BEYOND THE NUMBERS:
GAINING PERSPECTIVE ON THE MATHEMATICS PROBLEM TOWARDS
THE SUCCESSFUL TRANSITION OF STUDENTS
INTO UNIVERSITY MATHEMATICS

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By
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Vanessa Karina Braun, candidate for the degree of Master of Education in Curriculum & Instruction, has presented a thesis titled, *Beyond the Numbers: Gaining Perspective on the Mathematics Problem Towards the Successful Transition of Students into University Mathematics*, in an oral examination held on June 14, 2018. The following committee members have found the thesis acceptable in form and content, and that the candidate demonstrated satisfactory knowledge of the subject material.

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Abstract

The purpose of this study is to gain a deeper understanding of how the Mathematics Problem— the issue that students entering precalculus (and other bridging-style) mathematics in university are performing at an extremely poor level— is experienced and perceived by mathematicians. Additionally, this study looks at what effect these perceptions have on precalculus/bridging courses and how this information can be used to influence programming for incoming students in Western Canadian universities. Using hermeneutic phenomenology, this study found that participants view mathematics with a dual lens, which creates unique problems in mathematics lecture halls. Moreover, participants perceive that the dual nature of mathematics in combination with a lack of communication between high school teachers and university professors and lecturers has only contributed to the Mathematics Problem, resulting in a need to bridge the gap between mathematicians and high school mathematics educators. Finally, it is theorized that an asset-based approach to future precalculus/bridging strategies, as opposed to a deficit model, could create the opportunity for influential programming at Western Canadian universities, remedying the Mathematics Problem.

keywords: mathematics problem, secondary-tertiary transition, precalculus, asset-based approach
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CHAPTER ONE: Introduction

I sat in the warm light of an August sun, going through page after page of midterm exams. I had spent several days coming up with this midterm; I had combed through old professors’ midterms, my own notes I had provided, and the assignments I had assigned. My supervisor reviewed the midterm a week before the exam. He, like me, considered it to be fair. And yet, here I was with a red pen, over and over again, circling wrong calculations, putting question marks beside whole sections of inappropriate processes. When all was said and done, only a handful in my small summer class of forty-eight students passed the midterm. For the duration of the weekend, I fretted over the marks, went over them again and again. I reminded myself that I was a fair grader, but I doubted myself. I doubted all my teaching abilities that weekend.

The weekend finished and first thing in the morning, I went to see my supervisor. (As a graduate student teaching a university course, I was provided with a supervisor. He doesn’t intervene unless asked, and this was one of those times that I was thankful he was appointed to me.) I went into his office, hesitant to show him the results of the midterm. He looked through the list of midterm marks and compared them to the current grades in the class. It was easy to see that about forty percent of students were passing, most just barely above a fifty percent. He looked up after some time and simply said, “This is fine. Perfectly normal, in fact, for precalculus.” This was the lightbulb moment; it was the moment that I began to question how a forty percent pass rate for an introductory course could be viewed as “perfectly normal” (V. Braun, personal experience, 2016)
In 2007, the Ministry of Education in Saskatchewan began a major shift from its current mathematics curriculum to a new model, grounded in two frameworks designed by the Western Northern Canadian Protocol (WNCP, 2006; 2008). Implemented in six phases, the goal was to align mathematics curricula across Western and Northern Canada in order to, “enable easier transfer for students moving from one jurisdiction to another… [and] clearly communicate high expectations for students in mathematics education to all education partners” (Western Northern Canadian Protocol, 2006, p. 2).

High school mathematics saw the development of pathways, three different types of mathematics that correspond to the educational needs of different career choices. The design and resulting recommendation of each pathway were based on the results of an online survey of post-secondary institutions, businesses, and industries throughout Western and Northern Canada. The Precalculus pathway was designed for students who are interested in the sciences or engineering. Foundations of Mathematics is recommended for students interested in business, education, or the social sciences, while the Workplace and Apprenticeship pathway is suggested for students interested in the trades. In a personal conversation with Herman (January 25, 2016), he spoke of how the math classes offered to students entering the University of Regina were not meeting the needs of students under the new curriculum, providing the opportunity for an overhaul of the bridging courses offered at the University of Regina.

In Fall 2013, the University of Regina introduced Math 102, a three-credit, pre-calculus course that introduces students to a college-level course load comprised of
secondary-level content, as a response to the curriculum change in Saskatchewan (A. Herman, personal communication, January 25, 2016). Even though the prerequisite for Math 102 is Foundations of Mathematics 30, a grade twelve course, which assumes an understanding of fractions, exponents, and algebra, the content of Math 102 ranges from basic addition and subtraction of fractions to graphing and understanding trigonometric functions, resulting in a great deal of review both at the beginning of the course and throughout it. Because of the breadth and depth of knowledge students are expected to gain by the end of the twelve-week course, expectations for students are relayed clearly and precisely by lecturers or professors. Such expectations include a daily revisit of content learned, completion of class-assigned problems, and additional studying for exams (Braun, 2016). Additionally, the instructors themselves, specifically the two lead instructors who are often taking on the biggest load of Math 102 students in the Fall and Winter semesters, are highly supportive towards students in finding success, so much so that they are full-time professors with limited, if any, research time. Said professors are highly competent and have “at least five years of relevant teaching experience prior to appointment…” (University of Regina and the University of Regina Faculty Association, 2014, p. 22). Yet, even with the content itself coming from secondary level curricula, the expectations clearly and simply laid out, and the employment of competent mathematics educators, Math 102 has the highest rate of failure out of any first-year mathematics course offered at the University of Regina at 40%, with a class average between 50% and 60% (A. Herman, personal communication, January 25, 2016).
According to Herman (2016), the high failure rates associated with Math 102 at the University of Regina can be attributed to two factors: time and lack of student understanding of high school level mathematics. The time constraint associated with college-level courses is a serious issue for students:

[I]t is just hard for many of the students that are in it[.] [They] are there because they had problems with math in high school to begin with, and in the University system it's hard to make up for that… [W]e do 40-50 hours even including tutorials. (A. Herman, personal communication, January 25, 2016)

The time allocated for secondary school mathematics courses is approximately 80-85 hours per course (G. Russell, personal communication, February 10, 2016), which is close to double the amount of hours spent in a university mathematics course. Herman’s (2016) characterization of students in Math 102 as students who did poorly in high school mathematics may not solely affect the low success rates in Math 102, but, when coupled with Math 102’s evaluation process, an impact can be determined. Currently, Math 102 students are graded on a combination of quizzes, midterms, and a 50% final. Poor performance in previous mathematics classes can result in math anxiety, a process known as Deficit Theory (Carey, Hill, Devine, & Szücs, 2016). Math anxiety is “commonly defined as a feeling of tension, apprehension, or fear that interferes with math performance” (Ashcraft, 2002, p. 181) and can manifest itself as a poor attitude and lack of willingness to try problems (Smith, 2004). This unwillingness to try problems means that students may not be attempting unevaluated, or even evaluated, homework
outside of class time. Without working on problems outside of class, math anxiety very quickly leads to future poor performance, a notion known as Debilitating Anxiety Theory, resulting in a bidirectional cycle between anxiety and poor performance in mathematics (Carey et al., 2016, p. 5). Test-based evaluation does not break the cycle; rather, it encourages it. The lack of time, varying high school experiences of students, and test-based evaluation are three factors that may contribute to poor success rates in Math 102 at the University of Regina.

While issues surrounding Math 102 are theorized above, it is important to recognize the unique placement of Math 102 at the University of Regina and other precalculus/bridging courses in the wider Western Canadian university context. Math 102 often acts as a buffer between students’ high school and university mathematics experiences. How are students supported in Math 102, and classes like it elsewhere, during the transition from high school to university mathematics? With such a high rate of failure in Math 102, how many students must retake the course or are unable to complete their programs because Math 102 is a often a prerequisite for a required course, such as Applied Calculus I or Calculus I? How many students are not completing degrees in science, technology, engineering, and mathematics (STEM) fields, as well as business, education and kinesiology, because of an incomplete understanding of foundational mathematics? Is the issue at the University of Regina only part of a Canada-wide issue of mathematical under-preparedness, that could result in low success rates and subsequent drop-out rates in areas of STEM, business, education, and kinesiology? If it is, then the problem of mathematical under-preparedness is more far reaching than Saskatchewan
itself. Internationally, the issue of mathematical under-preparedness is heavily documented (Crowther, Thompson, & Cullingford, 1997; Hawkes & Savage, 2000; Kajander & Lovric, 2005; Rylands & Coady, 2009; Treacy & Faulkner, 2015; US National Commission on Excellence in Education, 1983); in Canada, however, little is known on how severe the problem is at the post-secondary level.¹

¹ The terms university, college, post-secondary, and tertiary schooling are used synonymously throughout this paper to refer to bachelor-level institutions, although the author accepts that differences exist between them outside this paper
CHAPTER TWO: Literature Review

Currently, Canadian research addressing the issue of high failure rates in precalculus courses at the university level is extremely limited (Clark & Lovric 2008; 2009; Kajander & Lovric, 2005). There are, however, a number of statistics from universities across the world reporting issues with the mathematical abilities of incoming university students that offer a glimpse into how international the problem has become (Crowther et al., 1997; Hawkes & Savage, 2000; Rylands & Coady, 2009; Treacy & Faulkner, 2015; US National Commission on Excellence in Education, 1983). Particular attention has been given to the transitional period from secondary to post-secondary mathematics and the critical nature of this time period for the development of proper, long-lasting mathematics skills (Clark & Lovric, 2008; 2009). The solutions to the issue of mathematical ineptitude within the transitional period are grounded in deficit-thinking, where students are blamed for their ignorance of university-level mathematics and high school teachers are regarded as enablers. “The student who fails in school does so because of internal deficits or deficiencies” (Valencia, 2012, p. 2). In fact, many of the statistics from around the world cite an increase of cultural diversity in the student population as the main reason for the sharp progression towards mathematical illiteracy (Crowther et al., 1997; US National Commission on Excellence in Education, 1983).

Alternatively, an asset-based model focuses on “the capacities, skills and social resources of people and their communities” (Ebersohn & Mbetse, 2003). It is both relationship and internally driven, where the relationships between individuals or groups are assets within the community (Central Coast Community Congress Working Party,
2003). It would see a diversity of students as an advantage and push those trying to reconcile the problem to identify systemic failures. An example of an asset-based approach, known as the rite of passage framework (Clark & Lovric, 2008) encourages post-secondary institutions to examine their own systems, practices, and policies as students transition to higher levels of mathematics that are meant to resolve under-preparedness, to be discussed in detail below. According to the rite of passage framework, universities can determine how they can utilize the diverse capacities of their incoming students, and respond to it accordingly. Before discussing both the asset-based approach and rite of passage framework, however, it is important to first understand the extent of mathematical under-preparedness in precalculus and bridging courses and how it has been identified through past research.

The Mathematics Problem

The concern that students are under-prepared for university-level mathematics is not new, although it has yet to be successfully addressed. Known as the Mathematics Problem, the notion that the skill level of entry-level students into post secondary institutions is heavily declining, the idea captures how nations such as Canada and the UK, have failed to address the decline in mathematics skills of students in bachelor-level institutions (Rylands & Coady, 2009). In 1978, Hogan made the following observation in the UK: “Students entering university this year to study engineering, science, and mathematics know less than they did ten years ago, have trouble solving but the simplest one-stage problems… [and] cannot handle simple mathematical expressions…” (as cited in Crowther et al., 1997, p. 785). In the United States, a Nation at Risk found that “the
College Board’s Scholastic Aptitude Tests (SAT)… average mathematics scores dropped nearly 40 points… from 1963 to 1980… and only one third [of 17-year-olds] can solve a mathematics problem requiring several steps” (US National Commission on Excellence in Education, 1983, para. 12). In addition to identifying the lack of math sense as a problem more than forty years old, the observations above expose the magnitude of the issue, extending from country to country in the Western world.

Since 1983, several studies have surfaced throughout the Western world targeting the issue of mathematical under-preparedness in university. In 2000, the UK published a report finding that “there is strong evidence from diagnostic tests of a steady decline over the past decade of fluency in basic mathematical skills… of students accepted [into] degree courses.” (Hawkes & Savage, 2000, p. iii). A report from the University of Western Sydney in Australia reports that “students lack the appropriate mathematical background to cope with first-year mathematics and mathematics related subjects” (Rylands & Coady, 2009, p. 741). At the University of Limerick in Ireland, 53.7% of students were deemed at risk of failing their first year mathematics course in 2012 as they scored 18/40 or less on the diagnostic test in sharp contrast with 25.6% in 2004 (Treacy & Faulkner, 2015). And in a large survey done at McMaster University in Canada, only 43.45% of Calculus I students surveyed could correctly determine the rate of change from a revenue problem and, more distressingly, only 11.05% could correctly interpret the rate of change in context to the question (Kajander & Lovric, 2005). This example from Kajander and Lovric’s study (2005) hints at the different classifications of learning defined in Bloom’s Taxonomy. Bloom’s Taxonomy is the hierarchical
classification of educational goals (Armstrong, n.d.). In 2001, following a revision, the
titles of the education goals took on verbs to describe the “cognitive processes by which
thinkers encounter and work with knowledge” (Armstrong, n.d., para. 10). From
concrete to abstract, the categories are: Remember, Understand, Apply, Analyze,
Evaluate, Create (para. 10). Kajander and Lovric’s example (2005) separates one
question into two parts, namely a part that requires application and one that requires
analysis. In this particular study, a question that forms is why is there a breakdown
between the categories of Apply and Analyze? Without scaffolding the question into two
parts, it would be more difficult to see where students struggle.

When considering the Mathematics Problem, there are a number of specific areas
of study to familiarize oneself with. The following topics will be discussed at length for
the remainder of this literature review, respectively: (a) the secondary-tertiary transition
as the main perpetrator of the Mathematics Problem; (b) the need for an asset-based
approach such as the rite of passage framework; (c) the rite of passage framework in
action; (d) Stakeholder Theory as a means to design and implement lasting programs;
and (e) the lived experience of stakeholders as pivotal for understanding and remedying
the Mathematics Problem. Together, these topics will help to lay the foundation of this
study and help direct understanding towards why and how this study developed.

The Secondary-Tertiary Transition

With numerous studies identifying the Mathematics Problem (for example, see
Rylands & Coady, 2009, Crowther et al., 1997, Kajander & Lovric, 2005), there is
another body of research that provide explanations for it, including where the problem
initially surfaces. Almost exclusively, existing research focuses on the secondary-tertiary transition (STT), the period encompassing senior high school mathematics and first-year university mathematics, as the main culprit behind the Mathematics Problem. Researchers have identified several factors within the STT that have resulted in the poor mathematical ability of university-level students: the relationship between weak mathematical performance and math anxiety (Beilock & Maloney, 2015; Hembree, 1990; Park, Ramírez, & Beilock, 2014), the poor relationship between high school teachers and college-level professors (Hemmi & Ryve, 2015; Selden, 2005), and the deficit thinking that surrounds the STT (Hernandez-Martinez et al., 2011). The Mathematics Problem and the problems associated with the STT have resulted in the reality that recent generations of university students, at least since 1963, are not proficient in the style of mathematics being presented to them by older generations, resulting in the ‘STEM crisis’, where countries, such as the United States, have an overabundance of STEM (Science, Technology, Engineering, and Mathematics) field positions and not enough graduates to fill them (Bielock & Maloney, 2015).

**Performance and anxiety: a link.** The distressing truth of the ‘STEM crisis’ is foreshadowed in a study from 1988. Waits and Demana (1988) found that high school students interested in pursuing careers in the fields of science, mathematics, and engineering are at a severe disadvantage when they enter university with poor math skills. Eighty percent of students who were ready for calculus at the beginning of college graduated in four to five years, while students who needed to take one to five remedial classes had a 56% graduation rate. (Waits & Demana, 1988). This study suggests that
remedial mathematics courses at the college level are doing little to help students reach their goals in STEM fields.

While the participants in the study by Waits and Demana (1988) are only identified based on their high school math scores and classes they took, it is important to recognize other factors that might affect their scores. Poor mathematical ability when exiting high school inherently affects students’ mathematical performance in university. However, while it is difficult, but not impossible, to overcome the lack of basic mathematical skills in a twelve-week remedial course, or even several of them, it is much more difficult to overcome math anxiety, which often accompanies low secondary test scores and grades (Beilock & Maloney, 2015; Hembree, 1990; Park, Ramirez, & Beilock, 2014). Students who report high levels of math anxiety consistently score more poorly than students who do not.

While “treatments that resulted in significant mathematics anxiety reduction were accompanied by significant increases in mathematics test scores” (Hembree, 1990, p. 43), it is important to recognize that not all interventions are financially feasible. When comparing classroom interventions with out-of-class treatment, Hembree found that interventions such as calculators, small-group work, and inquiry-based methods were not effective in reducing math anxiety. Because of the cost associated with out-of-class interventions, such as tutoring, not many are realistic to employ without the student handling the cost.

The difficulties with out-of-class interventions for math anxiety has led to new research since Hembree (1990). Park et al. (2014) found that expressive writing boosts
mathematical performance because it inhibits intrusive thoughts people experience during times of anxiety. In this study, adults completed a mathematics literacy test before and after completing ten minutes of unguided, expressive writing about their math anxiety. Those who identified as having math anxiety scored better after completing the writing activity. “Expressive writing may help anxious individuals to reappraise their view of the upcoming math task- seeing it as an energizing challenge rather than an a demotivating threat” (Beilock & Maloney, 2015).

Expressive writing is just one method that can be employed in a classroom setting, and Beilock and Maloney (2015) suggest that although “a simple writing exercise can[n]ot undo damage caused by years of avoiding math” (p. 8), it is a start to identifying classroom-ready, cost-effective mediations for math anxiety. While inadequate math skills and math anxiety are characteristics of the student, it is also important to discuss characteristics of other persons impacted by the Mathematics Problem.

**The teacher/professor relationship.** Low mathematical ability and high anxiety when exiting high school are issues that highlight the importance of mediation occurring at the high school level. However, because the STT includes both secondary and post-secondary events, when students enter university without adequate mathematical skills, the task falls on post-secondary institutions and remediation techniques to support mathematical performance amongst students. “One general complaint about incoming tertiary students is that their secondary mathematics learning is ‘surface learning’, whereas at university they are expected to engage in deep learning of concepts” (Selden,
2005, p. 134). A surface approach to learning mathematics is described as doing so “with
the intention of reproducing the mathematics to satisfy assessment tasks while students
who adopt a deep approach to learning mathematics focus on learning for understanding”
(Crawford, Gordon, Nicholas, & Prosser, 1998, p. 459). Surface learning is characterized
by memorization of facts with little to no regard for the underlying principles or
theorems and an overemphasis on evaluation (Entwistle & Ramsden, 2015). Deep
learning, on the other hand, focuses on understanding through the formation of
relationships between ideas and critically examining the teaching material (Beattie IV,
Collins, & McInnes, 1997, p. 3). This occurs through building on prior knowledge. One
such example, provided by Selden (2005), is the idea of the tangent line:

In secondary geometry, the tangent line to a circle is often defined to be
that unique straight line that touches the circle at just one point and is
perpendicular to the radius at the point of contact. However, upon coming
to calculus… the tangent to a function at a point is defined as the limit of
approximating secant lines, and somewhat later, as the line whose slope is
given by the value of the derivative at that point. (p. 134)

While post-secondary institutions struggle with the perceived surface understanding of
mathematics of students entering university, research points to the content knowledge of
mathematics teachers as important to encouraging deep learning in students, as well as a
number of pedagogical aims that are equally as critical (Hemmi & Ryve, 2015). These
aims include an environment where students have the opportunity to learn, clarity of
mathematical goals for students, and explicit connections between mathematical
concepts (Hemmi & Ryve, 2015). Furthermore, a large amount of literature is dedicated
to fostering ‘deep mathematical learning and understanding’ in secondary students and
recognizing that there is no generalizable method to attain success (Chinnappan, 2008;
Even & Tirosh, 2002; Watson & Geest, 2005). However, there is also evidence that
students in high school are “simply aiming to ‘pass’ rather than understand at a deeper
level” (Hong et al., 2009, p. 887) and that math exams are graded with the intention of
passing students (Gruenwald, Klymchuk, & Jovanoski, 2004). So, even students who
leave high school with sufficient grades in mathematics are often at a disadvantage,
because their grades may not accurately reflect their mathematical understanding.
Although the above research may indicate issues within the structure of high school,
teachers themselves are trying to create active participants out of their students, and to
help them develop connections between the course content and their daily lives (Meador,
2017).

The above issues with regards to surface versus deep learning in high school
students emphasizes the need for greater communication between secondary and post-
secondary institutions. Because the STT is a transition, it is vital that both sides work
together to determine where the systemic breakdown occurs to create and maintain a
smooth passage between the two levels of mathematics. In particular, several studies
speak to the disparity between mathematics teachers’ views and professors’ views on the
STT and how it impedes success (Hong et al., 2009; Wade, Sonnert, Sadler, Hazari, &
Watson, 2016). Although research by Wade et al. (2016) established that professors and
teachers agree that first-year university students must be supported in learning
foundational skills of algebra and precalculus in high school, learning how to accurately decipher a textbook, and being responsible for their own success in group work, they disagree on how great a focus should be placed on calculus in high school. Teachers argue that calculus should act as a review of both algebra and precalculus while professors see “algebra as standing alone, not as content that should be taught and strengthened through the instruction of upper level mathematics” (p. 11). Hong et al. (2009) identify an additional problem, namely that teachers and professors are unaware of how calculus is being taught in the other domain, influencing the finding that teachers feel “that their students are well prepared for further study, whereas lecturers tended to disagree slightly” (p. 886). The above findings suggest that teachers and professors are not communicating enough with one another about the nature of mathematics and mathematics education. Perhaps only after teachers and professors recognize that they are working on two sides of the same coin, will they be able to work towards closing the gap between success and failure in tertiary mathematics (Wade et al., 2016).

Finally, while this study focuses on the STT and the people involved, such as the high school community and university, it is important to note that universities are also attempting to close the gap for students by educating their in-service and pre-service teachers differently. For example, the University of Regina is taking steps to further educate current and future elementary and middle years teachers through the recent creation of a certificate program building on an undergraduate degree. Known as the Certificate in Teaching Elementary School Mathematics (TESM):
This program provides experiences to deepen one’s understanding of mathematics concepts, with courses in number sense, spatial reasoning, and modelling and representation, as well as courses in culturally responsive pedagogy, inclusive education, and research in the field of mathematics education (Undergraduate Certificate Programs, 2018).

Thus, it is through the involvement of numerous parties that the success of remediating the Mathematics Problem can occur.

So far, this literature review has examined how prevalent the Mathematics Problem is across several countries and how the STT has been the main focal point for research determining where and why the Mathematics Problems developed. Out of the large body of research addressing the Mathematics Problem in the STT, the issues of math anxiety and the relationship between professor and teacher are prevalent. However, these two issues stem from a ubiquitous discourse found in the Mathematics Problem: deficit thinking.

**Out of Deficit Thinking**

While the majority of the research on the responses of teachers and professors to the Mathematics Problem is qualitative in style, much of the literature on students involved in the Mathematics Problem rely on test scores and class averages (Treacy & Faulkner, 2015; US National Commission on Excellence in Education, 1983; Waits & Demana, 1988). By focusing on quantitative research, the resulting data provides support for a deficit model, a model that spotlights the weaknesses and inabilities of the person. It is not until students are given the opportunity to use their voice in the research
surrounding the Mathematics Problem and STT that a shift from a deficit model to a
more positive discourse (e.g., viewing transition as an area that needs to be reduced
versus viewing transition as an opportunity to grow) can occur (Hernandez-Martinez et
al., 2011). Hernandez-Martinez et al. set out to determine how the voices of students can
be used to create a more positive narrative for all students moving through the STT. They
interviewed two separate cohorts of British students entering tertiary institutions: the first
group being high achieving and the second being deemed ‘at risk’ due to low
mathematics scores and socio-economical backgrounds. The first group of students had
an expectation that tertiary mathematics was going to be completely different than the
mathematics they did in high school: “in general the feeling was one of a ‘step-up’ in
difficulty… accompanied by a sense of personal development” (p. 125). Those in the
second group “rationalized the experience of transition as one of facing a hard challenge
that, even when they failed, helped them to grow up” (p. 125). Although the two groups
differed in their achievement in secondary mathematics, they both found ways to
rationalize the transition. Most notably, the group who performed poorly saw their failure
in university-level mathematics as a learning moment.

The study done by Hernandez-Martinez et al. (2011) highlights a pivotal shift
away from deficit thinking and towards an asset-based model. An asset-based model is
one that focuses on the opportunities and strengths of a group of people, as opposed to
their problems and weaknesses (“Comparison Between Asset and Deficit Based
Approaches,” 2018). As asset-based approach “assumes that… there are… untapped
resources and capacities inherent in every individual, organization, or community which
can be put into use to improve current conditions” (para. 3). Without the voices of students, readers fail to realize that both student groups of the study by Hernandez-Martinez et al. (2011) are approaching the challenge of mathematics as a space for personal growth. This could not be known if the scores on their exams were the only data recorded.

Overall, the stories that emerged from the study by Hernandez-Martinez, et al. (2011) were ones of overcoming problems, and becoming independent and autonomous. The positive discourse that emerges from this study suggests we move beyond deficit thinking towards the possibility that the STT contains both the problem and the solution to the Mathematics Problem. As such, the STT is no longer the environment from which the Mathematics Problem simply emerges, but rather the environment that will best alleviate the Mathematics Problem.

**Utilizing the rite of passage as a right to learn.** Clark and Lovric (2008) designed a model and carried out a study that questions the deficit model traditionally employed to explore the Mathematics Problem in the STT. Known as the rite of passage theoretical framework, Clark and Lovric use an asset-based model to address the needs of the students. “Rite of passage” is described by Clark and Lovric (2008) as “events and activities that assist the person undergoing it to achieve necessary [emphasis added] changes… from one well-defined situation to another” (p. 26, 30). A rite of passage is not something to be avoided; rather, it is something to be embraced as ensuring successful transition of human beings through different stages of their lives. When described as a necessary movement from one area of life to another, the STT is no longer
connected to the knowledge a student lacks, because the transition involves an evolution of knowledge that is possible only during transition, regardless of how much he/she knows. In addition, the rite of passage model removes blame from both well-defined situations (the high school and the university) and instead emphasizes the active role the community or communities must play in order for successful transition to occur (Clark & Lovric, 2008). The rite of passage model looks to the student, teacher, and professor as key players in creating a successful transition to university mathematics, each providing important perceptions and actions to aid in the transition. It is important to note, however, that Clark and Lovric’s (2008) interest in using the rite of passage framework is exclusively in the university setting, meant to inform post-secondary institutions. The research on the rite of passage has yet to make its way into the high school classroom.

**Transition without duplication.** There are four core principles that characterize the rite of passage framework from within the university context to enable a successful transition for tertiary students: transition without duplication, transition without haste, transition towards maturity, and transition towards “unlearning”. The rite of passage framework is built upon the perspective that it is not possible to have a smooth transition from secondary to tertiary mathematics (Clark & Lovric, 2008) and each principle in the framework supports that idea.

The first principle of the rite of passage framework requires that institutions cease trying to duplicate the high school experience in university. Instead, exposing students to mathematical rigour, proper notation, and formalism (i.e. areas of content not believed to be undertaken in secondary school) may help students overcome the hardest obstacle:
moving from surface to deep learning (Clark & Lovric, 2008). An example of how this may be done is found at McMaster University in Ontario. McMaster University familiarizes students with mathematical rigour through a three-credit course, Math 1C03: Mathematical Reasoning (Clark & Lovric, 2008). This course teaches students to think mathematically while exploring mathematical concepts and designing proofs (Haskell, 2015).

Professors at other universities incorporate mathematical technique directly into their pedagogy:

The blackboard is a wonderful two-dimensional medium to de-linearize a discussion in class. For example, a proof is often not actually one linear sequence of implications from beginning to end, but consists of components with criss-cross arguments. (Luk, 2005, p.170)

By de-linearizing mathematics, students are encouraged to think beyond traditional “textbook solutions” and begin questioning the principles that a traditional conception of mathematics is built upon: static ideas versus dynamic thinking, rigid assumptions versus flexible theories, and confined arguments versus open discussions.

As another kind of approach, Gueudet (2008) suggests expanding the range of mathematical tasks expected of students and encouraging multiple solutions to a single problem. By creating open tasks (i.e., tasks which allow for multiple representations and/or solutions), students become more autonomous in their mathematical thinking (Boaler, 1998).
Through the work done by Clark and Lovric (2008), Luk (2005), and Gueudet (2008), it is evident that post-secondary educators agree surface to deep learning is an area worthy of focus, arguably because they themselves possess some deep understanding of mathematics. Whether it is through the creation of a new course or through employing techniques within the lecture hall, professors should be encouraged to teach mathematical conceptualization towards mathematical autonomy, a first step in the evolution of knowledge.

In addition to altering how students think about mathematics from the secondary level to the tertiary level, it is important that students are exposed to the belief that high school and university are different and should remain so. This view is shared by Hernandez-Martinez et al. (2011) who challenge the rationality of practices that strive to make university more like high school, because these only take institutional perspectives on transition, leaving out the voices of those for whom transition means not only a change in curriculum, for instance, but a ‘step-up’, a challenge that, when supported by the institution, offers them a sense of development, the possibility of ‘growing up’, of becoming more active participants in society, which in the end is what education is about. (p. 128)

Because a rite of passage is the change from “one well-defined situation [such as high school, or other secondary institution] to another, equally well defined [such as university or college]” (Clark & Lovric, 2008, p.30), it is not reasonable to try to converge secondary and post-secondary experiences together. By accepting the
differences each institution is characterized by, the opportunity to refocus students on their likeness (e.g., everyone is new) and not on their differences (e.g., socio-economic classes of secondary school) arises. Producing a university experience that is expectantly different from the high school experience is only the first principle of the rite of passage framework. It acts as the first vital piece to remedying the Mathematics Problem and acts as a cultural shift within universities.

**Transition without haste.** Unlike the first principle of the rite of passage framework, the second principle, namely a transition at a pace individual to each student, is not a static situation requiring a shift forward, but rather a situation that requires a cessation of backward steps in favour of forward leaps. The STT should not and cannot be expedited (Clark & Lovric, 2008). In September 2003, Ontario universities saw the emergence of a unique scenario regarding students entering first year mathematics. Because of the curriculum changes resulting in the loss of grade thirteen, two different cohorts of students were entering their first year of university: those who had done five years of mathematics education in high school, and those who had done four years. A study by Kajander and Lovric (2005) took the opportunity to study this special case at McMaster University. Comparing results from the five-year cohort and four-year cohort, it is evident that “students’ performance is strongly correlated [emphasis added] to the time they spend doing mathematics in high school” (Kajander & Lovric, 2005, p. 152). Students in the four-year cohort had a more difficult time with basic computational skills, sketching graphs of quadratics, and answering questions related to traditional calculus. In the first semester Calculus I class, the five-year cohort fared better on all means of
evaluation (quizzes, midterms, and final exams), resulting in a 4.8% discrepancy of final grades between the two populations. Because the study utilized a unique situation in Ontario, it is not generalizable across Canada. However, it does send a message about time allotment for studying mathematics: that less is not really more.

However, at the secondary level, changes in some laws and regulations have resulted in some students being able to accelerate their mathematics education. In Japan, a paper presented by Nishimori in 2004 (as cited in Selden, 2005) recognizes a direct relationship between the downsizing of the middle school curriculum by 30% and the degradation of foundational mathematics skills as perceived by university math professors. By urging students to enter the STT sooner and with less content knowledge and experiences, the Mathematics Problem is only exacerbated. If Nishimori’s study (as cited in Selden, 2005) is any indication of the need to abandon time-related restrictions to mathematics understanding, then the same principle would seem to be able to work from within the STT.

In addition to an expedition of mathematics at the secondary level, there are universities in Canada that are also cutting down class time to do precalculus. The University of Regina used to offer a two-semester course designed for students who needed math remediation in precalculus (A. Herman, personal communication, January 25, 2016). Herman explained that due to budget constraints, however, it was cut and replaced by a single-semester course. Although above research is stating that more time is necessary for students to successfully transition into university mathematics, policy changes and budget cutbacks have resulted in the opposite effect. “By following the
'shortest path’ (to where?) [university] students have no time to actually do mathematics, to think creatively about it, nor to internalize important ideas and concepts” (Clark & Lovric, 2008, p. 32), resulting in poor mathematical understanding, high failure rates in subsequent mathematics classes, and increased potential for withdrawing from university altogether.

Transitioning without duplicating the high school experience and without setting time pressures are two principles controlled by the post-secondary institution. The last two principles of the rite of passage framework relate directly to the individual student and his/her actions.

Transition towards maturity. Students must also take responsibility for their learning at the post-secondary level regardless of how they are being taught (Clark & Lovric, 2008). “Whatever methods of instruction are chosen, ultimately it is the student who has to negotiate the transition” (Clark & Lovric, 2008, p. 33), making it essential that, if a textbook is included, students learn how to read it and use it to aid their understanding. Every student has the ability to take responsibility for their learning; it is a matter of encouraging students to take responsibility for their learning.

Transition towards ‘unlearning’. Finally, students must utilize the STT as a ‘dying and rebirth’ process, abandoning old attitudes and beliefs about mathematics, or unlearning mathematics, and be willing to accept new ways of thinking mathematically (Clark & Lovric, 2008). One example of this is rejecting the notion that mathematics is an isolated exercise (Clark & Lovric, 2009), an exercise that is characterized by taking notes and individually completing assignments. Through peer groups and peer
collaboration, the opportunity to learn only grows: “[t]he best way to test whether we have learnt something is to teach it to someone else” (p. 760). As students teach one another how to perform a mathematical task, they must be able to think flexibly and adapt to the learning habits of their peer, moving beyond the rigidity and tradition often afforded to mathematics.

Another area of unlearning that mathematics students must face is the necessity of completing homework. Research states that there is very little correlation between the completion of homework and final grade in high school (Maltese, Tai, & Fan, 2012), yet it often becomes the central activity in university mathematics. It is up to the student to face this reality.

Rite of Passage in Action

The rite of passage framework is composed of four principles that reject the notion that students are simply under-prepared for or unable to learn mathematics at the university level. Instead, in this framework, the university is tasked with creating a space free of replication and time constraints while promoting an environment where students are able to mature academically and unlearn some beliefs they may have about mathematics. In 1998, Oregon State University (OSU) introduced a program to aid students transitioning into post-secondary mathematics that put into practice several of the principles of the rite of passage theory, called the Math Excel program.

The Math Excel program offered at OSU was developed to encourage students to work collaboratively on mathematics in introductory calculus (Duncan & Dick, 2000). This program was completely voluntary, encouraging students to take responsibility for
their learning, exercising a founding principle of the rite of passage theory: transition to maturity (Clark & Lovric, 2008). Executed as workshops, the Math Excel program met twice per week for eighty minutes and consisted of twenty-four students. While the problem sets given were slightly more difficult than their regular homework questions, they were clearly relevant to the course content. Students were free to pick their own groups and eventually settled into regular cohorts. At the end of the semester,

Over 90% of the students in all the Math Excel sections indicated they perceived that (a) they would not have earned as high a grade in their mathematics class… and (b) they viewed cooperative groups as a highly effective means of learning mathematics. (p. 371)

The Math Excel program meets the rite of passage requirements that students must make mature decisions about their learning and that learning takes time. Additionally, it encourages students to see mathematics as involving collaboration and cooperation, following the principle that old beliefs must be challenged and unlearned when transitioning into university mathematics.

Furthermore, the use of the Quantitative Understanding: Amplifying Student Achievement and Reasoning (QUASAR) model to create scaffolding worksheets for students to use throughout sessions further challenges students to move beyond traditional, algorithmic methods of doing mathematics (Dick, 2003, p. 68). QUASAR was an American national project from the 1990s that “aimed at improving mathematics instruction to middle school students in economically disadvantaged communities” (p. 68). However, from the project, a model was developed that emphasized “critical
thinking, reasoning, problem solving, and the communication of mathematical ideas
[which] are entirely consistent with the goals of a Math Excel workshop session” (p. 68).
For example, the final task in the scaffolding process, titled *Doing Mathematics*,
“require[s] complex, nonalgorithmic thinking… [where] there is not a predictable, well-
rehearsed path suggested by the task, instructions, or by previously worked example” (p.
70). Overall, the Math Excel Program offers students the opportunity to develop a deeper
sense of mathematical understanding through self-determination and collaboration,
anticipating the rite of passage framework set forth by Clark and Lovric (2008) nearly a
decade later.

The Math Excel program is one example of a bridging program offering
substantial aid to first-year mathematics students. By treating the transition from
secondary to tertiary mathematics as a rite of passage instead of a shortcoming of the
student, teacher, or system, the opportunity to better support students through the
transition becomes accessible. Furthermore, the development of a long-lasting support
system for students through the STT becomes more readily available as shame and guilt
related to students’ inability turns into a realization that *all students* experience the
challenges associated with the STT and do have the capacity to overcome them. Beyond
a description of the Math Excel program available to the public and Duncan and Dick’s
(2000) study of it, little literature exists on the overall development of the program and
how different people within the university structure were consulted to personalize the
program to the OSU campus, except to say that it has “been sustained long past its initial
Stakeholder Theory: The Value of Experience

The development of programs in universities to combat the Mathematics Problem can be effectively conceptualized through Stakeholder Theory. While fundamentally a theory in business, Stakeholder Theory also has applications in the university setting. Business, in its most basic form, is defined as “a set of relationships among groups which have a stake in the activities that make up the business” and how these relationships create value (Freeman, Harrison, Wicks, Parmar & Colle, 2014, p. 24). In Canada, while universities are not necessarily seen as money-making businesses, they do turn out value in the form of educated citizens. In a sense, education is the product and students are the customer; they “exchange resources for the products and services of the firm, and in return receive the benefits of the products and services” (Freeman et al., 2014, p. 25). The customer involved in any business transaction is typically seen as a stakeholder, as are owners, employees, and the greater community. While many intricacies exist in definitions of stakeholders, one widely accepted definition states that a stakeholder is “any group or individual that can affect or be affected by the realization of an organization’s purpose” (Freeman et al., 2014, p. 26). In the case of the university, and in particular the development of a program to aid in students’ transition from high school to university mathematics, the primary stakeholders include the university as a body, the professors or lecturers, high school math teachers, math help centres or tutors, and the students. Stakeholder Theory then states that because “no stakeholder stands alone in the process of value creation… [the best] approach to business is about creating as much value as possible for stakeholders, without resorting to trade-offs” (Freeman et
al., 2014, p. 28). Relating this notion to designing a successful program for precalculus university students involves gaining better insight into how each stakeholder can contribute to the maximum value creation, that is, the highest number of students successfully completing the course and, subsequently, being successful in mathematics endeavours in the future.

The consultation process of Stakeholder Theory advocates for the voices of every stakeholder in the development and redevelopment of the business or program. Scheid (2011) offers a four step process to using Stakeholder Theory: (a) determining who the stakeholders are; (b) determining how important each stakeholder is; (c) deciding what knowledge each stakeholder will bring to the table; (d) making decisions about the project as a collective group (para. 7). It is important, in order for the success of precalculus programs in university, to consult with students, teachers, and professors, both those directly teaching students and those involved in secondary programs, such as math help centres. How the voices of students, teachers, and professors are actually defined and what is valued in their voices is a further area that needs to be addressed.

**Lived Experience as Knowledge**

A vast majority of the literature that looks at the role teachers and professors play in the Mathematics Problem in the STT and their opinions on the origins of the Mathematics Problem deal almost exclusively with the thoughts, opinions, and beliefs of teachers and professors themselves (Hong et al., 2009; Wade, Sonnert, Sadler, Hazari, & Watson, 2016). While this is acceptable for examining certain aspects of the Mathematics
Problem, in order to acquire a complete voice of the teachers and professors, understanding their *lived experience* is equally beneficial.

Lived experience, as defined in the Sage Encyclopedia, “is a representation and understanding of a… research subject's human experiences, choices, and options and how those factors influence one's perception of knowledge” (Given, 2008). The Mathematics Problem is a *human issue*, and as such, requires a thoughtful and reflective process in determining how to manage it. The simple application of a universal theory will not create a consistent and constant change across Western Canadian universities and beyond. Rather, it is through the understanding of how professors and others involved in current precalculus programming at universities perceive the Mathematics Problem and how these perceptions developed that will provide key insights into the complexities of the Problem and can aid in remediating the Problem at the student level.

It is the expectation that those currently involved in programs will continue to be involved with the programs’ evolution, and if they are to continue to be involved, they must believe in, or at least be willing to try, new methods of teaching, facilitating, and learning. Lived experience, more than just opinion or personal theory, provides a better understanding for researchers and developers of potential program progression.

It is the combination of lived experience, as well as the other ideas within my literature review, including the Mathematics Problem, asset-based approaches to the Mathematics Problem, and Stakeholder Theory, that has led to the defining of the grounds for my study, which I will now discuss.
CHAPTER THREE: Research Design

Aim of the Study

The aim of this study is to better understand the perspectives of professors, lecturers, and other post-secondary educators on the Mathematics Problem and see how their perspectives are reflected in their lived experience. The specific questions are: (a) How do the experiences and thoughts mathematicians have in the STT influence the Mathematics Problem? (b) How is precalculus (and other bridging courses) at the post-secondary level shaped by the lived experience and issues mathematicians have? (c) What opportunities do the previous two questions have to influence current practice of the precalculus program at the University of Regina and beyond?

Methodology

To work towards answering my research questions, I will first clearly define the methodology I chose to work with. I will provide details on the qualitative nature of my research, as well as hermeneutic phenomenology, followed by the specifics of my methods. It is through the explanation of my methods that I hope to clearly identify how and why my research unfolded as it did.

Qualitative research paradigm. This qualitative study explores the Mathematics Problem through the lens of constructivist learning theory. While also referred to as constructivism in realms outside of mathematics, the distinction between constructivist learning theory and constructivism is an important one because this study crosses between realms of mathematics and mathematics education. In mathematics, constructivism is defined as how new knowledge is constructed or reconstructed through
the use of proof: “For constructivists, knowledge must be established through constructive proofs, based on restricted constructivist logic, and the meaning of mathematical terms/objects of the formal procedures by which they are constructed” (Ernest, 1997, p. 11). Constructivism in mathematics is directly related to mathematical objects, laced with themes of logic and formalism. Constructivist learning theory, on the other hand, is defined as the epistemological framework in which “meaning is constructed, not discovered,” validating participants’ viewpoints because each “subject construct[s] their own meaning in different ways, even in relation to the same phenomenon” (Gray, 2017, p. 20). This framework, unlike mathematical constructivism, is used in this study to understand the Mathematics Problem both at the individual campus level and in the greater, Western Canadian community. While common themes characterize research around the Mathematics Problem in the literature, using constructivist learning theory in this study gives credence to both the recurrent themes and unique experiences shared by participants, because the constructivist view sees human beings as inventors of knowledge and not discoverers (Larochelle & Bednarz, 1998, p. 5). Each unique experience and the personal interpretation of it is just as valid as the experiences documented over and over again, and thus are equally vital to developing practical solutions and mediations to the Mathematics Problem in universities in Western Canada.

Hermeneutic phenomenology as research methodology. Because the aim of this study is to learn about and investigate the lived experiences and understandings of mathematicians who teach precalculus at the post-secondary level, phenomenology in
some form was a natural choice in methodology. In particular, Heidegger’s (1927/1962) hermeneutic phenomenology provides the foundation to create knowledge in all aspects of the research process.

In order to understand hermeneutic phenomenology, we will first examine the evolution of phenomenology, from transcendental to hermeneutic. Phenomenology is defined by Usher and Jackson (2014) as “the careful and systematic reflective study of the lived experience” (p. 181). Phenomenology began as a purely descriptive research philosophy and methodology under the careful eye of the developer, Edmund Husserl. Husserlian phenomenology, also described as transcendental phenomenology, is the methodology of “determining the essential nature and acts of consciousness” (p.183). In other words, transcendental phenomenology is completely descriptive in essence and strives not to interpret the lived experience, but rather to come to a deeper level of knowing about it.

While transcendental phenomenology introduces the lived experience as meaningful to knowledge creation, it stops at interpretation. However, because interpretation is pivotal to this study, it is important to search for a methodology that also favours interpretation, which leads me to hermeneutics, particularly hermeneutic phenomenology. Hermeneutic phenomenology is not only descriptive, but is also interpretive (during the data analysis phase). The hermeneutic circle, the process predominantly used for analyzing text, is a constant dance between the text as a whole and individual parts of the text to better understand the text (Laverty, 2003). While it lacks an algorithmic process, an example of it would be an initial reading of the text,
developing connections and relationships between different segments of the text, and creating an interpretation based on the previous two stages (Speziale & Carpenter, 2011). The way the hermeneutic circle is used in this study will be discussed in greater lengths in the data analysis section.

**Role of the researcher.** In addition to the benefits provided by the interpretive nature of hermeneutic phenomenology during the analysis phase for this research, the role of the researcher differs greatly between hermeneutic and transcendental phenomenology. While transcendental phenomenology utilizes *bracketing* (the act of rejecting judgment to accurately analyze experience) as a method to set aside biases and assumptions about the phenomenon “in order to engage the experience without preconceived notions about what will be found in the investigation” (Laverty, 2003, p. 28), hermeneutic phenomenology does not. Instead, hermeneutic phenomenology continuously calls upon the biases and assumptions of the researcher, with the intent of ingraining the biases and assumptions within the analysis and interpretation itself (Laverty, 2003). The researcher is asked “to give considerable thought to their own experience and to explicitly claim the ways in which their position or experience relates to the issues being researched” (Laverty, 2003, p. 28). In this study, my own positions and experiences are provided throughout the paper, as italicized paragraphs, to enlighten both myself and the reader on the experiential knowledge I have brought with me into my research.

In this study, hermeneutic phenomenology aligns well with the wider epistemological foundation, constructivist learning theory for two main reasons. First, by
taking a constructivist approach, I am accepting the experiences, perceptions, and attitudes of the participants as knowledge and knowledge worth exploring. Second, through a constructivist lens, I am able to identify myself as a co-constructor of the dataset, highlighting the bias and assumptions that my experiences have led me to, which is also a component of hermeneutic phenomenology. Through a constructivist learning theory lens and a hermeneutical mindset, I am able to acknowledge my personal bias, not as a limitation of the research, but rather as a set of important knowledge, used as a tool to appropriately interpret the data.

Method

With an understanding of the underlying methodology (hermeneutic phenomenology) and epistemological framework (constructivist learning theory), this section will explore the specific methods used throughout this study. An explanation of the use of homogenous purposeful sampling to find and recruit participants, followed by a detailed description of the participants, the interviewing process, and finally and explanation of the data analysis process will be provided.

**Purposive sampling.** Participants for this study were professors, lecturers, and math help centre coordinators employed by faculties of Science at bachelor-degree-level institutions across Western Canada who offer a precalculus mathematics course, or similar bridging course. Western Canada currently has thirty-one degree-granting post-secondary institutions. This is not to say that other types of post-secondary institutions, such as colleges and technical schools, do not have similar issues as the ones addressed in this study; however, it is not reasonable to assume that all types of post-secondary
institutions have the same demographic of students and afford their students similar experiences. Therefore, they should not be considered equivalent and will not be considered for this study.

Homogenous purposive sampling ("Research strategy," 2012), which was used to determine participants for this study, is a technique that aims to create a group of participants with similar traits. In this case, I was seeking participants with a background in mathematics and an occupation at a university that is connected to the teaching of a precalculus or similar bridging course. The search for participants began with determining which post-secondary institutions in Western Canada are considered universities, which was done through the website, Universities Canada ("Member Universities," n.d.). After identifying thirty-one universities, determining which universities offered a precalculus course, or similar bridging course, was completed through access to the institution’s public website.

After meeting the additional criteria of offering a precalculus or similar bridging course, twenty universities remained as potential sources of participants in the study. A request for an external ethics review was sent out to the remaining twenty universities, eight of which provided a response and eventual approval of the research study. Following a second request for an external ethics review, no other universities provided responses.

**Recruitment.** The eight universities that provided approval from their ethics boards were then individually contacted via email in order to recruit eligible participants. To find the contact information of mathematics instructors who taught precalculus/
bridging courses or were involved in math help centres in the universities, public university websites were used. These professionals, all employed under their respective faculties of science were contacted via email to determine interest in the study. Five responded, and an additional professor from one of the five universities was contacted as I deemed that his/her participation would be of great benefit to the study. Altogether, data from six educators representing five universities was collected.

Participants. All six participants who consented to participate teach or have taught a precalculus/bridging or calculus course at the university level. Additionally, some of them are currently working with their respective math help centres, where students are able to come for additional math help outside of their classes. While each participant has a diverse collection of experiences, they have all received higher-level training in an area of mathematics. Five out of the six participants have their doctorates in mathematics and one has their master’s degree in mathematics. Because of their high level of mathematical understanding and their high achievements in academic mathematics, they will henceforth be referred to as mathematicians.

Professor U has been teaching at the university level for over twenty-five years and holds a PhD in mathematics. The only participant of this study who is a department head, Professor U does minimal teaching now, but has a great deal of past experience teaching. In addition, as department head, he has the unique position of addressing the concerns of his fellow colleagues and spearheading changes in the department.
Professor V is the only participant who does not have his PhD. Instead, he has a master’s in science, with a focus in mathematics. He has been a teaching for ten years and is currently the coordinator of the math help centre at his university.

Professor W, the only female professor interviewed in the study, has a PhD in mathematics education. She has been teaching for about twenty years, all of which have been with first-year undergraduate mathematics courses. Currently, the precalculus course she teaches has a limit of forty students.

Professor X has a PhD in pure mathematics and is new to his current university. Currently, he teaches a mathematics course designed for elementary and middle years preservice teachers, where students go back to the essentials, such as basic operations and logic.

Professor Y also has a PhD in pure mathematics and has been teaching at his current university for seventeen years, but overall he has been teaching at the post-secondary level for forty years. He has taught numerous precalculus and calculus courses at his university, and is currently teaching precalculus to hundreds of students.

Professor Z works at the same university as Professor W and has a PhD in applied mathematics. While working almost exclusively at the calculus level, Professor Z has done a vast amount of research in calculus readiness to determine where students struggle in calculus and why they struggle.

Each of the participants for this study offer a wide variety of experiences related to the Mathematics Problem and the STT, but, most importantly, they have a passion for
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their students and mathematics and a drive to change the current state of mathematics education at the university level.

Collection of data. Data for this study was collected via audio from phone and Skype interviews. Each interview was approximately one hour long and was semi-structured- comprised of premeditated prompts with the option for the interviewer to further explore topics brought forth by participants (Mills, 2014, p. 37). Interviews featured numerous open-ended questions, as is typical with hermeneutic phenomenological studies (Usher & Jackson, 2014). Audio from the interviews was recorded and transcribed. Additionally, some participants sent notes following the interview via email. This additional data was also used and analyzed.

Data analysis: hermeneutic circle. As previously mentioned, the hermeneutic circle is the main process used for the data analysis of this study. Prior to any research, I looked closely at my own pre-understandings, how my own experiences with precalculus at the post-secondary level have affected my own knowledge, biases, and assumptions. The opening paragraph of this study sheds light on the deficit thinking that I had at the time in regards to precalculus teaching. The concern I had for my students during my MATH 102 teaching experience in the summer of 2016 stemmed mainly out of quantitative data, the midterm grade. This concern resulted in more office hours being offered, a discussion with the lab instructor as to how to best utilize lab time, and whether I could monitor students’ at-home work time. I began thinking about the premise of this research study as a way to dive deeper into the Mathematics Problem and pull out
remedial efforts that were having an effect on the dismal success rates of precalculus and other bridging courses.

It was not until I began my literature review that I truly understood how my bias of precalculus and the inabilities I perceived my students to have was deficit thinking. Although I understood intuitively, and through my education as a teacher, that there was something ineffective about an all-test evaluation, I failed to make the connection to deficit thinking until I began reading and researching.

Prior to the interviews, I set up a preliminary coding system to use in my analysis of the data, to break down the interviews into parts. The categories for coding included perceived causes of the Mathematics Problem, namely surface learning at the secondary level, math anxiety, and poor communication between teacher and professor, as well as each of the four principles of the rite of passage framework: transition without duplication, without haste, towards maturity, and towards unlearning. Following the interviews, I transcribed the audio and did one complete reading of every interview, before beginning the coding. After reading through the interviews several times, coding, and digesting the contents of them, a number of other categories, which I had not thought of, emerged from the data, creating relationships and connections between previous categories and the interviews themselves. Utilizing a deductive-inductive approach to analysis proved to be advantageous to this study as it allowed me to develop more coding categories and remain open-minded to the experiences of participants. Following the period of coding, reverting back to the entire interview became necessary, including re-listening to the audio files themselves. Unfortunately, when files are transcribed,
passion and emotion are erased from the text. However, passion and emotion are important keys to better understand the phenomenon experienced by the mathematicians.

During the data analysis: the coding, reading, listening, and rereading, I was also fully aware of a consistent reflection on my own experiences. As different categories emerged from the data, the realization that their emergence was not coincidental became clear. Each of the new developments tied to my own experiential knowledge. Developments are found in italics throughout the study and provide glimpses into how I have co-constructed the data. Some experiences are profound and singular, taking up an entire memory, such as my semester with a brilliant instructor. Others are frequent occurrences in my life, particularly my time as a tutor, and create patterns of behaviour. It is through the acknowledgment of each experience that I hope to bring to light how I have interacted with the data and why certain patterns and relationships amongst data became evident. Additionally, such reflections serve as a constant reminder that “in order to understand a phenomenon, the person must first of all have his or her own knowledge and experience of the phenomenon” (Usher & Jackson, 2014, p.184).

**Limitations**

Of course, every epistemological and methodological choice has its limitations. This section highlights four main limitations of this study: credibility, transferability, sampling in relation to time constraints, and transcription.

As a qualitative study, it is critical to determine trustworthiness (Birks, 2014). Trustworthiness consists of four factors: credibility, transferability, dependability, and confirmability (Murphy & Yielder, 2010). A number of safeguards have been
implemented in this study to establish credibility, including researching a proper methodology and its correlating methods for the research questions and inviting all participants to review, accept, and/or amend any of their analyzed results. Nonetheless, there are still limitations to credibility. Due to the semi-structured format of the interviews, the use of verbal and nonverbal cues given by the interviewer/observer during data collection as well as the difficulty of analysis and coding in general pose possible threats to trustworthiness. Furthermore, the semi-structured design of the interviews also makes it difficult to transfer this study to other settings or groups, resulting in a lack of the principle of transferability.

Another limitation of this study is the sampling method in combination with time constraints. Because the population size of the institutions was only thirty-one and the numerous steps needed to be taken to recruit participants, namely ethics approval at the site level, the decrease in sample size occurred quickly and at every step of the process. There is a chance that with more time, I could have prompted other ethics boards that did not respond to me, naturally resulting in more participants. However, this did not occur, resulting in a nineteen percent participation rate which, according to Creswell (1998), is within the range of acceptable participation for a phenomenological study.

A final limitation to this study is the transcription process. Unfortunately, when files are transcribed, passion and emotion are erased from the text. However, passion and emotion are important keys to better understand the phenomenon experienced by the mathematicians, so they are introduced in the data analysis, although not expanded upon.
Despite these limitations or issues, the results of this study are important as they seek to authenticate and validate the lived experiences of those involved in the Mathematics Problem. They offer a glimpse into the perceptions and beliefs that one of several types of stakeholders have with respect to the Mathematics Problem and provide insight into how Western Canadian universities have begun and can continue to remedy the problem.
CHAPTER FOUR: Findings

The purpose of this study is to better understand the perspectives of Western Canadian mathematicians, those who work in departments of mathematics and have a deep understanding and appreciation for mathematics, on their experience and understanding of the Mathematics Problem in their lecture halls and classrooms. An analysis of the data collected revealed three main perceptions: (a) mathematics has a unique dual nature, creating an environment where it is difficult to promote learning; (b) the STT (secondary-tertiary transition) encompasses a phase of dual spaces, but lacks a bridge between them; and (c) the task of creating independent, creative thinkers rests on university professors. The above findings are not generalized assumptions about the Mathematics Problem and the STT, but rather common themes emerging from the data sets in this study. This chapter will discuss each perception and how it is supported by a synthesis of the data.

Prior to discussing this, it is important to touch on the various types of experiences participants wanted to share. While I had chosen to look at how bridging courses, such as precalculus, interact with the Mathematics Problem because I have had the experience of teaching precalculus, participants in this study have provided a broader view of the issue. Many have included their experiences with calculus students and students in other introductory classes who have come into their math help centres. Initially, I had made the decision to only mention these experiences as an afterthought. However, after further analysis, I realized that the Mathematics Problem interacts with a wide range of mathematics classes at the university level, which is a result of the duality
of mathematics (to be discussed later). Because I’m interested in the lived experiences of professors, the range of experiences utilized in the analysis below include ones beyond the bridging courses themselves, including my own.

The Duality of Mathematics

Recently, I was tutoring a student, Mary, in university calculus. One of the questions we were working on involved using the quotient rule embedded in the product rule. Mary utilized both rules without any hesitation and came out with a long, complicated-looking rational expression. She then put her pencil down and said, “Now what?” I was actually quite surprised at this as she had flawlessly used both rules and only had to simplify the expression to finish it off. It was algebra, an area of mathematics she’d been studying since the ninth grade, that was giving her so much trouble.

In a later question, Mary was asked to find the equation of a line tangent to a given curve. She immediately recognized that the derivative at the point of tangency gave her the slope of the tangent line, but was lost as to how to find the equation of the line itself. It took some coaching from me and a reintroduction of linear equations for her to know what to do. (V. Braun, personal experience, 2017)

The above scenarios represent two different, yet inextricably linked issues prevalent in the experiences of the professors involved in this study. The first issue, namely that students are having trouble retaining prerequisite knowledge to be successful in precalculus and eventually calculus, is detailed in the experiences of every participant of this study. For example, Professor X, who teaches an introductory mathematics course to elementary and middle years teachers recalls the difficulty of exploring even simple
proofs because students’ “fractions skills are very poor. Their [skills for] setting up equations for problems are very poor. Their long division is quite awful.” Professor U reports similar issues within his own classroom: “The problem is that [students] don’t know how to add two rational expressions together and the reason they don’t know how to do that is because they don’t know how to add two ordinary fractions together.” In addition to explicit classroom experiences, Professor V notes a particular university policy that hinders his students from completing Calculus I problems. The university that Professor V teaches at does not allow calculators in Calculus I, resulting in students’ inability to simplify fractions or algebraic expressions, for example. Their inability to simplify fractions or expressions stems from the calculators’ ability to do elementary operations for them, such as multiplication or division. Such basic math skills are unfamiliar to students. It appears that these kinds of experiences are a longstanding issue and carry the following characterization by Professor U: “[The information students have trouble with] is prerequisite knowledge that the students either never mastered or it’s been so long since they’ve done that material that they don’t know how to.”

Participants who consistently teach classes have, over time, developed different teaching constructs to help encourage students to practice and retain foundational concepts, with independent practice being the main focus. For instance, Professor Y assigns “quite a bit of homework that is a review of high school mathematics.” The most common method of distributing homework is the internet, as Professor Y creates online modules for his first year course students to access. This stems from the notion that many of Professor Y’s students are straight from high school and typically have an affinity for
the online world. However, he has found that students often “lack [the] maturity… [to] use those resources,” whether that would be an inability to read textbook-style modules or a lack of interest to complete non-compulsory homework.

In addition to using practice to brush up on high school skills, Professor X and Professor U believe practice helps students acquire fluency in mathematics, the notion that mathematics is not only a field of problem solving and skill development, but is also a language in its own right and requires the understanding of symbols and terms in order to become proficient. In particular, Professor X sees independent practice as a way to learn the language of mathematics, in addition to developing skills:

I try to get [students] to work through as many questions as possible at one time. So after every class, I have a little assignment… just doing the same thing over and over again and it’s basically to get fluency in the mathematics- the language aspect to it… every symbol means something and you need to be fluent in the language in order to understand the math that you’re doing.

The fluency of mathematics that he is referring to here is only one part of his personal theory of mathematical fluency, but an important one. For example, without understanding the purpose of an equal sign, and thus not understanding equality, students fail to grasp a variety of mathematical concepts, such as balancing equations. In particular, the kind of fluency that Professor X refers to here is synonymous with the learning of another language, one that needs to be continuously practiced and reaffirmed.
Another dimension of independent practice that Professor U introduces is productive struggle as a means for students to actively engage in mathematics skills that are initially difficult or cumbersome. In his experience, “a student will try to do a question. It doesn't work and so the strategy is maybe to just give up or to try exactly the same thing and have it not work again.” Productive struggle, on the other hand, may start the same way: trying, struggling, and failing, but rather than the student utilizing the same method again, he/she tries different strategies until finding success. Productive struggle not only acts as an additional focal point of independent practice, but it also acts as the bridge between the issue of prerequisite knowledge at the university level and the second issue participants frequently referred to: creative problem solving.

While productive struggle is seen in this study to directly link to the relearning or reframing of knowledge previously known, it, in itself, is a skill that transcends mathematical content according to several participants. Professor U describes productive struggle as a life skill, rather than a basic mathematical principle: “[Life] is mostly struggle and failure until you figure out what to do.”

Echoing Professor U, Professor V refers to the importance of the struggle because of the nature of school in the twenty-first century. Students today are able to google an answer immediately, but the struggle that students have to go through may be the most important, because it is more about life than about mathematics. Other professors refer to productive struggle in a more positive way. Professor X describes his experience with students in his classroom:
[My students] haven’t seen the nature of just playing around with some math and trying to feel for it and thinking things… students don’t have a lot of experience with [play]… It’s kind of a new way of thinking for them.

Interestingly, Professor U also describes the notion of struggle as play:

Students need to know how to play with a problem, develop an understanding of it, and eventually, once they’ve got some understanding and some insight, maybe they can solve it… We [mathematicians] ask ourselves some question and we play with the problem for awhile and eventually, if you get lucky, and you’re smart enough and flexible enough, you get some insight.

When thought of in terms of play, as opposed to struggle, the idea of trying again becomes less of an arduous task and invokes more positive feelings.

A term used to refer to the successful implementation of struggle or play, and one that will be used for the duration of this study, is creative problem solving, introduced by Professor Z. Creative problem solving, as told by Professor Z, is the “coordinating or drawing together [of] various math skills that [students] have learned in the past and bringing many of them at once to bear on a problem where it is not certain from the outset what steps… should be appl[ied].” For example, students could be encouraged to complete a series of worksheets on elementary operations and order of operations in a precalculus course as a means to increase their ability to recall such foundational skills. This type of work is algorithmic. On the other hand, students could be asked to
reproduce the digits 0-100 using only four 4’s (e.g., \(44 - 44 = 0\), \(\frac{44}{44} = 1\), \(\frac{4}{4} + \frac{4}{4} = 2\)).

Such a task encourages students to successfully utilize elementary operations and the order of operations, like the worksheets, while moving away from an algorithmic method, unlike basic worksheets. Professor Z sees the combination of practice and creative problem solving, the culmination of both above tasks, as the way that students come to know mathematics in university:

Homework is the work you are doing at home, on your own and I don't really see any other kind of learning at the adult level. The goal is to create independent learners and that means, by definition, learning at home or wherever you do that would work... [T]hink of homework as the central activity of independent learning.... So somehow there's a transition from the youngest grades towards university, where certainly, independent learning is the goal. I don't see a way to accomplish that without making homework the central activity.

The evidence above points to a uniqueness of mathematics: its dual nature, specifically that both practice and creative problem solving are integral parts of understanding mathematics. Professor Z’s belief in mathematics summarizes the first part of its nature in the following way: “Math is a bit special. It’s quite special because learning is so cumulative that [if] you miss some important skills or bits of knowledge early on, that hampers learning forever.” The “skills and bits of knowledge” Professor Z is speaking of refer to the content of mathematics, that is, the language, concepts, and basic skills of mathematics. With enough practice, according to the participants and as
discussed above, students should be able to grasp the language, concepts and basic skills, hence the use of frequent independent practice opportunities.

The second aspect of mathematics, creative problem solving, is much more difficult to identify and teach. While Professor Z can recognize the distinctiveness of mathematics, he admits to struggling with how to teach creative problem solving: “I seem to have an innate skill myself at creative mathematical problem solving, but it’s not clear to me how to instil it in others.” He does, however, make a move to recognize it as a component of Bloom’s Taxonomy, which is a hierarchical classification of learning objectives lying on a continuum from concrete to abstract and simple to complex (Armstrong, n.d.): “I think in university mathematics, we tend to ramp up the difficulty of the problems at the same time we are also asking for more synthesis [from Bloom’s Taxonomy] and I think doing these at once is asking a lot of students.” As demonstrated by Professor Z’s experience, the duality of mathematics can create problems for students who are given questions that simultaneously challenge the Knowledge or Comprehension level of Bloom’s Taxonomy and the Synthesis level.

The duality of mathematics creates a unique set of issues for professors to adequately address. Through the examination of the experiences and opinions that the participants have had in regards to prerequisite knowledge and creative problem solving, it appears that the Mathematics Problem is more complex than previous literature suggests.
The Bridge Yet to be Built

After finding my calling in mathematics and mathematics education, I finished the final two years of my undergraduate studies working back and forth in the Department of Mathematics and the Faculty of Education to complete two degrees. One semester my classes would be solely in the Faculty of Education and I’d find myself completely engrossed in pre-service teacher life: the group projects, the time spent in classrooms, and even the friends I hung out with outside courses. Then I’d flip to a semester in pure and applied mathematics. Instead of group projects, I’d be spending my time working on individual assignments in groups. Instead of time spent in classrooms, there were countless hours spent at the library. And instead of fellow teacher friends, I hung out with fellow mathematician friends. The gap between areas of study was already widening and I constantly felt myself being tugged back and forth, unable to exist in any sort of in-between space connecting math education and mathematics. Who would have thought this intangible aperture would only grow? (V. Braun, personal experience, 2012-2015)

The secondary-tertiary transition (STT), the transitional phase students move through as their experience changes from high school mathematics to university mathematics, is a period in the lives of university students that has significant issues of achievement, including the Mathematics Problem. As participants explained their experiences with the Mathematics Problem, this transitional phase naturally emerged in the form of opinions, frustrations, and beliefs about the high school space, the university
space, and the bridge that exists, or could exist, between them. A great deal of knowing surfaces from these two unique spaces and the space between them.

**Student perception.** There are numerous beliefs expressed in the data about the high school experience of students, and these beliefs typically fall into one of two categories: student perception or systemic obstacle. Out of the six professors, five of them made note of the negative attitudes students bring into their classrooms about mathematics. Professor X notes the negative experiences that his students have had with mathematics in primary and secondary school that have led to an overall negative perception of mathematics. Professor Y says that in his experience:

No one is taking a precalculus class because they like mathematics.

Everyone is forced to take that class if they have any ambition in science or applied science or business or economics that they need to take the calculus course.

Professor Y argues that precalculus is somewhat of a necessary evil, a course that has one purpose only: to prepare students for calculus. Interestingly, Professor W questioned the name of the precalculus course offered at a community college that she taught at, which was eventually renamed “Elementary Functions”, but was met with criticism after large colleges stopped accepting it as a prerequisite for calculus. The term “precalculus” offers little to no indication of what the course content is; yet, the name holds great power over other, larger colleges, that deem it as necessary for calculus.

In conjunction with the negative attitudes towards mathematics, negative work habits of students in precalculus were reported as abundant. Participants note the lack of
work ethic that students have in their classes, the frustration and defeat students experience when they do not meet success quickly, and students’ perception that mathematics is useless. However, the poor work habits are not always a result of a poor perception of mathematics, according to several participants. In terms of the transitional phase that precalculus students find themselves in, their priorities do not always line up with the courses they are taking. Professor Y puts it in the following way: “This is maybe their first or second semester in university and in this complicated transition from high school to university, the academics are sometimes not the top priority in the fight to survive.” Additionally, Professor W has found that some “students, not necessarily in pre-calc, but in similar courses that are around the similar level… fail in first term and then they come back another term and they say, ‘I’m ready to work this time.’ And end up doing quite well.”

Work ethic, or the lack thereof, in students is one piece of the larger high school space, specifically mathematical maturity as defined by participants. When students can take the initiative to complete ungraded assignments, moved by the need to become more fluent in a particular skill or improve their problem solving abilities, students demonstrate mathematical maturity. Unfortunately, according to Professor Z, “[Professors] are assuming that students are learning [independence] at high school when they arrive in our classrooms, [and] that they can independently do their own work.” When students push to prioritize mathematics in their daily lives, such as the students Professor W taught twice, the ones who did well the second time around demonstrate mathematical maturity. When students are able to willingly take on new challenges in
mathematics, they demonstrate mathematical maturity. Professor W holds the high
class community responsible for the lack of encouragement the first time around:

I feel sometimes the students aren’t really encouraged to challenge
themselves in high school and that’s hurting their preparation for
university. Student just haven’t necessarily taken enough math in high
school… There are questions as to what courses they actually took in high
school, how many math courses they actually did… A lot of students that
intend to go to college aren’t necessarily advised to take as much math as
possible.

Her argument is that taking mathematics courses in high school, beyond what is required
of the student, even when not excelling, is better than not taking the course at all. By
taking such courses, students present themselves with challenges, forming the necessary
skills to take on further challenges in the future.

Student perception of mathematics encompasses numerous areas in the student’s
psyche. From attitude to habit to maturity, how students’ perceptions were shaped, or
how participants make speculations on how they were shaped, by their grade school
mathematics appears to be pivotal to understanding the STT.

**Systemic issues in the transition.** While student perception of mathematics in
high school occupies one problematic area, systemic obstacles occupies the other.

Participants largely explained how *algorithmic ways of thinking* are a systemic obstacle
that professors have to cope with in their classrooms. Participants see algorithmic
thinking as not only difficult to handle, but also, as Professor U puts it, “absolutely
antithetical to the [math] requirement.” In other words, Professor U is arguing that algorithmic thinking is the exact contrary to creative problem solving.

Professor X goes as far as describing algorithmic thinking as the “grade school way” of thinking, where “in high school, you go from algorithms and computing to university that’s more solving puzzles, which is more the way math is in general- solving puzzles and talking about generality.” And, according to some participants, the area that requires change in order to dissuade algorithmic thinking in students is how teachers engage with their students and the content they are teaching. As explained by Professor X, “[High school teachers] should have a higher knowledge of what they are teaching than just the concepts themselves.” If teachers did have a more complete knowledge of the mathematics they are teaching, he says, then students will get a better idea of how to operate beyond formulaic thought. At a previous college, Professor W completed a series of tests, comparing university professors and their high school teacher counterparts regarding their mathematical knowledge found that “high school teachers… didn’t really know the material that well… [and] there [were] questions about quality of instruction in high school…” Although done in another country, she has found her experience in her current province to be similar to the results of her study. Professor V also discussed concerns he had about the quality of instruction in high school mathematics classrooms and whether teachers were equipped to teach for understanding. He was concerned that while wanting to investigate patterns in mathematics, for example, his efforts are hindered by the prerequisite understanding of mathematics students have coming into university. Similarly, Professor U expressed concern as to whether students are able to
tap into creative thinking if they have not in high school: “[Creative thinking] needs to go way back, like I said in K-8 [education]”. If students are not coming to university with creative problem solving abilities, he questions what chance they have at succeeding in mathematics once they reach university as young adults.

The high school space, according to participants, creates a multitude of issues for university professionals to address once students reach them. From the poor attitudes students may bring in, to the type of algorithmic thinking they believe is integral to mathematics learning, participants in general were quite displeased with how students perceived mathematics to be taught at the high school level. It is important to note that while several participants saw school teachers as producing numerous obstacles to the goal of creative problem solving in mathematics, they did not present their beliefs in a harsh tone towards teachers as individuals. Rather, their passion was directed towards the system, so much so that a number of them have been players in pursuing change in their individual universities in order to promote programs in Education faculties that put an emphasis on mathematics education. In order to preserve confidentiality, however, said programs will not be discussed in this thesis.

Thus far, this section has examined how participants’ perceived attitudes and beliefs about their students affects participants understanding of the Mathematics Problem and their actions towards it. Furthermore, this section has also investigated how participants frequently consider the systemic obstacles that are a part of the Mathematics Problem. In addition to the obstacles they see at the secondary level, they also identify numerous obstacles at the post-secondary level, which will now be discussed.
For participants in this study, the high school space is one where many of them can meet with teachers and make educated conjectures about what goes on inside the mathematics classroom, but very few had teaching experience in the high school classroom itself. The university space, on the other hand, is an area where participants have numerous experiences and, as a result, are able to comment directly on their personal experiences inside the lecture hall. The main concern for participants is the lack of educational training that university lecturers receive to teach mathematics. Professor Z explains that after getting his PhD, he was “just turned into a classroom and just expected to figure it out without any support really.” Professor X goes one step further, commenting on the damage a mathematician’s thought process can have on both the lecturer and the student, “most lecturers at university haven’t had any education training; they just get thrown in the deep end. So they think like mathematicians and they don’t think the way a high school student would think about math.” A dilemma shows up in Professor X’s comments about high school mathematics and university mathematics. While it is important for high school teachers to have a deeper understanding of the mathematics they teach, lecturers in universities are not necessarily equipped to handle incoming university students because of the lecturers’ lack of pedagogical training, even though they may demonstrate deep mathematical understanding. Rather, it is the combination of these skills: a deep level of understanding of the mathematical content (sometimes working in conjunction with the ability to think like a mathematician) and sound mathematics pedagogy that can result in successful teaching and learning. It appears that, according to Professor X in combination with other comments made by
participants, high school teachers lie on one end of the spectrum and university lecturers lie on the other. Both have key pieces of knowledge and understanding, yet are incomplete without one another. They are incomplete without the building of a bridge between the high school space and the university space.

Participants were quick to justify the need for better communication between themselves and their high school counterparts. In particular, Professor U commented on the need for cooperation amongst both types of educators: “There’s a lot that can be accomplished if the mathematicians and the math educators work together instead of working against each other.” Unfortunately, they felt very little is being done in participants’ universities to bridge the gap between educators and mathematicians. A few participants commented on small projects they had taken part in that brought teachers and professors together, but rather than set up as semi-permanent programs, these projects were set up to research how teachers and mathematicians interact and not to create lasting change in the STT. Additionally, while participants argued for the need of cooperation, Professor X noted that nothing can bridge the two spaces until it is built from both ways- “from the university to [the high school] and from the high school upwards.”

As seen in both the literature review and the data from this study, there are numerous obstacles for both students and university educators to address in the STT. What students are bringing with them from high school (e.g., negative work habits, mathematical immaturity), is just as detrimental to their mathematical understanding as what they are meeting in the university setting (e.g., mathematicians who have not been
formally trained to teach). Furthermore, the need to bridge the space between the high school community and the university community is evident, even desired; yet, it has not been accomplished by the universities represented in this study and so remains difficult to identify for participants. Instead, the responsibility has fallen on university professionals to try to instill habits in their students, such as independence and positive work ethic, to patch holes in content knowledge, and to promote new ways of thinking, such as creative problem solving.

**Teaching Towards Independence and Creativity**

*I didn’t take my first university math class until the second semester of my university career. Prior to that course, I had my heart set on law school. It wasn’t until I sat in Calculus I with a sessional who was one of the best lecturers I’ve had to this day that I began to really appreciate mathematics and mathematics education. Her teaching style was fair, honest, and critical. She exhibited a high level of content knowledge on a daily basis and always made sure to answer questions from students completely. She had a class of one hundred and fifty students. I imagine I looked like every other student in that hall. I didn’t do particularly great or particularly poor. In that class, I was the kind of student that a teacher wouldn’t worry too much about. I attended a few of her office hours, but not enough for me to leave a lasting impression. Still, I had such a great experience with her that I ended up switching my major to Mathematics before the semester was over. Six years later, I ran into her again. And she still remembered my name.* (V. Braun, personal experience, 2009)
The participants and their universities have developed numerous strategies, which are discussed below, to help promote mathematical maturity and creative problem solving students going through the STT. In particular, math help centres are used at each of their universities as a means for students to seek help, while the participants themselves work especially hard in and outside of class time to promote an environment of learning. By examining the practices of the help centres and the practices of actively teaching participants, data from this study (shared below) supports the hypothesis that participants have a vested interest in seeing their students succeed. However, they have also stated that the greatest obstacle to their goals of mathematical maturity and creative problem solving in students are often hindered by the lack of time they have each semester.

The issue of time. The lack of time is an extremely problematic area in the precalculus classroom, as identified by many participants. Professor Y made the terse comment that he “cannot approach the course in a way that, in three and a half months, [he] can patch all holes that students had in their math education: elementary and high school.” His matter-of-fact tone spoke to his nearly forty years of experience teaching at the post-secondary level. In addition to time being a problem for Professor Y, efficiency with large class sizes is also a problem. In particular, he questions how he can make himself available to two or three hundred students, the average class size at his university, in an time-effective way.

Professor X approached the issue of time in a different manner. His claim is that if a university provides a course, such as precalculus, with more time (e.g., separates it
into two semesters), students will still be more inclined to take the shorter course at a
different university so as to get it over with, unless the increase in time is a universal
trend. Furthermore, he argues that the separation of precalculus into two courses also
carries political implications, “where this is just the watering down of university math,
where what we did in two courses twenty years ago, [for example], now we’re doing in
three.”

In terms of time, participants also discussed how their universities are attempting
to combat the issue. First, Professor W works at a university where precalculus class
sizes are limited to thirty or forty students. As a result, she is able to enact a different
teaching style than if she had a large lecture:

I know their names… I keep their attention a little bit better. If they’re
talking amongst themselves, I can say, “Hey, Josie. Do you have a
question?”… If you’re talking to a hundred people, it’s really hard to
register if they are listening.

The remaining universities that the participants teach at do not have the benefit of small
class sizes, so instead take to different measures. An approach to helping students
efficiently in large classes is through the use of technology. Professor Y has a set of i-
Clickers in his lecture hall, small remote-controlled devices that sync up to the master
computer via bluetooth. Each student receives one as they come into class and use them
throughout the class to attempt examples on the board. Using a multiple-choice schema,
each student picks the answer they believe is correct and the answer shows up on the
board as a percentage of students’ choices, completely anonymously. Professor Y says it helps both students and teachers in the following way:

For students, this is a quick check-up [to see] where they are mentally or in respect to the [topic]. For [the] instructor, it is quite a reality check. You just gave your best lecture ever… You make something so trivial and so obvious and then you ask your 200 students and you see they they are divided into five equal groups all over the spectrum.

In this case, the instructor can go back and try to explain the concept in a different way to the entire class, rather than using up office hours to address the same problem one at a time. The i-Clickers are a way for Professor Y to simultaneously make a large class feel much smaller and save time for more individualized issues students are having.

Finally, Professor Z, a key player in the redesign of the precalculus program at his university, discussed how precalculus as a subject area is massive, but the focus for instructors should be on “reinforcing the fundamentals, which are more often those things that are missing, than factoring fourth degree polynomials.” The reason, he claimed, is because factoring fourth degree polynomials, for example, represents such a small sub-class of problems, that students are better off sticking to the basics. While time creates a unique problem for participants to deal with when trying to encourage mathematical creativity and maturity, they have developed some strategies to help cope. In addition, math help centres and other methods employed in and outside the classroom have also aided participants in furthering student development in mathematics.
The math help centre. Math help centres are key components of student success for every university involved in this study. The services they provide range from one-on-one tutoring support from graduate students in mathematics, to shortened “primer” courses, often offered as two or three week summer programs, to free preparatory courses extending over an entire semester. Additionally, the centres offer students the chance to be part of a community of learners and to recognize the need for help not because they cannot learn something, but because they need to have it explained in a different way or need to practice more. However, students are not required to utilize math help centres, and as a result, according to Professor V, there tends to be a “bias of grades” when looking at the effects of math help centres. He argues that the bias of grades is because the students coming into the math help centres are “motivated to get help, motivated to learn, motivated to get an ‘A’, etc.” Therefore, they are already exhibiting characteristics of a mature student. Furthermore, Professor Z commented that, during a provincial meeting last year, “although everyone is running the math help centres and we tend to believe strongly that it’s helpful, it doesn’t seem like there’s anyone that’s gathered data that would actually show one way or another.” Nonetheless, no participant held the view, or was willing to say, that math help centres do not help. Rather, it is that the data to support the theory is hard to obtain.

Nurturing relationships and enhancing knowledge. Outside of the math help centres and inside the classrooms and offices of those actively teaching bridging courses, participants mentioned how their own attitudes or interactions may help students through the transition from high school to university mathematics. Some participants mentioned
their passion for the subject as being a way to tear down students’ barriers. Professor W and Professor Y included their ideas of small class sizes and technology, respectively, as ways to teach for understanding. However, the most prominent feature of the pedagogy of participants was their tendency to view students as individuals. Every participant who is currently teaching a precalculus course made note that by treating students as singular and not as one group entity was the most important thing they could do to ensure success. Professor Y explains it in the following way:

We need to find a way to look at students as individuals, even in those big courses. We need to find a way to approach them as individuals and if you do this, I think we are going to support them in this transition. That doesn’t mean we need to compromise our criteria in any way, but if we listen to our students, it will show that we [think of] them as people. I think that would help them to deal with academics and everything else that is going on in this transition.

One way that Professor W does this is through keeping attendance records, which she explains is “a symbolic gesture… [doing] it mostly to let [students] know that it matters if they are there or not.” She goes on to comment that “universities [should] at least recognize that they are going to have a better success rate with the undergrads if they bring the teaching to a more personal level.” Outside of the classroom, Professor Y describes his time spent in office hours:

I make clear that I don’t have answers [for] my students. I have suggestions and I’m ready to share my suggestions. So I am rather as a
grandfather than a mother or father. And I think that approach is still respecting them and still putting some responsibility on my students.

While making it clear that he does not wish to be viewed as the omniscient professor, Professor Y also refers to the need for student responsibility, which was a common theme amongst participants. While the professor acts as a mentor, a grandfather, or a facilitator, students are required to accept responsibility on their end as well as work with the professor him/herself. Participants detailed a careful balancing act of not wanting to help too much, or as Professor W says, “spoon feeding”, with wanting to encourage success in mathematics. It is by forging and maintaining this balance that students are steered more clearly towards mathematical maturity and creativity.

In addition to the programs run at the university for students entering mathematics, two participants commented on the need to step back and respond to the Mathematics Problem through elementary and middle years education. Professor U provides an explanation as to why he believes many universities need to move towards more substantial mathematics education for elementary and middle years teachers:

It is my firm belief that if we are going to resolve issues of student preparedness in grade 12, we can't be working on what's going on in grade 12. We have to be working on what's going on in elementary school. I think that's where we are losing students.

Professor X currently teaches a math course designed for elementary and middle years pre-service teachers. Its main components include gaining a deeper understanding of the mathematics they are going to be teaching in elementary and middle years, learning
fluency in the symbols and terminology, and learning how to construct elementary proofs. The program is in its early stages and success cannot yet be determined; however, Professor X is hopeful. Participants in this study recognize the need for education long before the Mathematics Problem or the STT is relevant to students and are adapting to changes that their universities are making to accommodate that need.

Overall, the emergent themes from the data analysis lead to three concepts: (a) the duality of mathematics points to the complication of the Mathematics Problem; (b) the dual spaces of the STT and the lack of connection between them leads to the need for systemic change in how the Mathematics Problem is handled, (c) the perception that the university space is tasked with facilitating mathematical creativity and maturity requires a consistent plan, with the instructor’s relationship with the student being prioritized. Next, the data will be synthesized with previous literature to answer the research questions of this study and to provide areas where further research can take place.
CHAPTER FIVE: Discussion

Investigating the experiences, including perceptions and issues, mathematicians have with the Mathematics Problem, and draw meaning from them, is at the heart of this research project. This chapter will connect emergent themes from the data collection with the research questions and literature. First, the Mathematics Problem will be scrutinized under the supposition of the dual nature of mathematics. Second, the view of a deficit or asset-based model will be examined within the STT and suggestions on how an asset-based model would best contribute to bridging the gap between high school and university mathematics personnel will be given. Third, this section will further examine the example of how Stakeholder Theory could reshape precalculus, and other bridging courses, using the experiences of this study’s participants. Finally, I will examine whether the rite of passage framework is an adequate structure to implement based on the lived experience of participants of this study and the above discussion will be examined.

How Duality Breaks the Deficit Model

How the notion of the duality of mathematics affects the Mathematics Problem and approaches to remedy it is twofold. First, an examination will take place of how past literature on the development of the Mathematics Problem leads to the idea that mathematics has generally been looked at in a singular, unilateral way. Second, evidence supporting a shift away from a deficit model in the examination of the Mathematics Problem can be found in the data collected from this study.
The Mathematics Problem has historically been studied through the lens of quantitative data, specifically test scores (US National Commission on Excellence in Education, 1983; Crowther et al., 1997; Hawkes & Savage, 2000). While test scores provide an efficient way to look at many years of data in a short period of time, without breaking down the data to determine where the issues are, not only in content, but in cognitive thinking, the data is less useful. Furthermore, until recently, many of the tests used are almost exclusively multiple-choice in design, such as the American SAT and a large report from the UK, which only further hinder researchers from pinpointing where the issues in thinking are. More recent studies that use long answer testing, while being provided with a greater detail of thought process, are still fixated on basic mathematics skills and right versus wrong answers (Treacy & Faulkner, 2015). If mathematics is unidimensional, only built from skills and content, then the analysis of overall exam scores, while showing trends over time, still does not provide specifics about problematic areas in content, let alone something other than content and skills. Analyses make statements such as “only one third [of 17-year-olds] can solve a mathematics problem requiring several steps” (US National Commission on Excellence in Education, 1983, para. 12), and “high failure rates mean retention is worse” (Rylands & Coady, 2009, p. 751). However, there is no mention of the type of several step problems that students have trouble doing or what area of mathematics is problematic. As a result, entire groups of students are negatively characterized based on what they cannot do in an overgeneralized manner.
Unlike much of the diagnostic research done on the Mathematics Problem in the past, Kajander and Lovric’s study (2005) examined students based on a dual-dimensional system of mathematics. For example, students were asked to determine the rate of change (i.e., perform mathematical skill) and correctly interpret the results in the context of the word problem (i.e., engage in problem solving). By reporting on both the skill and the problem solving method, readers and other researchers gain knowledge into where the problematic areas are and how widespread they are, as well as what kind of issues they are. The perception of a multi-dimensional model of mathematics, as represented by this study, can provide more information on why the Mathematics Problem still exists, even forty years after identifying it.

While a deficit-thinking model has been a main focus of past research on the Mathematics Problem, the need for a different approach is evident in the lack of progress that has been made on the Mathematics Problem internationally (Ryland & Coady, 2009). Unfortunately, deficit thinking is not only pervasive in research itself, but in how mathematicians throughout this study viewed the prerequisite mathematics skills students were entering university with, or rather the lack thereof. Discussion on the lack of foundational skills to precalculus, such as operating with fractions and simplifying algebraic expressions, was frequent throughout the interviewing process when discussing issues with content knowledge. Moreover, mathematical immaturity and the lack of prioritization of mathematics, phrases with unfavourable connotations, were provided as reasons for the continued lack of foundational skills after classes had started.
However, in the numerous cases where creative problem solving came up in relation to the Mathematics Problem, the phrases used to describe the experiences changed. Inviting students to “play with a problem” was spoken of by two participants who try to encourage play through the passion they bring to the lecture hall. Additionally, when two other participants validated creative problem solving as a life skill in their own experience, they discussed how critical it is that students learn how to be creative problem solvers. The questions became ones of, “How can I create creative learners?” versus “Why didn’t students retain these skills from high school?” Evidence from this study supports the notion that deficit-thinking permeates every area of the Mathematics Problem in the university community. However, when mathematics is observed as two interconnected pieces, the need to fall into deficit thinking shifts. What deficit thinking becomes, nonetheless, depends upon the circumstances, beliefs, and experiences of those involved.

**Building a Bridge out of Assets**

An area most prominently affected by the deficit thinking model in this study is the perception of the high school space. As outlined in the findings, participants made a number of claims about high school teachers, in particular about their lack of working knowledge of mathematics, resulting in poor retention of concepts and skills in students. While there is existing literature to support their theory, such as the finding that exams in high school are graded to pass students (Gruenwald, Klymchuk, & Jovanoski, 2004) and the summary that surface learning, as opposed to deep learning, is most common in students exiting high school (Selden, 2005, p. 134), Selden also claims that other factors,
such as the expansion of student knowledge at the university level has lead to impediments for students in the STT, such as the development of the tangent line through geometry and calculus. There is also research that draws parallels between the Mathematics Problem and the lack of dialogue between high school teachers and mathematicians and how it has only exacerbated the issue (Hong et al., 2009; Wade, Sonnert, Sadler, Hazari, & Watson, 2016).

This lack of dialogue between the high school community and university community did not go unnoticed by the participants in this study. While the main concern for participants is the lack of higher mathematical knowledge K-12 teachers have, it is important to note that several Western Canadian universities are taking initiatives to further the mathematical understanding of future teachers. Participants discussed how programs that have been created to help elementary educators gain key insight into mathematics and how it can be taught in K-12 education. Professor X, for example, teaches a mathematics course designed for elementary and middle years preservice teachers. This course introduces several “baby proofs” to help future teachers make connections and build relationships between topics in mathematics, developing a deeper understanding of the topics they learned in grade school. As previously mentioned, the University of Regina is also looking to encourage current and future elementary and middle years teachers to deepen their mathematical content knowledge, problem solving, and pedagogy in the mathematics classroom (Undergraduate Certificate Programs, 2018). Professor U’s explanation that elementary school is pivotal to breaking the cycle of the Mathematics Problem offers insight into why universities are moving
towards additional programming for elementary and middle years educators. While the above programming offers grade school educators the opportunity to build a more foundational knowledge of mathematics, it is important to note that the majority of the programs have origins in education faculties, not mathematics departments and the programs described here are geared towards elementary and middle years teachers.

When looking at the STT and specifically the two types of educators directly linked to the transition, high school teachers and university professors, there has been little research done on bridging the gap between them. While most participants expressed a desire for an open dialogue with high school teachers in their community, few had experiences with it. What is evident, however, is that a deficit-thinking model is not advantageous in this situation. An asset-based model, on the other hand, could offer the beginning of a long-lasting relationship between parties. While a deficit-thinking model focuses on problems or areas that are lacking, an asset-based model looks at the strengths of the different parties in the community, or in this case, communities (“Comparison Between Asset and Deficit Based Approaches,” 2018).

Professor X highlighted an important paradox that exists between the perceptions of high school teachers and professors. While high school teachers do not know enough mathematics, and so cannot adequately teach students content, mathematicians who know the most mathematics may not have training in education, resulting in feelings of helplessness when they are first put into a lecture hall to teach. Here we have a case where teachers and professors are defined by what they cannot do- their weaknesses. If, instead, the situation is approached using an asset model, looking at the resources and
capabilities brought to the table, for example, a high school teacher’s pedagogical knowledge and a mathematician’s ability to connect unique concepts in mathematics, then a major shift towards opportunity can occur. It is important to recognize that an asset-based model does not only benefit the students in the STT, such as the Math Excel program at OSU discussed in the literature review; it also benefits the two other main parties pivotal to change in the STT. If teachers and professors engage in an asset-based approach to the Mathematics Problem, as opposed to a deficit-thinking model, one fraught with assumptions about one’s own and the other community, not only are students represented in a different way, but relationships between groups change and flourish.

One recommended approach to the Mathematics Problem is Stakeholder Theory. As mentioned in the literature review, Stakeholder Theory is the notion that all those involved in a business venture are invaluable to the successful creation and maintenance of the business (Freeman, Harrison, Wicks, Parmar & Colle, 2014, p. 24). As a result, each of their opinions is valued individually as well as a part of the relationships between parties (p. 26). Because Stakeholder Theory almost exclusively refers to business, it is not often described as asset-based. Asset-based approaches are typically attributed to areas of social justice. As a result, the asset-based approach and Stakeholder Theory are rarely considered together. However, the principle attribute of Stakeholder Theory is that every stakeholder is part of the decision-making process (Freeman et al., 2014), while an asset-based approach recognizes the value that everyone in the community, including individuals and groups, bring in the form of skills, interest, and experience (Central
Coast Community Congress Working Party, 2003), resulting in a cooperative, internally-driven decision-making process. It is thus reasonable to draw the conclusion that Stakeholder Theory can be used as an asset-based approach, one that could be highly advantageous for the STT community to utilize. Theorized advantages include the opportunity for all stakeholders to voice their opinions about the Mathematics Problem and the STT as well as present their strengths as tools to aid in the diminishing of the Mathematics Problem. Additionally, with an internally-driven decision-making process, stakeholders in the STT could act as influencers of change without worrying about external parties, such as the economy or politicians. Overall, the process of Stakeholder Theory offers the STT community with several strategies to help facilitate its remediation efforts of the Mathematics Problem.

**Precalculus: An Opportunity**

Currently, precalculus courses and other bridging courses in universities are designed exclusively by university personnel. Participants in this study describe the numerous teaching methods they employ in their classrooms: creating online modules for students to review prerequisite knowledge; creating exit assignments for students to practice foundational mathematics skills; and presenting their passion for mathematics in ways that they hope to rub off on students. They talk about building and maintaining relationships with students during class time, office hours, and even beyond. After speaking to the participants, it became evident that while they hope their students do well in their courses, creating people who enjoy or appreciate mathematics is also important. While few participants were explicit about this hope, it was a combination of the passion
they spoke with and the desire to build relationships with their students. Professor Z, however, was candid about how he hoped students would view mathematics, that is, “with a greater sense of purpose for all [the] tools that they’ve learned.”

Not surprisingly, high school teachers want the same things for their students: “to understand that the concepts they are teaching are meaningful. They want their students to make real life connections” (Meador, 2017, para. 6). By this standard, teachers and professors want the same thing; they have the same vested interest, yet so far have failed in addressing it together. They may have different opinions on how to achieve success with students, but that would all be considered during the decision-making process rooted in asset-based Stakeholder Theory. In addition to teachers and professors being key stakeholders, students could also be pivotal members of the process, providing their thoughts, opinions, beliefs, and perceptions. It is through the collaboration of these stakeholders and others that lasting change to the Mathematics Problem as a whole might be created to aid in the transition of students entering university mathematics.

**Implementing Lasting Programs**

While Stakeholder Theory offers a model for the decision-making process in developing programs to help facilitate students through the STT, the rite of passage theoretical framework is designed to assist stakeholders in implementing lasting programs. This section will discuss how the four principles of the rite of passage framework either coincide or conflict with the lived experiences and perceptions of participants. It is important to note that the perceptions that participants have of the high school classroom cannot be validated in this study. However, until the rite of passage
collaborates with Stakeholder Theory, or another approach that includes high school teachers, perceptions are valuable as *truths* to participants.

**Transition without duplication.** The first principle of the rite of passage framework, built on the notion that the experience in high school cannot be replicated in university is found in numerous conversations with participants. In particular, rather than focusing on content areas in mathematics, participants instead defined pedagogical actions they perceive to be different from those in high school. First, Professor Z explains the relationship he tries to develop between students and homework, one that changes as students mature, in the following way:

> The goal is to create independent learners and that means... learning at home... Think of homework as the central activity of independent learning... So somehow there's a transition from the youngest grades towards university, where certainly, independent learning is the goal.

While independent learning is the central goal for Professor Z at the university level, research into the effects of homework on grades in high school determine that there is little correlation between completed homework and final grade (Maltese, Tai, & Fan, 2012). Homework at the high school level is theoretically less centralized than it is at the university level. In this case, the rite of passage framework would accept the transition from dependent to independent learning as a transition without duplication. However, while Clark and Lovric (2008) describe areas in university mathematics that are not believed to be taught in high school, such as mathematical rigour, Professor Z’s view of homework as an independent learning experience is seen more as a gradual shift,
beginning in elementary school and finishing in university. This is vital as it recognizes
the individuality of each student’s experience through the STT. For example, some
students may have developed as independent learners before entering university, while
others may struggle and need assistance understanding what it means to be an
independent learner.

Another area frequently discussed by several participants was how they interact
with students and how they perceive interactions between high school students and
teachers. Professor W remarks on how she does not mark homework and is not
concerned with whether or not students attend class. From her perspective, “I am not
spoon feeding them… I’m not doing anything if they don't choose to come to class. So I
am treating them differently than they would be treated in a high school classroom.” The
need to give responsibility to students is evident in Professor W’s remarks, which is
different from how she views the high school classroom. In this instance, Professor W is
encouraging students to transition to university mathematics with the expectation that
they will take up more responsibility than they did in high school.

Professor Z and Professor W both provide examples where transition without
duplication is active in their pedagogy. While perspectives of high school classrooms or
teachers may not be accurately defined, without the voice of teachers themselves,
perceptions will remain unchanged.

**Transition without haste.** The most problematic area in the right of passage
framework is adequately addressing a transition without a timeline. As mentioned in the
literature review, while Clark and Lovric (2008) require that temporal constraints not be
placed on the STT, politics and finances often overrule this requirement in the real world. For example, Professor X compares a course offered at one university as a single semester course to the same course offered at another university but extending over three semesters. From this example, two main questions arise. First, are students willing to pay for three terms as opposed to one at another university? Second, what can be said about the academic integrity of the university offering the course over three semesters? Although the research supports the idea that students need more time doing mathematics in the STT (Kajander & Lovric, 2005), the above discussion questions how to make it happen in a way that satisfies students and policy makers.

As far as the lack of time participants felt they have in their classes, participants expressed, often in deflated tones, that successfully filling the gaps in students’ mathematics knowledge was an impossible feat in three and a half months, resulting in some participants exercising their academic freedom, such as Professor Z, who argued that factoring fourth degree polynomials was a skill that students could probably go without if he had to choose. While transitioning without any regard for time is great, in theory, it is much more difficult to implement in the real world, as supported by both this study and prior research.

**Transition towards maturity.** “It is the student who has to negotiate the transition” (Clark & Lovric, 2008, p. 33). While the university community provides numerous resources to ease the transition into university mathematics, this responsibility ultimately falls upon the student. The principle of transition toward maturity is ultimately supported by all participants of this study. All participants commented on the lack of
maturity that students come into their courses with. In particular, Professor W and Professor Y discussed the prioritization of their mathematics course for first year students. Professor W questioned whether unsuccessful students were not completing homework because they did not understand how to or if mathematics was simply not a priority. Additionally, the culture shock of moving from high school to university, according to Professor Y, is enough for students to neglect mathematics. While immaturity can showcase itself in many ways (e.g., lack of work ethic, incomplete assignments, inability to take initiative), from the perspectives of the participants, the common theme amongst perspectives is that it comes down to student prioritization of the mathematics course.

With this common theme in mind, participants offered numerous ways they and their universities have tried to remedy the problem. When examining technical skills, such as textbook reading and getting homework help, the most common method of aiding students was through math help centres. Unfortunately, as Professor V pointed out, students who were finding their way to his math help centre were students who were already motivated to take the initiative, students who would end up with A’s and B’s. They had begun, in whatever small way, to make a concerted effort towards maturity. Professor X explained how, in his work with elementary and middle years teachers, he uses his enthusiasm for mathematics when he is up at the white board to try to spark the curiosity and interest of students, to allow them to come to the conclusion that mathematics is worth doing. Professor W uses attendance as a tactic to let students know that she cares about them and that their success in mathematics is something she hopes to
see from them. Professor X and Professor W both employ their techniques subtly, almost subconsciously onto the student. Professor Y, on the other hand, is very explicit about his methods to encourage students to take the initiative:

“I’m there to listen to my students. And sometimes that’s all they need: someone to listen to them… to make clear that I don’t have answers for my students. I have suggestions… I’m rather as a grandfather than a mother or father.”

He makes it clear that he does not have answers for his students. He gives students choices and opportunities. His argument is that as long as students can feel like individuals, they will commit to growth.

It is the combination of help centres, which are typically set up to help small groups or even individual students, the will to inspire through passion, and the commitment to the individual student in a caring environment, that participants believe will aid students towards maturity. However, under the principles of the rite of passage framework in combination with Stakeholder Theory, getting a complete understanding of supports that will work to encourage responsibility and maturity in students requires the experiences and perspectives of another stakeholder in the STT: students.

**Transition towards ‘unlearning’**. Like the section on transition towards maturity, gaining a rich understanding of student’s process to *unlearn* mathematics is best done by speaking directly with students. Until this occurs, true stakeholder principles have not been implemented. However, understanding how professors
perceptions of unlearning have formed is also an important step in the process as professors have a role in facilitating the unlearning process.

Critical to mathematics, as discussed through the concept of mathematics duality, is creative problem solving. Participants claimed that many of their students do not understand creative problem solving in mathematics, let alone how integral it is to the discipline. This notion is at the core of the principle of unlearning (Clark & Lovric, 2009). Professor U encourages students to engage in productive struggle as they work on homework assignments. Unfortunately, his experience is that students will often try the same wrong method twice, as opposed to trying a new method the second time. In contrast to the negative connotation of “struggle”, Professor U and Professor X instead describe it as “play”. To “play with a problem,” one examines it and determines how they may go about solving it, try it, and try again in another way. Although productive struggle and play may be synonymous in this case, “play” invokes a good-natured action as opposed to “struggle.” Both, nonetheless, come down to developing creative problem solving and how to unlearn algorithmic ways of thinking about mathematics in favour of creative problem solving. All participants expressed the need for students to move beyond formulaic methods, but again, without involving and considering the voice and experiences of the student, achieving this transition may be difficult.

The combination of the four principles of the rite of passage framework with the perceptions of the participants of this study, provide a potential foundation for building lasting change in the STT in Western Canada. Additionally, an asset-based approach to the rite of passage framework could offer additional support within the STT. Stakeholder
Theory provides one such support as an internally-driven process to make decisions. It is through such recognition that lasting change can be implemented.

**Implications of this Study**

*The desperation I felt after marking those precalculus midterms on that hot August evening was a feeling I’d be grateful to be able to forget. I was at a complete loss, and even after several more weeks of teaching, I was not doing any better. Several students dropped out of the class before the final. In the end, even after changing my game plan for the second half of the semester, I still ended up with a greater than fifty percent fail rate. Out of my remaining thirty-seven students, only two had a final mark above a sixty-five.*

*If I could go back now, after many months of working through this research project, I like to picture that I’d do a number of things differently. I’d listen to my students in a way that participants say they do. I wouldn’t use the size of the class as an excuse to teach in a certain way. I’d have more practice for students, more time for collaboration, more time for learning. I’d fight a little harder to dissuade the typical evaluation criteria. I’d listen to my own voice, a mix of high school teacher and university instructor, but I’d listen to the voices of my students more. In essence, I’d change everything. (V. Braun, personal experience, 2018)*

The third research question of this study is the following: What opportunities does the research above have to influence current practice of the precalculus program at the University of Regina and beyond? In response, there are two recommendations that I would like to make to both the University of Regina as well as other universities in
Western Canada. First, practice Stakeholder Theory when designing new programming related to the STT. Second, utilize a rite of passage framework to move beyond viewing the Mathematics Problem as a problem, but rather as a critical time period that requires support, guidance, and independence. Together, these two recommendations can help to facilitate a smoother transition and aid in creating successful mathematics learners.

Utilizing asset-based Stakeholder Theory when designing new programming involves four steps: (a) determining who the stakeholders are; (b) determining how important each stakeholder is; (c) deciding what knowledge each stakeholder will bring to the table; (d) making decisions about the project as a collective group (Scheid, 2011, para. 7). In the case of the STT, a working relationship between mathematicians, mathematics teacher educators, high school mathematics teachers, and students is necessary. How these relationships work and the level of importance each will have would need to be decided as a collective, but Stakeholder Theory necessitates them in some capacity. It is evident through this study that the majority of decisions within the STT, as described by participants, are being made by either mathematicians on their own or by mathematicians and mathematics teacher educators. While a relationship between mathematics departments and education faculties is a start, it cannot be the only active relationship utilized while creating and maintaining programming.

In addition to the active relationships necessary to build superior programming, using a rite of passage framework will move stakeholders from deficit-thinking to an asset-based approach, with the opportunity to utilize strengths from all stakeholders. In particular, student voice is vital throughout any process undertaken as they are the ones
experiencing maturation and unlearning. It is through hearing their voices that educators in all stakeholder positions can gain a deeper understanding of how to foster maturity and unlearning. The rite of passage framework supports Stakeholder Theory as it brings forth value to the experiences of all stakeholders.

**Taking the Next Step**

*During my time as an education student, I very quickly became aware of catch words and phrases such as “student-led instruction”, “facilitator”, and “asset-based teaching”. My fellow pre-service teachers and I would watch videos, listen to lectures, and engage in activities that centred on these terms. We’d be encouraged to try them out in the classroom after watching successful stories of students engaged in meaningful learning, furrowed brows characterizing their concentration. We’d try it out, never with the same amount of success that the people we admired did.*

*Today, after listening to the stories and experiences of participants, dissecting them, and putting them back together again, I made a note of something that was missing each time I tried to redesign a lesson or try something new. Although I poured hours over creating lessons that I saw as beneficial for my students, I failed to incorporate their voices into the lesson, the very voices that I claim are assets in the classroom. The simple recognition is not enough. (V. Braun, personal experience, 2018)*

Going forward, there are a number of areas that can be further researched in relation to solving the Mathematics Problem. First, gaining insight into the perspectives and experiences of high school teachers and students transitioning may offer key information to contribute to Stakeholder Theory and the rite of passage framework and
how they might be applied to bridging the gap within the STT. Second, analyzing the relationships between teachers and professors in the mathematics community is beneficial to determine how perceptions between parties change as relationships form. Finally, researching a project that utilizes Stakeholder Theory, such as designing programming in the STT, at the university level would be pivotal to determining how it works in the university community.

Although there is a great deal of research that still needs to be done in respect to the Mathematics Problem and the STT, it is apparent through the body of research that exists already, that academia is taking notice. Furthermore, while a limitation of this study was the removal of passion and emotion from the raw data as it was transcribed, as discussed in the research design section of this study, it should be known that every participant in this study has made clear, through either explicit or implicit means, that they are actively working to remedy the Mathematics Problem in their own classes, universities, and beyond. It is through this interest and passion that the Mathematics Problem may one day cease to be.
REFERENCES


University of Regina and the University of Regina Faculty Association (2014). Collective agreement between University of Regina and the University of Regina Faculty Association, July 1, 2014 - June 30, 2017. Regina, SK. Retrieved from: https://www.uregina.ca/hr/assets/docs/pdf/employee-relations/Faculty-CBA-2014-2017-final.pdf


APPENDIX A: Regina Ethics Board (REB) Approvals
Beyond the Numbers: Gaining Perspective of the Mathematics Problem and Possible Interventions in Western Canada

March 30, 2017

The University of Regina Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period indicated. There is no change in experimental protocol, consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS

In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: http://www.uregina.ca/research/infrastructure/ethics-compliance/human/forms/ethics_forms.html.

Dr. Catherine Habash
Chair, Research Ethics Board

Please send all correspondence to:

Research Ethics Board
Research and Innovation Centre 100
Regina, SK S4S 0A2
Telephone (306) 337-7722  Fax (306) 337-8076
researchethics@uregina.ca
BEYOND THE NUMBERS

Research Ethics Board
Certificate of Renewal Approval

PRINCIPAL INVESTIGATOR
Vanessa Stein

DEPARTMENT
Education

RENEWAL

SUPERVISOR:
Dr. Gail Russell

TITLE
Beyond the Numbers: Gaining Perspective of the Mathematics Problem and Possible Interventions in Western Canada

ORIGINAL DATE OF APPROVAL
MARCH 30, 2017

NEW PROJECT DATE WITH Mandatory Renewal
MARCH 30, 2019

TODAY'S DATE:
MARCH 26, 2023

Full Board Meeting  
Delegated Review  

RENEWAL CERTIFICATION
The University of Regina Research Ethics Board has renewed the above-named research project for an additional 17 months beginning March 30, 2019.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair of the Research Ethics Board for consideration in advance of implementation.

ONGOING REVIEW REQUIREMENTS
In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open and under study completion. Please refer to the following websites for further instructions:
https://www.regina.ca/research/ethics/renewal-an-studies-and-reports

Art Steininger
Research Ethics Board

Please send all correspondence to:
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Research and innovation Centre 160
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Telephone (306) 337-6413, Fax (306) 337-6400
www.uregina.ca/ethics
APPENDIX B: Recruitment Email
[To Whom It May Concern],

My name is Vanessa Braun. I am a graduate student in the Faculty of Education at the University of Regina currently working on data collection for my thesis. My thesis, titled Beyond the Numbers: Gaining Perspective of the Mathematics Problem and Possible Interventions in Western Canada, is looking at how mathematics bridging courses, such as precalculus and mathematical modelling, are structured and implemented to encourage the mathematical success of first-year students. The objectives for my thesis are as follows:

1. Quantitatively determine whether or not the Mathematics Problem (the growing concern that incoming post-secondary students are not ready for university-level mathematics) is evident in Western Canadian universities

2. Learn how Western Canadian universities are guiding their incoming students towards success in mathematics

In order to determine whether or not the Mathematics Problem is affecting Western Canadian universities, I will be examining the failure rates of precalculus and/or mathematical modelling courses (i.e., bridging courses). After this, I will be reconnecting with universities through both individual interviews and focus groups to determine how universities today are helping students towards mathematical success in remedial programs.

If you have a course such as the ones identified above (e.g., precalculus) and would be interested in helping me with my project, please email me at: halas20v@uregina.ca. Also, please do not hesitate to ask for any clarification on any of the points above. Participation in my study is completely voluntary and you have the opportunity to drop out at anytime.

This study has received approval from the University of Regina Research Ethics Board.

Thank you for your time and interest,

Vanessa Braun
APPENDIX C: Letter of Initial Contact
[To Whom It May Concern],

Thank you for expressing interest in my research study: Beyond the Numbers: Gaining Perspective of the Mathematics Problem and Possible Interventions in Western Canada. As mentioned in the earlier email, my research study is broken into two parts: secondary data analysis and, later on, interviews and/or focus groups. Below are a list of several questions and requests I would like you to respond to, as well as my rationale behind asking them.

1. What is the name and nature of the bridging/remedial class offered at [insert name of University]? For example, is it a precalculus course, a mathematical modelling course, etc.

2. Please attach the syllabus to the reply of this email. The syllabus will be crucial in understanding how similar or dissimilar bridging/remedial courses are between universities in Western Canada.

3. Please attach a copy of past years failure rates, including withdrawals from the course since its conception/for the past ten years. Students names, lecturers/professors names should not be included if at all possible. The precalculus class offered at the University of Regina is only four years old. I understand that many programs may have seen an overhaul in the past 5-10 years. If so, I only require failure rates from the class in its current form. If it has been in existence for many years, I only need a maximum of ten years of data.

4. Would you be interested in being part of an individual interview and/or focus group with other Western Canadian universities about the bridging/remedial programs being offered? The purpose of the interviews and focus groups is to gain a deeper understanding on the perspectives, experiences, research, and current policies and practices being implemented by [insert name of University].

*Note: Because of the nature of the study, anonymity cannot be guaranteed during the data collection. For the final thesis, no names of universities, professors/instructors, or any other identifying feature will be used. Confidentiality is guaranteed for questions 1-3. Confidentiality for the next phase, interviews and focus groups, will be discussed at length for all participants.*

Immediately following the collection of the data, identifiers such as student names, lecturers/professor names will be removed if included with the data.

If you express interest in being a part of the second phase of the study, you will receive an email regarding interview policies and procedures. Please note that the interviews will last for approximately one hour and the focus groups will last for approximately two hours.
Completion of the above questions and requests will constitute consent to participate in the first phase of the study (i.e., secondary data analysis) and permission for the researcher to use the data gathered in the manner described. (Please see attached consent form).

Please reply to the questions above by sending an email to halas20v@uregina.ca. If you have any questions, comments, or concerns, please let me know. I look forward to hearing from you, and thank you, again, for your interest.

This study has received approval from the University of Regina Research Ethics Board.

Respectfully,
Vanessa Braun
APPENDIX D: Data Collection and Interview Consent Forms
Project Title: Beyond the Numbers: Gaining Perspective of the Mathematics Problem and Possible Interventions in Western Canada

Researcher(s): Vanessa Braun, Graduate Student, Faculty of Education, University of Regina, 403.652.9452, halas20v@uregina.ca

Supervisor: Gale Russell, Faculty of Education, 306.585.4510, Gale.Russell@uregina.ca.

Purpose(s) and Objective(s) of the Research:

- The data collected during this phase of the research study will:
  - provide statistical data on the nature of the Mathematics Problem in Western Canadian universities
  - help the primary investigator to gain an initial introduction into the Mathematics Problem to inform the second phase of the study: interviews and focus groups.
- This data will be used in thesis work, as well as other research, which includes publishing and presentations.

Procedures:

- As a secondary data collection, this phase relies heavily on the willingness of universities to provide failure/success (and withdrawal) rates of their bridging/remedial course offered.
- The format of the secondary data is not particular. Students names, professor/lecturer names are discouraged. All that is necessary is the semester, the class size, and the rates of withdrawal and failure.
- Additionally, you are asked to also send a copy of the course syllabus, so the primary investigator can gain a better understanding of the content of your bridging/remedial class.
- Please feel free to ask any questions regarding the procedures and goals of the study or your role.

Potential Risks:
- There are no known or anticipated risks to you by participating in this research

Potential Benefits:

- The most immediate benefit of this research is the ability to inform the Department of Mathematics and Statistics at the University of Regina, as well as other universities, on successful strategies and practices used to ensure mathematical success of novice university students.
- Currently in Canada, there is very little research on the Mathematics Problem (i.e., the notion that first-year university students are greatly lacking prerequisite mathematical knowledge and are experiencing high rates of failure). This study has the opportunity to inform the academic world on the Mathematics Problem and whether or not it is evident in Western Canadian universities.
Confidentiality:
• Because the principal investigator is in direct contact with you, anonymity cannot be guaranteed.
• You and your university’s confidentiality is extremely important and measures will be taken to ensure said confidentiality throughout the study. Any data sent with student/instructor names/numbers will be immediately deleted upon reception. Any identifiable information about you or your university will not be disclosed during the reporting or dissemination of the research findings.
• Pseudonyms will be used, where necessary, to ensure the confidentiality of you and the university you represent.
• Although the data from this research project will be published and presented at conferences, the data will be reported in aggregate form, so that it will not be possible to identify individuals. Moreover, the Consent Forms will be stored separately from the secondary data, so that it will not be possible to associate a name with any given set of responses.

Storage of Data:
• All electronic data will be stored on a password-protected laptop, and any physical data will be stored in a locked car during transportation and in a locked office otherwise.
• All data will be in the care of the primary researcher, Vanessa Braun, and her supervisor, Gale Russell once it is obtained from participants.
• All data will be stored for approximately six years, at which time the digital data will be permanently deleted and all other physical data will be destroyed.

Right to Withdraw:
• Your participation is voluntary and you can answer only those questions that you are comfortable with. You may withdraw from the research project for any reason, at any time without explanation or penalty of any sort.
• Should you wish to withdraw, please speak directly to the primary researcher, Vanessa Braun, who will, at earliest convenience, terminate all data related to you and your university.
• Your right to withdraw data from the study will apply until August 16, 2017. After this date, it is possible that some results have been analyzed, written up and/or presented and it may not be possible to withdraw your data.

Follow up:
• To obtain results from the study, please email halas20v@uregina.ca after November 1, 2017.

Questions or Concerns:
• Contact the researcher(s) using the information at the top of page 1;
• This project has been approved on ethical grounds by the UofR Research Ethics Board on March 31, 2017. Any questions regarding your rights as a participant may be addressed to the committee at (306-585-4775 or research.ethics@uregina.ca). Out of town participants may call collect.

Consent
IMPLIED CONSENT FOR QUESTIONNAIRE
By completing the questions in the email and sending data, YOUR FREE AND INFORMED CONSENT IS IMPLIED and indicates that you understand the above conditions of participation in this study.
Project Title: Beyond the Numbers: Gaining Perspective of the Mathematics Problem and Possible Interventions in Western Canada

Researcher(s): Vanessa Braun, Graduate Student, Faculty of Education, University of Regina, 403.652.9452, halas20v@uregina.ca

Supervisor: Gale Russell, Faculty of Education, 306.585.4510, Gale.Russell@uregina.ca.

Purpose(s) and Objective(s) of the Research:
• The data collected during this phase of the research study will:
  o provide qualitative data on what universities in Western Canada believe are issues in regards to are doing to help students become successful mathematical thinkers
  o gain the perspectives, beliefs, and attitudes of those working with novice university students in mathematics
  o potentially inform policies and practices at the University of Regina and beyond on future bridging/remediation mathematics courses
• This data will be used in thesis work, as well as other research, which includes publishing and presentations.

Procedures:
• Two types of interviews will take place: individual interviews and focus groups. You will have the opportunity to be involved in either or both of them.
• Prior to the interview/focus group, a list of questions to consider will be emailed to you to review. These questions will provide you with an opportunity to reflect on the material in the interview/focus group before engaging with the principal investigator and/or other participants.
• The individual interview will be approximately 1-hour in length, take place over the web-conferencing tool Zoom during a time that is convenient for both the principal investigator and you. That time will be decided upon via email. The interview will be recorded via Zoom.
• The focus group will be approximately 2-hours in length, take place over the web-conferencing tool Zoom during a time that is convenient for all participants, decided over email. The focus group will be recorded via Zoom.
• Please feel free to ask any questions regarding the procedures and goals of the study or your role.

Potential Risks:
• There are no known or anticipated risks to you by participating in this research

Potential Benefits:
• The most immediate benefit of this research is the ability to inform the Department of Mathematics and Statistics at the University of Regina (as well as other universities) on...
successful strategies and practices used to ensure mathematical success of novice university students.

- Currently in Canada, there is very little research on the Mathematics Problem (i.e., the notion that first-year university students are greatly lacking prerequisite mathematical knowledge and are experiencing high rates of failure). This study has the opportunity to inform the academic world on the Mathematics Problem and whether or not it is evident in Western Canadian universities.

**Confidentiality:**

- Because the principal investigator is in direct contact with you during the interview and/or focus group and you are in direct contact with other participants during the focus group, anonymity cannot be guaranteed.
- Your confidentiality is extremely important and measures will be taken to ensure you and your university’s confidentiality throughout the study. Any identifiable information about the participant will not be disclosed during the reporting or dissemination of the research findings.
- Pseudonyms will be used, where necessary, to ensure the confidentiality of you and the university you represent.
- Although the data from this research project will be published and presented at conferences, the data will be reported in aggregate form, so that it will not be possible to identify individuals. Moreover, the Consent Forms will be stored separately from the transcripts, so that it will not be possible to associate a name with any given set of responses.
- A limit to confidentiality is the possible storage of your IP address by the web-conferencing tool used for the interviews and focus groups, Zoom. However, Zoom guarantees that no relationship can be made between IP addresses and data collected.
- The primary investigator will undertake to safeguard the confidentiality of the discussion in the focus group, but cannot guarantee that other members of the group will do so. Please respect the confidentiality of the other members of the group by not disclosing the contents of this discussion outside the group, and be aware that others may not respect your confidentiality.

**Storage of Data:**

- All electronic data, including video and audio files, will be stored on a password-protected laptop, and any physical data will be stored in a locked car during transportation and in a locked office otherwise.
- All data will be in the care of the primary researcher, Vanessa Braun, and her supervisor, Gale Russell once it is obtained from participants.
- All data will be stored for approximately six years, at which time the digital data (transcripts, video files, audio files, etc.) will be permanently deleted and all other physical data will be destroyed.

**Right to Withdraw:**

- Your participation is voluntary and you can answer only those questions that you are comfortable with. You may withdraw from the research project for any reason, at any time without explanation or penalty of any sort.
- Should you wish to withdraw, please speak directly to the primary researcher, Vanessa Braun, who will, at earliest convenience, terminate all data related to you and your university.
- Your right to withdraw data from the study will apply until August 16, 2017. After this date, it is possible that some results have been analyzed, written up and/or presented and it may not be possible to withdraw your data.
- Focus Group: It may be possible that, prior to August 16, 2017, some of your data (i.e. a conversation between you and another participant), may be necessary for the full context
of the an idea/comment from another person and will be kept even after withdrawal from the study. Your own opinions, statements, etc. however, will be removed if desired.

Follow up:
• To obtain results from the study, please email halas20v@uregina.ca after November 1, 2017.

Questions or Concerns:
• Contact the researcher(s) using the information at the top of page 1;
• This project has been approved on ethical grounds by the UofR Research Ethics Board on March 31, 2017. Any questions regarding your rights as a participant may be addressed to the committee at (306-585-4775 or research.ethics@uregina.ca). Out of town participants may call collect.

Consent
• By signing Option 1 of the consent form, you agree to a 1-hour individual interview with the primary researcher.
• By signing Option 2 of the consent form, you agree to a 2-hour focus group with the primary researcher and up to four other personnel from other universities.

Option 1
Your signature below indicates that you have read and understand the description provided.

I have had an opportunity to ask questions and my/our questions have been answered. I consent to participate in a 1-hour individual interview for the research study. A copy of this Consent Form has been given to me for my records.

______________________________  _______________________
Name of Participant                Signature                 Date

______________________________  _______________________
Researcher’s Signature            Date

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Option 2
Your signature below indicates that you have read and understand the description provided.

I have had an opportunity to ask questions and my/our questions have been answered. I consent to participate in a 2-hour focus group interview for the research study. A copy of this Consent Form has been given to me for my records.

______________________________  _______________________
Name of Participant                Signature                 Date
A copy of this consent will be left with you, and a copy will be taken by the researcher.
APPENDIX E: Individual Interview Pre-Questions
[To Whom It May Concern],

As a participant in the individual interview, as discussed in the consent form, here are a list of questions to consider prior to the interview.

1. What is your role at the university and in the bridging/remedial class/program?
2. Why do you believe students are struggling with mathematics at the university level?
3. How does your university address these issues? If different, how do you think the university should be addressing these issues?
4. Is your program successful in helping students reach a university-level understanding of mathematics? How might it be more successful?
5. Do you believe all students struggle as they transition from secondary to post-secondary mathematics? Why or why not?

Although these are not the questions you will be directly asked, we are providing this list to you beforehand to give you the opportunity to begin considering the topics and themes of this study, as well as your responses to them.

If you have any questions, comments, or concerns, please don’t hesitate to contact me.

Thank you,

Vanessa Braun
APPENDIX F: Semi-Structured Interview Questions
Semi-Structured
Interview Questions

Questions

- Introduction: What is the nature of the remedial/bridging mathematics course offered at your university? How are professors/sessionals selected to teach it? What does the evaluation look like? What is the typical demographic(s) of the students entering this class? What is the typical format of the class?

- What kinds of supports are offered to students in class (e.g., office hours, labs)? What kinds of supports are offered to students outside of class (e.g., free tutoring services)? Are these supports effective? How could we improve their effectivity?

- What are your thoughts on the course offered, the policy and practices surrounding it, etc.?

- Do you believe that the Mathematics Problem (the notion that entering-university students lack prerequisite knowledge and understanding about mathematics) is evident in your university? Why do you think students are struggling with university mathematics, even when it may not be university-level (e.g., precalculus)?

- A number of published articles have come out of McMaster University in the past several years related to the secondary tertiary transition as a rite of passage, where students should be expected to do poorly until a complete transformation of mathematical thinking has taken place. In addition, it is argued that the university should try and replicate the high school experience and vice versa, that they are two uniquely-defined spaces. How do you respond to these ideas?

- Do you have any other thoughts about the Mathematics Problem?

*Note: Additional follow-up questions may be asked, as appropriate, with each participant.*
APPENDIX G: Transcript Release Form
**Project Title:** Beyond the Numbers: Gaining Perspective of the Mathematics Problem and Possible Interventions in Western Canada

**Researcher(s):** Vanessa Braun, Graduate Student, Faculty of Education, University of Regina, 403.652.9452, halas20v@uregina.ca

I, ____________________________, have reviewed the complete transcript of my personal interview in this study, and have been provided with the opportunity to add, alter, and delete information from the transcript as appropriate. I acknowledge that the transcript accurately reflects what I have said in my personal interview and/or focus group discussion with Vanessa Braun. I hereby authorize the release of this transcript to Vanessa Braun to be used in the manner described in the Consent Form. I have received a copy of this Data/Transcript Release Form for my own records.

_________________________    _________________________
Name of Participant     Date

_________________________    _________________________
Signature of Participant     Signature of Researcher