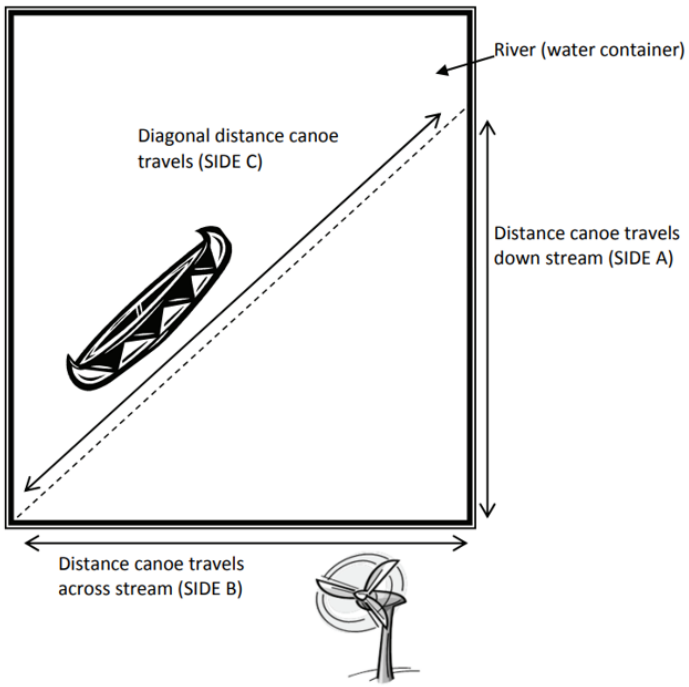
- Large plastic container (your river or lake) filled with water
- Model canoe that you made
- Erasable marker
- Fan (the current or wind)
- Metre stick or measuring tape

Directions

1. Set up the fan at one end of your water container (river) as shown in the figure on the next page.
2. Measure the distance of side B (the width of the river), and record it in the table on the next page. This will be the same value for each river crossing.
3. Give your canoe enough of a push so it can reach the other "shore" (other side of container).
4. Use the same amount of push and set up your fan on the lowest speed so that it will blow your canoe downstream, while still allowing your canoe to reach the other shore. With the fan blowing, push your canoe across the river.
5. Use the marker to put a line where the canoe hits the other shore. Measure alongside A (distance canoe travels downstream), and record this distance in the table.
6. Repeat steps 3-5 on medium speed.
7. Repeat steps 3-5 on high speed.

Reminder: the longest side of this triangle (that is opposite the 90^{o} corner) is called the

_____.



Finding the distance travelled (hypotenuse)

Fan speed	Side A (cm)	Side B (cm)	Side C (cm)
Low			
High			

Question Worksheet

1. When might you see a situation like this (a boat crossing a river) in real life?

2. What things would you consider when crossing a waterway in a boat or canoe?

3. Compare the length of the hypotenuse (side C) with the length of the other sides. Is it longer or shorter? What might that mean for the boat operator?

4. If you wanted to reach a specific spot on the other side of a river and you knew there was a strong current, where would you start your journey? Label it on the diagram below.

5. Historically, why might Indigenous peoples have wanted to cross the river?