Engaging in Speculation and Critical Reflection About Future Assessment Practice

by

Stéphanie A. La France

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

Master of Education

Department of Secondary Education
University of Alberta

Abstract

I see assessment as a continuous and dynamic process and practice of sitting beside one-another and co-creating evidence of learning mathematics in a way that contributes positively to the strength, wellness, value and worth of the student, the students learning, and the discipline of mathematics. Unfortunately, my assessment practice in mathematics has not showcased this definition. In fact, I have exclusively used testing as a means of gathering data on students learning. This assessment practice is situated within sterile, isolative and competitive environments that act as a means to place students in a hierarchy of competence, the consequence being that privileged populations continue to be privileged within and outside of the classroom, and mathematics, as a school subject, becomes dehumanised. I have faced many barriers to moving towards alternatives to testing, some of which are hard to imagine overcoming.

The philosophy driving this inquiry is that I must dream first and negotiate later. As such, the purpose of this research is to investigate my dream for assessment in mathematics if the barriers I face now were not so concrete, and propose an alternative vision for my future practice. I engage in research with the above definition in mind, and ask: what might I come to know about my future assessment practice?

I use the Dynamic Systems Model for Role Identity as a theoretical framework with four components: self-perceptions and self-definitions, ontological and epistemological beliefs, sense of purpose, and perceived action possibilities (Garner & Kaplan, 2019). I weave autoethnography with speculative fiction to propose an alternative approach to assessment practice in a way that engenders critical thought an assessment practice in relation to self and students. In weaving the two methodologies together, I present a proposal of an alternative

approach to assessment in mathematics, and do so in a critically reflexive way so as to showcase the influence of my own role identity on what I perceive to be an ideal assessment practice.

Through this research, three qualities of assessment practice emerged which are holism, multiplicity and shared responsibility. These three qualities shift the attention to more equitable assessment practice. I then suggest a task and analyse it on the basis of its alignment with these three dimensions of assessment practice. Finally, I find a new understanding of a future assessment practice in terms of my own identity by engaging in identity work. The discussion yields new understanding and entanglements with how I come to know what students know, what it means to do mathematics, and my role of self-as-educator.

This research is about speculating on and interrogating future assessment practice, and is useful in so much as it speaks to others in the field, and provides researchers who study others to hear directly from one of those others. The contribution to scholarship in mathematics education provides further insight into how we conceptualise what assessment could be if we were to diverge from normative approaches that act as barriers to pursuing alternative futures for assessment planning and execution that isolate and dehumanise students.

Preface

This thesis is an original work by Stéphanie La France and no part of this thesis has been previously published. Work in Chapter 3 includes a diagram (Figure 5) that was adapted from a collaborative project between myself and Dr. Steven Khan; this work is cited in the document. Work in chapter 5 is heavily influenced by—but not part of—collaborative projects with Dr. Steven Khan and Ms. Hang Thi Thuy Tran on mathematics for multispecies flourishing. These collaborative projects were inspiration for the elements of flourishing discussed in chapter 5.

Acknowledgements

I would like to acknowledge the many people who helped to guide, supervise, mentor and counsel me throughout the research process. Thank you to my supervisor Dr. Elaine Simmt, who supported me both academically and personally, provided encouragement, and guidance throughout the process of two transitions in research topics, and helped shape my ideas. I would like to extend sincere gratitude to Dr. Steven Khan for his mentorship, support, encouragement and collaborations on the many projects that stretched my thinking, helped me heal my relationship with assessment (and at times, myself), gain confidence and reflexivity as a researcher and teacher, feel worthy in the research world, and develop my skills in writing. In addition, thank you for always pointing me in the direction of infinite yet excellent reading suggestions! Similarly, I would like to thank Ms. Hang Thi Thuy Tran for helping me extend my thinking and for continuously supporting my growth as a researcher.

I would like to acknowledge my sister Lianne La France, my father Marc La France, my mother Brenda Bush, and my partner Amirali Bukhari for always welcoming endless discussions around assessment and mathematics education, accepting that that was likely all I would talk about for three straight years. You each provided feedback, encouraged me, made sure I stopped to eat, exercise and sleep, and inspired ideas through conversation. Thank you to Soleil, for sitting with me and purring as I wrote.

Contents

Figures

1 Context and Introduction

My least fond memories of school are memories of being assessed; my least fond moments of teaching are moments when I had to assess and report. In my experience, conversations about assessment often seem to have a tone of officiality and criticality; it almost seems an overvalued part of curriculum implementation: *assessment this, assessment that, quality assessment, standardised assessment, marking, grading, formative assessment, summative assessment, assessment for the 21st century…assessment has to be right; it has to be precise; it has to be valid and it has to prepare students for the future!* All of these terms and phrases have been thrown around seemingly as to convey some sort of authority. Despite this authoritative tone, I have experienced great ambiguity in what assessment entails and how the different types of assessment are defined. This obsessive preoccupation with assessment, as I perceived it before beginning this research, deeply frustrated me. As I began to read more literature on the topic and reflected, I found that it was not the over-valuation in and of itself that was frustrating, it was the over-valuation of specific assessment methods that I found problematic. I further realised that I cannot control others' beliefs about and valuation of assessment, but I could explore my own relationship with various assessment methods and continue to unpack that frustration. I have little doubt that assessment will continue to be a pervasive phenomenon, which is why it was important to me that I explore, interrogate and process the nature of assessment, and my beliefs about it starting with my past experiences and moving towards future possibilities. What troubled me about my assessment practice? Why had I not acted on my frustration, and how could I overcome barriers that prevent me from doing so? What does an ethical and equitable assessment practice look like? What are the characteristics of a quality assessment practice?

1.1 Personal Beliefs and Position Regarding Assessment Practice

At the start of this research, four years into my teaching career, I was concerned with the relationship my students had with my assessment choices: how they interacted with tests, what messages they were internalising as a result of taking tests, and whether they felt they could fully express their knowledge in written form. I would have thought that by that fourth year of teaching, I would have become confident in my opinions regarding assessment. I contemplated: why must student grades be based solely on their ability to produce written information *independently* within an arbitrary time-frame and *without* access to other tools or resources? While this consistent wondering and worrying may at first have seemed troubling, it was the very thing that initialised my pursuit for better practice.

Despite my use of tests, I am not, in fact, a supporter of them. This potentially makes my actions even more ethically questionable, because I was knowingly using an assessment method that was not only perpetuating mathematics as an exclusive club, but was unknowingly preventing me from moving away from the deficit model of teaching (Aitken et al., 2011). Two years before entering the graduate program, I had implemented some accommodations including the removal of time limits, the correction of errors for extra marks, and the conversion of multiple choice and numeric response into short answer questions, but these solutions were quite superficial hence were not effective solutions; I have come to believe they were fruitless. Even more, my reflections on those experiences have convinced me that I continued to enable the valuation of grades rather than the valuation of progress—the irony being that the document used for reporting grades is called a progress report.

I needed to heal my relationship with my assessments practice, as complicated as it may be. I contemplated alternative assessments but, because of my lacking confidence, I chose to

assume my longing for and beliefs about alternatives were misplaced, and that, as a novice teacher, I was in no place to suggest changes[1]. As a result, my assessment philosophy remains in conflict with my assessment practice, and I have reached a tipping point as I enter graduate studies.

There is a particular scene in a show called *The Good Place,* where the character, Michael, is tasked with designing a neighbourhood in *the bad place,* which is aimed at torturing those who have not made it to *the good place*. He utters the question: "Do you ever get the feeling that we could be doing it all differently?" to his colleague, who promptly responds by saying: "Yea, I guess. But, don't rock the boat here, pal. Just try to do a good job" (Schur, 2017). In this scene, Michael has a particular idea that goes against the grain and has not yet even shared it with his colleague; even so, she does not hesitate to warn him that going against the standard practice is the wrong thing to do. While no one has ever explicitly told me "don't try alternative assessment,"—in fact, I was almost always encouraged to do what I thought was best for the students even if that meant trying something new—I always felt there was a hidden message that trying new things was too risky; it was almost as if the end to the sentence "do what you think is best," while not said out loud, was: "...but be careful not to try something too crazy because if it fails, that is not good for the kids." This really created a conflict in myself. I felt that my ideas about what I thought would benefit the students, was incorrect. It was as though I did

[1] Interestingly, I would never impose this belief on a fellow novice teacher—a sign that I am either uniquely critical of myself, or that there is another unconscious reason that I do not trust my own professional judgement.

not know what I was doing or saying. I was just some naïve young teacher coming in and trying to rock the boat.

I began my research in what would be[2] my fifth year of being a teacher to explore precisely those risky assessment practices that I found myself daydreaming about. It may be uncomfortable to explore the problem of my own assessment practice in more depth, but I feel an increased urgency for change and I accept that facing feelings of discomfort and even shame are part of my process towards a better practice. I intend to share the knowledge I gained through this research and through the Master of Education (MEd) program—or at the very least, overcome this negative internal dialogue. I intend to change my practice regardless of whether others agree to the same or not because I feel confident that, with the added expertise, I have the ability to justify the disruption; there is a sense of urgency and responsibility on my part, to do what I think is right. The compulsive and perpetual questioning and interrogation into my own practice is what guides me in this research.

The purpose of this first chapter is to contextualise my research. In line with the autoethnographic method, I begin with the personal and situational context which led to my research. This narrative is intended to provide a context for understanding my journey towards a harmonised professional identity in terms of healing my assessment practice. It is my assessment practice that has been the most salient point of contention between my multiple selves and their roles. Following this narrative, I describe the specific context of the research by introducing the reader to specific terms and concepts relevant to the study. This introduction to the research ends with a statement of the research problem, significance and question. Thus, this chapter sets the stage for exploring the landscape of the research.

---

[2] I did not teach for the duration of my graduate studies as I was on a full-time leave.

1.2 Personal Context

This section of the chapter is meant to showcase the personal and professional context that from which this research began to develop. I begin by broadly describing my current personal and professional situation, followed by three more sub-sections that narrow down the narrative to the specific phenomenon of interest: assessment. I use Mason's (2002) notions of accounting of and accounting for both to organise my thinking about my circumstance, as well as research my own practice.

1.2.1 Situational Context and Teaching Experience

Recently at my school we adopted what is called a common assessment practice. This common assessment practice entails shared assessment tasks—in my context, paper and pencil tests—administered and synchronised across math teachers and classes with the same content and format. As a result, each teacher is compelled to address units of mathematics in the same order and then test at approximately the same date for all students of the same grade. While my assessments were in the French language, they were direct translations of the English tests: same questions, same format, and same time. This synchronous assessment practice enables the mathematics department members in my school to collaborate more closely and develop professionally as we create assessments together; in my mind, it has also helped to keep students' experiences consistent across teachers. Not surprisingly, there was a level of constraint in the design of my assessments. My colleagues and I use paper-and-pencil testing for all of our assessment tasks including quizzes (not for marks) and unit tests (counts toward the final grade). In addition to these quizzes and tests, the school hosted midterm exams and final exams. This was a very ordered and efficient assessment schedule. However, the rhetoric used to describe our assessments confounded me. With few exceptions, we used the term: quiz to describe a

formative assessment, and exam: to describe a summative assessment. The term test was used ambiguously to describe a paper-and-pencil format of assessment. We marked, graded and reported the results of both quizzes and tests, the only difference was that the term summative (used synonymously with exam) was used to calculate a final course mark, while the term formative (used synonymously with quiz) was not. In other words, all assessments were paper-and-pencil tests that were intended to both inform instructional planning and to communicate information about student learning to students and parents. To me this indicated that formative and summative assessment I used in practice were not aligned with the definitions in the theory I encountered either in the literature or at professional development sessions.

Since the implementation of the common assessment practice in my school, I have often chosen to exclude multiple choice and numeric response questions from the quizzes and tests I designed and instead presented the test items as short answer questions. I have also re-organised some of my units of study, which meant that my students did not write exams in the same order of topics as others. Finally, I encouraged my students to make corrections to their tests for extra marks. Even so, my tests continued to mimic high-stakes assessments such as the Alberta Provincial Achievement Test (PAT) in content and item wording. They were prescriptive and sterile.

1.2.2 Account of Assessment Practice

In the following paragraphs, I provide an account of my assessment practice as it relates to the use of quizzes and tests that I have created. It is a description that is free of speculation in

regards to meaning or reason, which is intended to be as objective[3] as possible (Mason, 2002). In order to situate the exploratory analysis, I present a chronological description including the test planning and design process, the test-taking process, and the inferences and reflections. I have included an example of a test I used in **Appendix 1** which I refer to in the following discussion.

Pre-Assessment Planning. When planning for assessment, each test was set up to elicit consistent solutions to predetermined, uniform questions that were aligned with one or two specific outcome(s) from the Alberta program of studies (Alberta Education, 2008a, 2008b, 2016). This curricular document is the guiding document set out by the provincial government, and is intended to indicate the content that ought to be learned for any given grade within a given year. Consider the Math 8 Unit Test on Pythagorean Theorem (**Appendix A**). This test aimed to evaluate student knowledge of pre-selected specific outcomes from the Mathematics Kindergarten to Grade 9 program of studies (Alberta Education, 2016). Namely, this assessment was designed to measure the level of grade 8 students' understanding of the following three specific outcomes from the Grade 8 section of the document (Alberta Education, 2016) where it is said that students will:

- demonstrate an understanding of perfect squares and square roots, concretely, pictorially and symbolically (limited to whole numbers) (p. 46).
- determine the approximate square root of numbers that are not perfect squares (limited to whole numbers) (p. 46).

---

[3] The use of the term objective is not in the sense of absolute objectivity, but rather in a sense that the majority of teaching practitioners with my level of expertise (mathematics) and experience would come to the same conclusion.

- develop and apply the Pythagorean theorem to solve problems (p.48).

Said differently, students must be able to understand perfect squares and their roots using numbers, diagrams, and manipulatives. Secondly, they need to be able to estimate square roots of non-perfect squares (e.g., $\sqrt{23}$ is approximately 4.8). The final outcome notes that students must be able to use the Pythagorean Theorem appropriately to solve problems relating to right triangles. As implied above, it is reasonable for the reader to assume that all of my unit tests looked almost the same and were designed to assess and evaluate students' understanding of specific outcomes. Many of these specific outcomes begin with "demonstrate an understanding of…" and often attend to lower levels of thinking (Ben-Hur, 2006), resulting in an assessment that favours memorisation and application.

Assessment Enactment. The test itself was implemented as follows. The test was intended to be written within a specific time frame: one class period. In other words, a fifty-minute block was set aside for students to complete the test individually, and during this time there was no instruction. Should students require extra time, I provided time at lunch or after school. On occasion, there had been a large percentage of students requiring extra time; in such cases, I set aside a second period. Most of the time, I gave students access to a calculator but in every other respect the test was closed-book; that is, students did not have access to any other resource be it the internet, a textbook or a fellow classmate.

The expectations for students' role and enactments were that, during the assessments, they sat in silence as they filled in their solutions independently. Students were allowed to raise their hand or come to my desk to pose questions or clarify information. Throughout the many tests I have proctored or supervised, I saw some students write feverishly and others stare

blankly at the test (note that students may have fallen into both of those categories for any given test or school year).

Post-Assessment Evaluation. After students wrote their test, each was scored and given a grade based on a teacher key prepared by me with anticipated solution pathways; however, I will note that if a student's solution deviated from my prescribed answer, they may still have received full marks provided that their solution was mathematically sound. Students' course grades were then calculated using the equally-weighted mean of the grades received on the exams; quizzes, the assessments that were meant to prepare students for the weighted tests, did not count towards the students' final grade, but I tracked and reported the result in the progress reports to parents. This was the common practice at my school.

I noticed that, often, the day after a test, students were keen to know when their test papers would be marked; I have even on a few occasions had students come to me on the same day to ask if I had marked their test yet. After the assessments had been marked and retuned to them, I often witnessed students crumple up their quiz or exam immediately after seeing their grade. Some students disposed of their tests it in the garbage, others put them in their binder, perhaps never to be looked at again, and the minority of students kept the tests to review later. Occasionally, I would get follow-up emails from parents asking what could have been done better, or asking for extra resources that could be worked on at home.

For each of my tests, excluding midterm and final exams, I identified for each student, test questions that needed revision without indicating what specifically needed to be revised; I would very rarely indicate exactly *where* in their solution students fell off course. I then instructed the students to make corrections on their tests for extra credit. These were attempts to improve my assessment practice; they were merely band-aid solutions. While I, in some sense,

attempted to communicate that the grade is not the most important element and that there is value in correcting mistakes, my assessment still operated within a paper and pencil testing paradigm. In this research, I aim to explore that which lies beyond the testing paradigm and into some deeper questions about what I ought to attend to in my assessment practice.

1.2.3 Account for Assessment Practice

There are several fundamental problems with my practice of testing that trouble me. This section is a reflection on the process described above and includes my personal role, responsibilities and queries as it pertains to ameliorating my assessment practice—which could encompass so much more than exclusively tests. I explore some problematics which motivated me to seek alternatives to the use of current standard assessment[4] which I have used so faithfully in my own teaching. In this section, I use Mason's notion of accounting for in order to address these perceived problematics. That is, an exercise in contemplating multiple potential reasons, or attributing possible meaning to different events in order to make sense of the account of; so, the key factor in accounting for is the pursuit of multiple justifications, and not privileging one over the other so as to challenge one's own assumptions (Mason, 2002). This is a necessary context to understand the process of coming to the research question.

In the following paragraphs, I have organised my thinking into two categories of noticing: problematics in my own assessment practice, and concerns with respect to the relationship between student, parent and teacher in regards to the assessment practice. I have set up this section as a notice and wonder-type discussion, starting first by noting some issues I

---

[4] The term current standard assessment is a term I use to describe what is referred to in the literature as traditional assessment. See discussion in section 2.1.3

notice, then moving to suggestions or wonderings for why these issues may be problematic for me.

Noticing Problematics in Assessment Practice. I noticed that the act of testing tended to be an interruption to the instructional time I had with students. I perceived this interruption as intrusive which is something Ruthven (1994) talks about in terms of testing taking away from instructional time. In order to determine the level to which these tests have become intrusive to instructional time, I looked at the mathematics of it. I considered the following example: the 2018/2019 school year calendar had one hundred and eighty-two instructional days and, at my school, students had math every day—that is to say that this number was the total available days for learning. In grade nine, there were ten units, each of which were assessed using two quizzes and one unit exam for a total of three tests per unit. In addition, nine days were used for midterms and final exams. So, for the 2018/2019 grade nine year, 39 days were taken up by paper and pencil tests. This represented 21.4% of the available instructional time. In other words, my students sat alone at their desks writing a test or silently staring at the test in front of them for one fifth of the available instructional time. One might account for this interruption as being necessary because it is an efficient way to gather individual student data. Even more, perhaps the time limits imposed on testing were not arbitrary at all; perhaps they were negotiated terms in order to mitigate this interruption.

In addition to the interruption, I wondered if this assessment practice was isolative. I wondered if it facilitated a perception of mathematics as alienating[5]. While there is research

---

[5] Here, I use the term subject to describe school mathematics (otherwise known as academic mathematics) (Pinxten, 2016), and differentiate this from the word discipline—a word

evidence to support feelings of isolation in mathematics (Brown et al., 2008), I cannot necessarily account for this sensed isolation by attributing it to testing. I could not say with confidence, that any of my students felt isolated or alienated, nor might I have been able to account for it as resulting from something in my classroom. Nonetheless, I believed that it was partly to blame.

I noticed that my assessments were all very similar and I wondered if this practice is unnecessarily monotonous and repetitive. How might I account for this repetition? I could argue that it is good practice for the students to develop test taking skills in so far as it enabled students to develop a familiarity with test-type questions. However, I could not account for the written format other than to say that it was mostly a result of my familiarity with tests; this was the type of testing I had known both as a student and as a teacher. I believed that it was the most convenient and efficient format for me to collect as evidence, but even so, why should my own convenience supersede students' communication preference? Should efficiency be valued over complexity, and potentially clarity in communication? Even more, my beliefs were not supported by experience as I had only used one assessment method.

Noticing Student-Parent-Teacher and Assessment Relationships. As I watched those students who stared blankly at their tests, I found myself wondering why this could be. Often, it was those students that hand in blank exams, and all-the-while I knew that they knew the content and were able to verbalise this information through conversations during instructional time. In

---

I consider to encompass the whole of mathematics including content not found in school curriculum.

these instances, I was torn[6], because I knew that the mark on their test did not validly address their level of understanding, yet the evidence I had was the memory of an experience which may not be perceived as concrete evidence by others—or, I must admit, myself. I realised that as an educator I had professional judgement, but it was challenging to account for a grade using evidence that was anything but a concrete artifact of student work—something I could hand to a parent as proof of my judgement call.

In my experience I had found that students' grades tended to be predictable, with students scoring within the same range for every assessment. I was often able to anticipate a student's grade range before they had written the assessment. There were two possibilities for this phenomenon that came to mind: The first is that the assessments were very repetitive. The second is that I anticipated the grade based on informed observations I made during the instructional time. I wonder, if there is such predictability what is the value of the assessment task?

Students seemed to dread the test but once it has passed, they were keen to know their grade. Once they knew their grade, many of them abandoned or let go of the content that the test was meant to assess. This was evidenced by passing remarks from students: "Once the test is over, I just forget everything" or (jokingly) "I just memorise everything for the test, and then I forget it." I was inclined to account for this phenomenon as indicative that students believed the information had an expiry date for its utility or validity, and once the unit test was done, the unit content was irrelevant. In other words, retention of information was not seen as necessary. Did

---

[6] Torn between my own intuition and what is generally accepted as trustworthy objective evidence—privileging the scientific (Ehrenfeld & Hoffman, 2013).

the students believe that once the test was written, there was no point in going back to learn what they had done incorrectly? Looking at the example of the Math 8 test in **Appendix A**, I can see how this could be the case. Not only is the specific outcome itself fragmented (Friesen & Jardine, 2009), the items in the test were designed in a way that elicited fragmented content out of context, which becomes irrelevant after the test (Jardine, 1996, 2012). Question 4 attempted to appeal to a relatable context through the use of square roots with a square table, but one could switch the table with any other square object, and the question would not change, so, the table is irrelevant to the question. Even more, why would someone find the length of a table by taking a square root of its area, when one could just measure the side with a measuring tape?

1.3 Introduction to the Research Problem

The broad topic of this research is assessment in secondary mathematics; in particular, my area of interest is understanding alternative approaches to assessment. As many researchers in mathematics education have noted, the term assessment is rooted in the Latin word *assidere*, which means 'to sit beside' (Heritage, 2010; Pai, 2018; Suurtamm, 2018). This 'sitting beside' historically was used in terms of sitting with council in an assistive capacity in order to settle the amount of a tax or fine (Harper, n.d.a; Hoad, 2003; Klein, 1971). I find this extended context important to discuss because it implies that 'to assess' is much more than 'sitting beside'. In fact, there are two parts to the meaning of the verb assess: First, two people sit with one another to collaboratively negotiate[7]; second, the result of this negotiation yields a measurable value.

---

[7] Here, I feel it is important to mention that the power relationship between council and the person assisting council is rather ambiguous, which begs the question: of student and teacher, who is the judge and who assists the judge?

In an attempt to provide a comprehensive definition of assessment, I would like to explore the potential contribution of the term evaluate. In the English literature and rhetoric, there is a differentiation between assess and evaluate; namely, that the term assess tends to span the entire process of learning, whereas the term evaluate tends to imply the assessment of the final product, including the inferences made and what is valued (Kress, 2009). In French, however, the terms assessment and evaluation are used interchangeably, and in fact, both translate to the term *évaluation*. Consider the following English and French equivalents from the two versions of the Alberta program of studies:

1. “La planification de l’évaluation devrait établir un équilibre entre l’*évaluation au service* de l’apprentissage, l*’évaluation en tant* qu’apprentissage et l*’évaluation de* l’apprentissage.” (Alberta Education, 2008a, p. 13)
2. “The assessment plan for the course should be a balance of *assessment for* learning, *assessment as* learning and *assessment of* learning” (Alberta Education, 2008b, p. 12)

The word *évaluer* in French, while not found in ancient texts, carries its roots in quantitative measure or valuation (Féraud, 1994; Larousse, n.d.) and, as such, stands in alignment with the second assumption about the verb assess. In addition, both evaluation and évaluation stem from the Latin word *valere,* which means to "*be strong, be well; be of value, be worth* [emphasis added]” (Oxford University Press, n.d.a). I find this to be significant as I discuss modern conceptions of assessment within the classroom context, and for the purposes of this thesis, as it pertains to the whole of assessment practice, I would like to provide a working definition based on the above findings. In line with the methodology, I have chosen to use in this research, I note that this working definition is subjective and situated within my own cultural context. In this way, it may or may not be aligned with the philosophies of other educators, but

as I will discuss later, assessment practice is deeply personal and contextual. Even more, the basis of this thesis is to speculate about a future of assessment in mathematics, thus, I present the following definition for assessment:

Assessment is a continuous and dynamic process and practice of sitting beside one-another and *co-creating* evidence of learning mathematics in a way that contributes positively to the strength, wellness, value and worth *of the student*, the students learning, and the discipline of mathematics.

I have neglected to include the ever-present implications of quantitative value; the reason I have done so is that the term assessment was adopted in education as a formal term within a colonial paradigm (Aikenhead, 2017). This meaning has continued to pervade as a result of accountability pressures and the western compulsion to simplify or find simple answers to, complex processes or problems (Donald, 2020; Doolittle, 2006). As such, I have come to see grading and assigning a quantitative value to learning as an example of imposing a simple solution to the problem of accountability and measurement, and I found that there may be implications for usage as a means of behavioural management or incentivising learning which I find concerning.

1.3.1 Research Problem, Purpose and Question

Through reading the literature, I realised I am not alone in my concerns about testing and in my ideas about alternatives to testing. This next section intends to share with the reader this relatable literature that legitimised my own experiences with assessment. The evidence discussed below intends to introduce the topic and relevance of this research in order to later discuss its significance. The reader may find that this section focuses on the negatives of different assessment formats, and in that respect, it may seem to neglect the many affordances that

different assessments can provide; these affordances will be covered in the literature review as the current section is intended to showcase the research problem that has led me to pursue and imagine better futures for my assessment practice

Problem with Current Standard Assessment. The frequent use of current standard paper and pencil testing carried with it many issues. Aside from the obvious limitation in design variety these current standard assessments implicitly risked the perpetuation of negative and erroneous messages about mathematics through their design and goals (Skovsmose, 2008). When I used these sorts of assessments, my instruction tended to follow suit (Ben-Hur, 2006; Binkley et al., 2012). Students potentially learned what to value, at least in part, through my assessments. There was more to be worried about than shaping students' misconceptions about mathematics through current standard assessment.

Critics of current standard assessment suggest that tests are centered around evaluating lower levels of thinking (Ben-Hur, 2006; Horn, 2012). For example, current standard assessments "show only whether students can recognize, recall, and apply specific knowledge to solve simple problems" (Ben-Hur, 2006, p.109). In this way, current standard models of assessment are non-representative of "real" mathematics discourse and "it seems that the whole school mathematics tradition establishes a prescription readiness" (Skovsmose, 2008, p. 168), where prescription readiness refers to the ability to follow a pre-set list of instructions or tasks (as opposed to thinking creatively or thinking on the spot). Aitken et al. (2011) noted that many stakeholders were concerned by narrow assessment content; I found myself to be one of them. Thus, one of the challenges with using testing tends to be situated in the low-level prescriptive nature of it.

Another challenge with current standard assessment is that it tends to facilitate a performance mindset. Many assessments tend to value achievement over learning (Binkley et al., 2012; Horn, 2012; Kollosche, 2018; Kress, 2009; Matters, 2009), and Binkley et al. suggest that "when doing well on the test, rather than learning, becomes the goal, schools may unwittingly promote a performance orientation in students, which in turn can work against students' engagement and persistence in learning, metacognition, and self-regulation" (p.20). This concern is heavily dependent on how we use the reported evidence, so it may not be a problem exclusive to testing. For instance, when students do not achieve a certain standard on the current assessments, the resulting poor grade puts them at a disadvantage for pursuing higher levels of education (Andersson & Palm, 2017; Kollosche, 2018; Matters, 2009); in a sense, testing acts as a sorting mechanism (Kollosche, 2018), and uses a deficit approach to evaluating student learning (Aitken et al., 2011).

I find these issues particularly troubling because I have noticed that students' marks on unit tests more or less remain the same from test-to-test even across learning modules. This could indicate that testing favours students who excel in memorization and reproduction regardless of if they understand content (Kollosche, 2018). Even more, testing may leave other students at a disadvantage, even if they know the content (Kollosche). In this way, testing not only privileges a specific type of student, it may not provide accurate information about the level to which students become competent in mathematics.

I am not attempting to argue that testing has no place in mathematics education; rather, I am attempting to bring attention to deep-rooted concerns about the many faults and ethical questions surrounding its excessive use. Using testing in moderation, in and of itself is not a solution, and varied forms of alternatives to testing continue to be researched, particularly in the

domain of formative assessment (Duncan & Noonan, 2007). As an aside, I find the lacking pursuit of alternatives to testing for summative assessment interesting, and I wonder why much of the research focused on alternative assessment has been mainly in relation to or conflated with formative assessment. I wonder about this uneven exploration of alternatives to testing; is it a lingering side-effect of accountability pressures? Is it because there is great difficulty in converting the data from alternative assessment tasks into a reportable format (Stenmark, 1991)? Why do I (and many of my colleagues) cling so tightly to using only testing for summative assessment tasks?

Challenges with Alternative Assessment. As I mentioned before, current standard testing is widely used amongst mathematics teachers and tends to be the design of choice (Duncan & Noonan, 2007; Elharrar, 2006). Thus, it would seem that I am not alone in my resistance to (or negligence of) using alternative methods of assessment. Stenmark (1991) suggests that this may be due to the pressures teachers face as a result of high stakes testing. Teachers may be compelled to focus on preparing students for high stakes assessments by mimicking this format in their classroom assessments. As well, if teachers deviate from the high stakes testing formats, and begin to explore alternatives, there are a variety of challenges that they may face.

Firstly, one significant concern in the literature is in regards to the content expertise and assessment literacy of the teacher. Aitken et al. (2011), and Duncan and Noonan (2007) indicate that continuing with testing may be a result of many factors including teacher assessment literacy, teachers' comfort level, community support and reportability, and teachers' perceptions regarding external mediating factors—all of which require increased levels of expertise to negotiate. In line with my own experiences, common challenges associated with designing

quality assessments (especially if they deviate from the norm) include teacher expertise and self-efficacy (Aitken et al., 2011; Burkhardt & Schoenfeld, 2018; McMillan, 2003). Aitken et al. noted that, in Alberta, often the education that preservice teachers receive regarding assessment is limited, and that the availability of in-service teacher training or professional development is insufficient. Even more, teachers' content knowledge, in addition to their pedagogical expertise, influences their ability to design and implement alternatives that are suitable for the subject they teach (Burkhardt & Schoenfeld, 2018). current standard testing, then, may be the default assessment of choice because of the design challenges associated with implementing quality alternatives to testing.

A second challenge is due to the fact that, because the nature of teachers' assessment practice is so heavily influenced and aligned with teachers' instructional practice, using alternative assessment requires a significant shift in instructional methods as well (Burkhardt & Schoenfeld, 2018; Hargreaves & Earl, 2002; Stenmark, 1991). That is to say that the epistemologies are aligned between assessment and instructional practice, with some exceptions. Alternatives to tests suggest more of a constructivist approach to learning than a scientific measurement approach (McMillan, 2003). This philosophical shift influences the planning of assessments as well, because they are geared towards collaboratively designing assessments with students and parents (Kress, 2009; Stenmark, 1991). Involving students and parents as collaborators in assessment design requires that teachers give up at least some power in the decision-making process involved in assessment. This may cause a sense of threat (Hargreaves & Earl, 2002), perhaps to a teacher's sense of professional expertise or to their comfort level of control over their own practice. While this increases transparency of the goals of assessments, it puts teachers in a more vulnerable position for critique (Hargreaves & Earl, 2002). Aitken et al.

(2011) noted that teachers will often use assessment methods that are within their comfort zone, as a result of this increased vulnerability and shift in pedagogical planning and design, the use of testing in mathematics continues to be widespread.

Thirdly, the role assessment plays in student learning carries with it a great responsibility that must be handled with care. As mentioned before, one of the design principles is to consider the purpose of the assessment: what function or role does assessment serve (AAC, 2017; Thompson et al., 2018)? Similarly, one ought to attend to the validity: what is it that we are assessing? Is it measuring what we want it to? Is it serving the intended purpose (Binkley et al., 2012)? Even more, one of the more scrutinised elements of alternatives to testing is reliability: will this assessment reproduce similar results at different times and with varied learning groups (Maclellan, 2004; Stenmark, 1991)? These standards for evaluating the quality and integrity of an assessment may not align with the philosophies of alternative assessment; in other words, alternative assessment requires a different set of evaluative standards because it differs so much from the standard testing model, but these standards may not be widely accepted causing teachers to opt for current standard modes of assessment (Stenmark, 1991).

Fourthly, as with any assessment, the information on student learning must be translatable into a format that can be reported, either to parents or other stakeholders; as such, there are concerns over translating alternative assessment data into reportable data (Burkhardt & Schoenfeld, 2018; McMillan, 2003; Stenmark, 1991). This is directly intertwined with issues of community and stakeholder support (McMillan, 2003; Morgan, 1999). That is, the support of parents and administrators, and these stakeholders tend to be more comfortable with and understand assessment data that they, themselves, have experienced in the past (Graue & Smith, 1996) which, oftentimes is largely based on paper and pencil testing and quantitative data. Even

more, parents tend to value this quantitative data more, feeling that it is more objective and, as such, more trustworthy (Graue & Smith, 1996).

Finally, and related to the issue of reportability, McMillan's (2003) study indicates that teachers' assessment practice is often in conflict with their assessment philosophies—and philosophies about learning in general. Based on my experience and on the pressures, teachers face as a result of high-stakes testing, I would argue that teachers may be simply and deeply worried about trying new assessments because, if they fail, they may not sufficiently prepare students to achieve on the large-scale province-wide accountability testing. The measurement community is very much focused on academic performance yet, in contrast, teachers tend to value student effort and believe that behavioural elements of learning are important to weave into assessment practice (McMillan, 2003). This difference of focus and philosophical perspectives between stakeholders in regards to assessment decisions (Aitken et al., 2011) can prove to be a powerful motivator to continue the use of testing.

In conclusion, there are many problems associated with testing yet, there are also many challenges associated with alternative assessment. All this is to say that, despite well-known and commonly-experienced issues with current standard testing, there are a plethora of reasons for which myself and other teachers might refrain from trying a different approach to assessment, and in my case, adopting an assessment practice aligned with the speculative definition I provided above. These felt constraints and tensions risk not only acting on our longings to try new things, but may also prevent us from even contemplating what could be. This is the problem that has led me to explore research that offers an opportunity to move beyond these concerns by two means: first, the speculative approach provides opportunity for a thought experiment, which

carries no immediate risk to students; and second, the exploration facilitated by autoethnography enables increased expertise and development of unity of philosophy and practice.

Research Purpose and Question. It is interesting to think that my progression through this MEd program has been more of an oscillation than linearity. I continuously cycled between the practical and philosophical of what assessment could be, each course pushing me further into the muddiness (Haraway, 2016) of the issue. Eventually, I came to wonder what happens if we dream first and negotiate later? Soon after, I came across an affirming statement: "we must first dream and think differently ideologically, even if it seems abstract or against the grain, before we can act upon our ideas and seek to implement alternative visions for the future" (Eizadirad, 2019, p. 203). For me, this is a suggestion that we must dream first and negotiate later, and it is what guides my current research question which intends to investigate my dream for alternative assessment in mathematics with the intention of then proposing an alternative vision for my future practice and the mathematical experiences of my future students. If assessment is to be a continuous and dynamic process and practice of sitting beside one-another and *co-creating* evidence of learning mathematics in a way that contributes positively to the strength, wellness, value and worth *of the student*, the students learning, and the discipline of mathematics, then *what might I come to know about my future assessment practice?*

1.3.2 Research Significance

This research is partly a pragmatic solution to the limitations that resulted from the COVID-19 pandemic, and largely a result of my unwavering love for thought experiments and deep contemplation. My research is a personal exploration and interrogation of my own reflections, contemplations, perspectives and assumptions. As a result of this research, I heal my relationship with my assessment practice and strengthen my sense of self as professional. My

hope is that I might bring forth ideas worth sharing that rock the boat, and that inspire other educators to limitlessly contemplate their assessment practices.

This, according to traditional evaluative measures for research, seems insignificant at first—or at least is only deeply significant to a very narrow population. I suggest that the value *is* the element of subjective speculation. The methodology and theoretical approach woven together with this type of research can broaden the research literature, Haraway (2016) suggests that asking questions involves seeking unanticipated engagements, attentions and entanglements with "off-the-beaten-path practices" (p. 127), and that the answers that follow from those inquiries, while potentially risky, bring enrichment. This, in turn, becomes a cultivation of response-ability (Haraway, 2016). Here, what is risky is speculating about alternative assessments that push pressures of standardised test results aside, that contemplate alternative value hierarchies, and that destabilise the power of the program of studies used in Alberta (Alberta Education, 2008a, 2008b, 2016). I am curious about what happens when I 'creatively sidestep' those institutional, political and social limitations that, most times, prevent us from moving into a philosophical dreamscape that may surprise us as to its realistic, implementable actions.

"Curiosity always leads its practitioners a bit too far off the path, and that way lie stories" (Haraway, 2016, p. 127). Here, the 'too far of the path' is going too far in contemplating the philosophical possibilities. What stories might I find? This practice of engaging in absent or "off the path" curiosities enables the practitioner to "stay with the trouble in speculative fabulation" (Haraway, 2016, p. 133) situated in and influenced by "ongoing pasts...thick presents, and still possible futures" (Haraway, 2016, p. 133). I use my own narrative, my own self-exploration, and its influence on my pedagogical choices in combination with a methodology rooted in providing

relatable, relational and contextual content that welcomes the reader to make their own subjective truths (Le Roux, 2017; Richardson, 2000) about their imagined assessment practices.

1.3.3 Connecting Research Methodology, Theoretical Framework and Purpose

The purpose of the research is to explore a potential alternative future for mathematics assessment in my own teaching practice so that I might begin to imagine how it could be implemented. This alternative future is written as a fictional narrative aimed at speculating about my future assessment practice. This speculative fiction is written as a subjective interpretation of my own potential future practice; a practice that is imagined through the lens of current and future normative practices. As such, the methodology of autoethnography complements the methodology of speculative fiction. Without the autoethnographical component, I risk producing a self-involved self-satisfying narrative with no opportunity for healthy self-criticism and interrogation. In simpler terms, there would be no reality check.

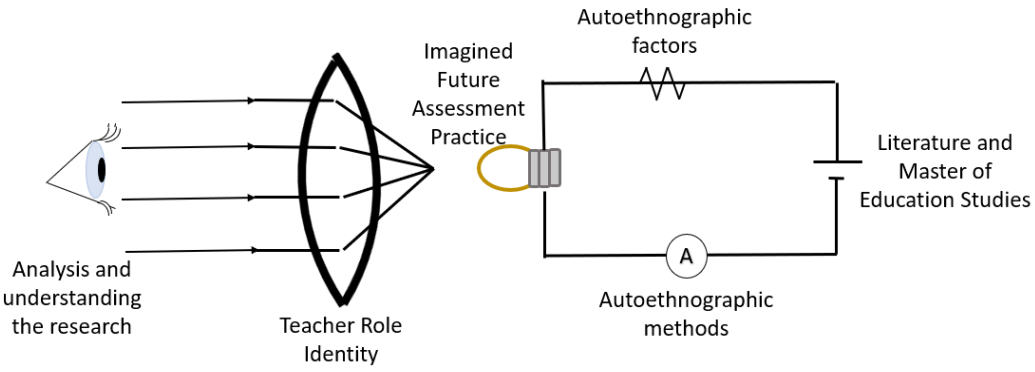
This is a very personal and subjective exploration, analysing and discussing the speculative fictions requires that I attend to my own sensitivities, assumptions and beliefs around assessment. Part of this requires that I maintain an awareness of how I perceive my role as assessor which, as I will discuss in the theoretical framework chapter, is influenced by my self-definitions and self-perceptions, my philosophical stance on teaching, learning and assessing, my sense of purpose which guides my decisions, and finally, the actions I perceive as possible within my teaching practice. I choose to use teacher identity as a framework for perceiving and interrogating these speculations and reflections. There are two parts to the next chapter: the first section outlines the literature regarding teacher identity using a specific model; the second section of this chapter intends to use this model to outline a personalised identity framework specific to my own context, which forms a basis for analysing the research data. The

contextualisation of the theoretical framework is necessary as this research is a self-study, and as such, it requires a personalised extension of the current literature regarding teacher identity. In essence, teacher identity enables deep understanding of teachers' choices, and the personal extension of teacher identity enables a deep exploration of my choices and speculations.

The research weaves together two methodologies (speculative fiction and autoethnography) to produce and analyse data in terms of my own teacher identity, and specifically, my professional role identity (the theoretical framework). I model the relationship between research purpose, methodology and theoretical framework in **Figure 1**.

Figure 1

Visual Depiction of the Research



Initially, I gather literature and review thinking (and assignments) within MEd program. This forms a basis for planning to write about imagined future practice—it is the potential differential that drives the research. The output is limited by autoethnographic factors including biases, blind assumptions, and subjective beliefs. The imagined future assessment practice becomes a concrete idea through the use of speculative fiction methods which are later analysed using autoethnographic methods. The process and product are understood and discussed using teacher identity as a framework because the autoethnographic method requires a deep understanding of the self and the contextual factors that influence thinking.

1.4 How to Read This Text

The chapters of this text follow a standard order. I begin with a chapter to introduce the context from which this research emerged and an introduction to the research with problem, purpose and research question. Following the first chapter, I present a body of literature that frames the research topic and introduces scholarship in the field of assessment in education; namely, classroom assessment. The third chapter, outlines the theoretical framework used to understand the research, while the fourth chapter, is intended to weave the two methodologies used in the study and the methods used to produce the research text. The fifth chapter is comprised of two fictional narratives that act as data to be analysed in the sixth chapter. Finally, following the discussion, I conclude with a summary of the research.

As I hinted at, above, there are two forms of writing within this thesis: fictional narrative and analytical. These two writing styles and the reasoning for using them are covered in detail in the chapter 4; however, for the purpose of briefing the reader, I shall elaborate, here. The methodologies woven together for this research include speculative fiction and autoethnography. Where the speculative fiction acts to provide, in a sense, data, the autoethnography acts to guide the analysis of the data. As such, I am essentially the participant of the research, and the two speculative fictions found in chapter 5 are intended to be read as essays with narrative examples throughout. The two speculative fictions form a body of text to analyse, using autoethnographic methodology. The analysis, on the other hand, is guided by an autoethnographic methodology. There are overlapping elements to speculative fiction and autoethnography which make them compatible to be woven together as a research methodology. As such, instead of presenting each methodology separately, I frame the methodology chapter in terms of the nature of the writing (both fictional narrative and analytical) and the nature of the research (both philosophical and

reflexive exploration-interrogation). In sum, the speculative fictions are likened to data and results, while the discussion is likened to analysis and discussion.

2 Literature Review

In order to speculate about a potential future of assessment, there is a need to investigate the current literature and proposed assessment practices within. This chapter is intended to describe the current landscape of assessment and my understanding of it, in order to set the stage for speculating alternative futures. I organise the following overview of assessment literature is organised into three main themes: technical aspects of assessment, which attend to specific structures, content, and uses of assessment data; evaluation of assessment, which presents literature regarding criterion for evaluating the quality assessment methods; and affective dimensions of assessment, which refers to the more abstract psychological implications of different assessment methods. These sections are by no means officially recognised themes; rather, they are how I have come to understand the intricate elements of assessment research. It is important to note that, while these themes are presented in organised categories, they are deeply interdependent and interconnected elements.

2.1 General Review of Assessment Relevant Terms

In the following paragraphs of this subsection, I excavate terms used in education with respect to assessment. Namely, I begin with a brief distinction between feedback and reporting, followed by an outline of different functions of assessment, and conclude this subsection with a conceptualisation of assessment in terms of design. These ideas in assessment are all important to consider when deciding on and designing classroom assessments. That is, assessments that occur within the classroom and are designed and implemented by the teacher. Feedback, reporting, function of assessment and design of assessment are important ideas to clarify, as they are rather broad in nature which allows for room for interpretation. The following discussions intend to clarify these ideas for the purposes of this study.

2.1.1 Feedback and Reporting.

There are two terms, feedback and reporting, which I intend to distinguish between for clarity. In order to assess student learning, there must be data provided by the student for the teacher to interpret and evaluate (Kress, 2009). For the purpose of this research, feedback is the result of the inferences and evaluation made by the teacher which is then communicated to the student, parent, or other stakeholder with vested interest. Reporting, on the other hand, is regarded as a sub-set of feedback; it is feedback in a form associated with summative data which occurs at the end of the learning period and is considered to be reportable (Stenmark, 1991). Thus, feedback and reporting are distinct but related.

2.1.2 Function: Assessment Of, For and As Learning.

The National Academies of Sciences, Engineering, and Medicine (NASEM, 2018) suggest that the purpose of assessment is to “drive the process of learning and motivation in a positive direction by providing feedback that identifies possible improvements and marks progress" (p. 153). In Alberta, which is my own teaching context, it is suggested that assessment be used to inform and guide pedagogy, help students set goals for their learning, determine grades, and motivate students (AAC, 2017; Learn Alberta, 2008). As outlined by the Alberta program of studies, the assessments for any given course "should be a balance of assessment for learning, assessment as learning and assessment of learning" (Alberta Education, 2008a, p. 17); this is further reflected in policy documents and district initiatives which will be discussed more in depth in the theoretical framework. Each of these three types of assessment bring unique tensions and challenges with them as they each serve different functions.

The first type of assessment is, in my experience, more elusive; it is formally known as assessment as learning and is meant to help students reflect on their own learning using the

feedback given from assessments for and of learning as well as feedback from peers and other experiences during instruction (Bennet & Gitomer, 2009; Learn Alberta, 2008). This form of assessment is required as per the Alberta program of studies (Alberta Education, 2008a, 2008b, 2016) which notes in the Affective Domain section: "students must be taught to set achievable goals and to assess themselves as they work toward these goals" (Alberta Education, 2008a, p. 4). In other words, assessment as learning functions to provide opportunity for students to reflect on their learning and is intended to be a more metacognitive practice. Some examples from my own practice include asking students to reflect on their answers or having students journal about the lesson. In my case, none of these assessments are logged or tracked in anyway.

*As*sessment *for* learning—also referred to as formative assessment—is intended to be used on a daily basis as a way of giving specific feedback that will allow students to progress further in their learning, and that will inform the teacher in their instructional planning (Learn Alberta, 2008; Thompson et al., 2018). In my experience, some formative assessment occurs in the form of a mental note in the moment, while other formative assessment occurs as planned events which later get logged in a grading software. This is reflected in the literature, as formative assessment is often an ongoing process throughout instruction which addresses the current learning level or competency of the student at any given moment (Black & Wiliam, 2009; Suurtamm et al., 2016). The insight gained from formative assessment is used to guide both the teacher and the student on how to bridge the gap between where students are in the learning process, and the learning outcome (Boaler, 2016; Frey, 2014; Thompson et al., 2018), and is “essential feedback” (NASEM, 2018, p. 154) that forms a foundation for empowering students (Boaler, 2016). In other words, this type of assessment does not count as reportable

data, although in my experience, we do report this feedback in the form of grades but they do not count towards students' final mark.

If I want to calculate the students' grades, I use a third type of assessment called assessment *of* learning—also referred to as summative assessment. The function of summative assessment is more narrowly defined: it is meant to provide evaluative information on students' achievement of learning outcomes at the time of assessment (Kress, 2009). The data collected via summative assessment is meant to be used for reporting purposes only, and has little influence on learning (Frey, 2014; Learn Alberta, 2008); this is reflected in my experiences witnessing students crumple up their tests after they see the mark. In essence, assessment *of* learning is the evaluation that happens when the defined period of time in which a student is expected to meet a benchmark has ended; for example, a test that comes at the end of a learning module (Bennet & Gitomer, 2009; Binkley et al., 2012; Suurtamm et al., 2016; Thompson et al., 2018).

Within the category of assessment *of* learning lies a very specific type of test called high stakes testing, or accountability testing. These tests occur at the end of the learning period (often at the end of the year, and their function is to make judgments about the quality of an educational system for accountability purposes (Thompson et al., 2018). In Alberta, examples of these tests include the Provincial Achievement Tests (PAT) or the Diploma Examination which are designed by governing bodies to measure on a large scale, the achievement of learning goals. These standardised tests, regardless of their summative status, tend to guide all three types of assessment (Binkley et al., 2012). They carry with them great influence in teachers' instructional and assessment practice.

To summarise, assessment *for* learning functions to provide feedback (in all of its forms) to the student between summative assessments and guide instruction, assessment *of* learning is

what determines the grade and is used for reporting, and assessment *as* learning is the guided reflection where the student has the opportunity to assess their own understanding. Thompson et al. (2018) and Pai (2018) suggest that an assessment can act as formative and summative simultaneously. An example of this might be quizzes, which are essentially unit tests whose marks give feedback that does not affect student grades, but are nonetheless used to guide learning and are simultaneously logged in a system for reporting purposes. These three functions of assessment have important implications in discussions regarding alternatives to paper-and-pencil testing.

2.1.3 Design: Alternative and Current Standard Assessment.

The function the assessment is intended to serve has influence on the mode and design of the assessment. In order to accomplish any one of these three functions, assessments can take many different forms design-wise (AAC, 2017). Two terms used to describe this design are current standard assessment—noted by Binkley et al. (2012) as traditional assessment—and alternative assessment Birenbaum (1996). These two designs of assessment are not entirely defined independently; in fact, I would conceptualise their sub-characteristics them more each being two ends of spectrum, where the sub-characteristic spectra all form a spherical space in which an assessment might lie (**Figure 2**). The following paragraphs, then, intend to discuss in more detail the current standard-alternative assessment multi-dimensional space.

The term current standard assessment is a term I use to describe what is referred to in the literature as traditional assessment. Traditional assessment as is characterised in the literature, includes paper-and-pencil tests that mimic the format and execution style of high stakes testing; they include largely multiple choice and numeric response questions but may include written response questions as well. The reason I have chosen to refer to this method of assessment with a

different name is because the word traditional is troublesome. Traditional implies a long-established practice existing as part of a tradition (Cambridge University Press, n.d.c; Oxford University Press, n.d.d). The trouble is that paper-and-pencil testing, while a long-standing practice in modern education, is not the traditional form of assessment historically speaking (Ben-Hur, 2006). In fact, the original means of assessment included more apprenticeship-style evaluations such as consultations or interviews (Ben-Hur, 2006; Stenmark, 1991), which are more in line with the definition for alternative assessment. Thus, in order to avoid ambiguity, I am using the term current standard assessment as it pertains to the most commonly used form of assessment in modern mathematics education (Elharrar, 2006).

Alternative assessment is term used to describe methods that deviate from testing. Birenbaum (1996) stated: "a variety of methods and devices are subsumed under the alternative assessment umbrella" (p. 8). The artifacts for evaluation (student data) using alternative assessment differ from current standard assessment because of the nature of the design, execution, student response and/or the feedback. These differences may be in regards to mode in which the prompt is presented or mode of student response (Kress, 2009), the content and level of rigour of the assessment (Ben-Hur, 2006; Boaler, 2016; Horn, 2012), and format (Ben-Hur, 2006; Birenbaum, 1996; Boaler, 2016; Horn, 2012; Suurtamm et al., 2016), where format refers to the nature of the implementation including timing of the assessment. Alternative assessment could be utilised as a formative evaluation or a summative evaluation; it depends on how it was designed and the function it serves. Thompson et al. (2018) noted that alternative assessments are typically a collaborative effort between teacher and student, making them learner-centred (Bennett & Gitomer, 2009; Horn, 2012; Thompson et al., 2018), whereas current standard assessments are more teacher-centred (Cumming & Wyatt-Smith, 2009). This is evidenced by

the collaborative nature of the assessment tasks, where the collaboration is both among students and between teacher and students (Horn, 2012; Suurtamm et al., 2016). Further, alternative assessments are typically feedback oriented, multimodal (Beesley et al., 2018; Kress, 2009) and address higher levels of thinking through open-ended tasks (Bennett & Gitomer, 2009; Swan & Foster, 2018). Thus, alternative assessment is broadly characterised as assessments that go "beyond [current standard] paper-and-pencil tests" (Cumming & Wyatt-Smith, 2009, p. 2). It is for this reason that I conceptualise current standard versus alternative assessment as existing within a space[8] made up of a set of spectra, each of which define a particular dimension of assessment. For the purpose of conceptualising the differences between alternative and current standard assessment, I will focus on three spectra, as the main differences between current standard assessment and alternative assessment can be conceptualised using (1) modality, (2) focus-orientation, and (3) roles and responsibilities. This is not to say that there are only three spectra that make up the set defined by this space; rather, there may be multiple dimensions one might use to compare differences between the two types of assessment. For ease of visualisation, I will discuss the aforementioned three.

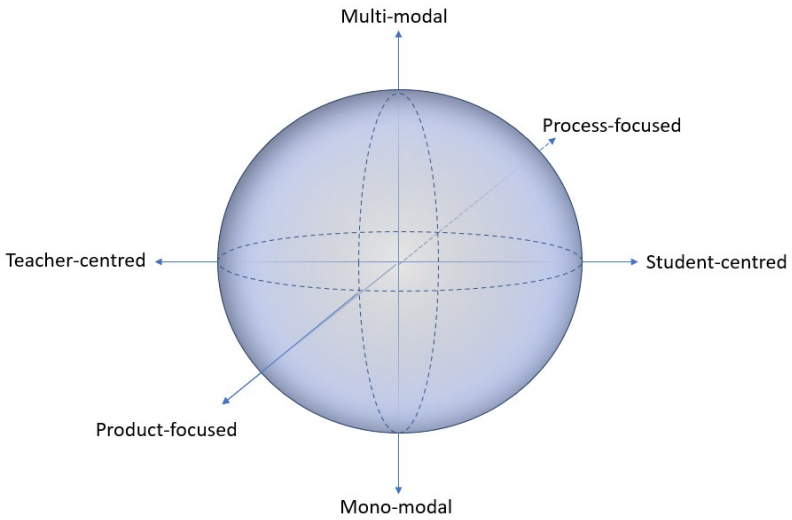
If one were to look at the three dimensions: modality, focus-orientation and role-centredness, we would find a space of three dimensions, each axis being a spectrum that represents an element of the set (**Figure 2**). An assessment task could lie in any given quadrant. Where current standard assessments tend to be mono-modal, alternative assessments tend to be multi-modal; where current standard assessments focus on product, alternative assessments are

[8] Here, I use the term space to describe a mathematical space, which is defined as a set of two-sided spectra.

designed to emphasise process; and where current standard assessments are teacher-centred, alternative assessments aim towards a shared ownership and student-centred approach. These three differences occur to various extents and are represented in **Figure 2, 3,** and **4**.

Figure 2

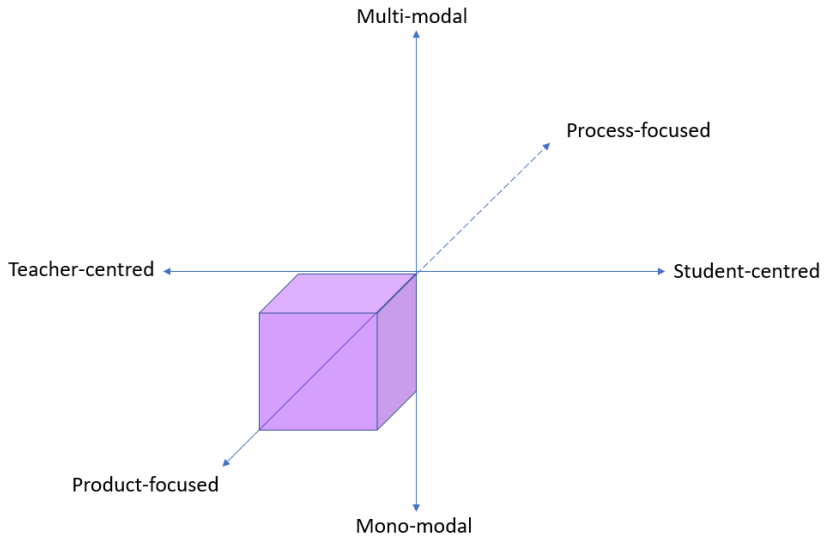
Visualisation of Current Standard Assessment and Alternative Assessment



Note. I would suggest that there is a fourth dimension (undepicted) that is: interdisciplinary-monodisciplinary.

Figure 3

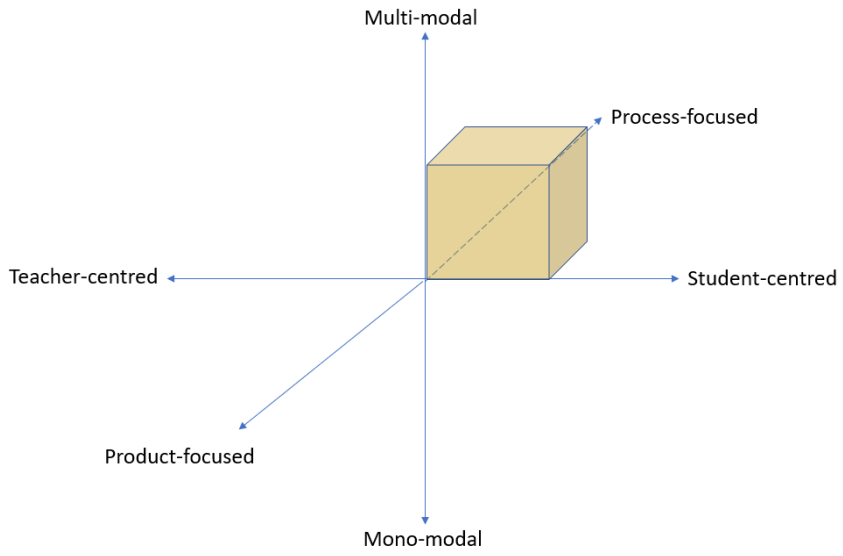
Visualisation of Current Standard Assessment Practice



Note. This diagram intends to represent the quadrant within which current standard assessment tends to dwell. Current standard assessments are teacher-centered—that is, designed, executed and evaluated by the teacher; mono-modal—typically written productions; and product-focused—namely, focused on the solution.

Figure 4

Visualisation of Alternative Assessment Practice



Note. This diagram intends to model the extreme of alternative assessment as per the literature. Alternative assessments aim to be multi-modal—prompts and student productions can take many forms; process-focussed—the goal is the solution pathway or the what of what happens before the solution is found; and student-centred—designed and implemented in collaboration with students or by students.

2.2 Assessment Design

As I noted above, whether an assessment is formative or summative depends on the inferences made from the assessment and how this information is used (Suurtamm, 2018). In this way, the assessment does not become an assessment until the information is used for some purpose. For the purposes of the following discussion, the main focus will be on describing the nature and design of assessment rather than the function. However, one must not forget that the function of an assessment influences the design as they both form a basis for evaluating the integrity of the assessment (AAC, 2017; Worthen, 1993).

Assessments can be designed, executed and used in a multitude of ways. As such, it is the teacher's responsibility to select the appropriate assessment method and design based on their professional judgement for what provides the most valid information about students learning (AAC, 2017). Both current standard and alternative assessments, as terms to describe design, can technically function as assessment *for* learning, assessment *of* learning or assessment *as* learning. The design and execution of assessment is the focus of this literature review.

2.3 Technical Aspects of Assessment

There are many considerations to be made when planning for assessment; this section intends to address the technical design components when it comes to planning and implementing a particular assessment. I choose to discuss these technical aspects under three main categories: assessment structure, which refers to structural elements such as format, roles and responsibilities, and timing; the assessment content, which is characterised by the discipline-specific content being assessed, the type of knowledge/skill addressed and the level of rigour involved in the assessment; and inference and reflection, which refers to the way in which the assessment data is interpreted and used. I have chosen to define and discuss these three dimensions and their sub-components separately, but it is important to note that, first, they are deeply interconnected and co-dependent, and second, that my choice to discuss assessment in terms of these themes is based on how I have come to organise my thinking around assessment. It is also not my intention to suggest that assessment practice can be fragmented in such a way as to plan and consider each component separately.

2.3.1 Structure

I use the term assessment *structure* to refer to the aspects of assessment that involve the specific structural elements of an assessment that are unique from the content. Structure, as I

conceptualise it, includes considerations about mode (including the mode of the assessment prompt and student response), the roles and responsibilities of each participant, and the nature of the timing. These three elements, while influenced by and influential to the content of the assessment, are separate from subject matter.

Mode. Mode refers to the way in which a prompt or student response is presented (Kress, 2009). For example, there are many ways in which we might elicit student expression, observe learning or express learning including listening, seeing, acting, verbalising or feeling. While current standard assessment tends to focus on written prompts and written student responses, assessments can include multiple modes of representation and expression (Beesley et al., 2018; Kress, 2009). Given that part of deeply understanding a math concept is being able to represent content in multiple ways (Roicki, 2016), it follows that quality assessment practice is situated in providing multiple and varied opportunities for expression and action (Kress, 2009; Suurtamm, 2018). In other words, considering the mode of the assessment prompt and the students' responses is part of planning for assessment, and assessment practice that is characterised as multimodal would include a variety of different modes of communication.

For example, one mode might be to use performance or demonstration, where students are given a performance task or demonstration of learning (Ben-Hur, 2006; Moon, 2004; Suurtamm, 2018; Tveit, 2009) either through direct interaction or via simulation (Bennett & Gitomer, 2009), and the teacher engages in observation of the students' interactions. During this time, there may be a verbal element added where the teacher or students ask focused questions during the task and engage in mathematical discussions (Boaler, 2016; Horn, 2012; Liljedhal, 2016; Suurtamm, 2018; Pai, 2018). Similarly, a verbal-style mode of assessment that is more targeted might include informal interviews, presentations, small group conferences or whole

class discussions (Ben-Hur, 2006; Horn, 2012; Stenmark, 1991; Suurtamm, 2018; Pai, 2018) which could occur in the moment or as planned events. An example of a written/textual mode of assessment could be the use of a test or reflective journal, either written by hand or using technology (Bennett & Gitomer, 2009), or a production of some artifact such as from a project (Birenbaum, 1996; Stenmark, 1991; Suurtamm, 2018). Each of these assessment artifacts may be prompted and responded to via written or verbal communications and acted out either by demonstration or dramatic expression. As opposed to current standard assessment, alternative assessment practice provides opportunities for multiple modes of prompts and expression of learning (Birenbaum, 1996; Kress, 2009).

Roles and Responsibilities. The second matter to consider in regards to the structure of the assessment is that of the roles and responsibilities of those involved; namely, the extent to which the assessment is student-centred or teacher-centred. An assessment is student-centred when planning for assessment involves teachers proactively anticipating students' responses and/or potential misconceptions (Holm, 2018; Suurtamm, 2018), or including students as collaborators in assessment design. In this instance, the role of the teacher is to be the moderator (rather than leader or all-knower) between student and program of studies through thoughtful assessment design (Gipps & Stobart, 2009; Wyatt-Smith & Gunn, 2009). In contrast, an assessment is teacher-centred when the assessment is designed independent of consideration for students' dispositions. For example, current standard assessment tends to be teacher-centred (Cumming & Wyatt-Smith, 2009) because they are designed, implemented, and evaluated by the teacher; the student is only responsible for providing answers to the items on the test. Proponents of alternative assessment suggest that it would be wise to adjust or shift practice as to create a collaborative effort between teacher, student, and in some instances, parents (Bennett & Gitomer,

2009; Horn, 2012; Kress, 2009; Thompson et al., 2018; Suurtamm et al., 2016; Wyatt-Smith & Gunn, 2009). In this way, alternative assessment practice is one that is student-centred where the roles and responsibilities of all participants are shared.

The justification of student-centred approaches to assessment has much to do with the nature of making inferences about student expressions (Kress, 2009); that is to say, interpretations and the resulting inferences about student learning are subjective and, as such, necessitate two-way conversations between teacher and learner in order to clarify and increase validity. This is directly in line with the definition of assessment practice I provided in the introduction. Some examples of student-centred approaches to assessment may include peer-assessments, self-assessments, or portfolio collections (Stenmark, 1991; Suurtamm, 2018) which provide an environment in which students can feel that their expressions of mathematical content have value.

An example of assessment where roles and responsibilities are shared that lies closer to the current standard assessment end of the spectrum is from Rapke et al. (2018). They had students work in groups to create exam questions and provide full solution keys including the grading schema. These student-created exams were then passed to another group who then completed the practice exams (all open-ended questions) and the solutions were marked, critiqued and discussed in detail by their peers. The official exam was then made by adapting students' created questions with the addition of one final teacher-created question. In this way, the final exam was co-created between teacher and students. On the more radical end of assessment, we might find, for example, students' reflections on products of their own learning (Moon, 2004) like projects or performance tasks which are planned collaboratively with students ahead of time with criteria for evaluation (Kress, 2009; Moon, 2004).

Timing. The final consideration for the structure of assessment is timing. What I mean by timing is the nature of implementation as far as designated time towards assessment. Many researchers continue to advocate for assessments that are woven into instruction—rather than being a separate, isolated event. It is noted that this separation between assessment and instruction "perpetuates the tendency to see assessment as something added" (Moon, 2004, p. 151) where it may be more beneficial that it be integrated into a lesson. In this way, it is important to plan for how the chosen assessment interacts with or is interacted with as part of building mathematical proficiency (Corrêa, 2018; Moon, 2004; Suurtamm, 2018; Wyatt-Smith & Gunn, 2009) and the respective underpinning philosophies of problem solving (Rapke et al., 2018) that drive instruction. Considerations of timing would include the when, how long, and how frequently is the assessment is implemented.

When it comes to timing, assessment becomes a complex and dynamic part of learning and understanding learning. Examples such as observations of students collaboratively working on a performance task, would be a classroom activity acting simultaneously as an instructional task and an assessment. Similarly, interviewing, giving feedback or conversing with students during these tasks creates a seamless transition between instruction and assessment. A term I am quite fond of to describe this phenomenon is what Pai (2018) called 'wondering together with students' because it showcases that feedback can take not only the form of assertions, but also can be shared in the form of a question-based moment-specific information. In this instance, a teacher is more attentive to student need, and priority is given to the purpose of assessment (to guide learning) rather than having a prescriptive assessment practice. Even more, feedback is given at a time that is in the best interest of the student, rather than a time that is most convenient for the process, thus valuing the student more than clean and neat efficiency.

This concludes the discussions about assessment structure which included the mode of assessment, the roles and responsibilities of the participants, and the timing of the assessment. What I notice from the literature I am drawn to, is a move in favour of *messifying* assessment. In other words, moving from monomodal to multimodal (a pluralistic approach), moving from teacher-driven to collaboratively-driven (thus shifting and disrupting control by the teacher which may cause discomfort), and moving from set and organised times for assessment towards assessment on an as needed basis (one that is unpredictable). Now, I move to the content of assessment.

2.3.2 Content

A second dimension of assessment to consider when planning for and designing assessments is that of content. What is the assessment intended to address as far as mathematical content and scope? In other words, designing for content involves interrogating what counts as valued knowledge, what depth and breadth of knowledge ought to be assessed—as it pertains to the cultural context of students (Wyatt-Smith & Gunn, 2009), and how it aligns with the discipline of mathematics. This may include what I term disciplinarity—the elements of what it means to do mathematics including specific curricular outcomes or skills related to the doing and knowing of mathematics (Suurtamm, 2018), the focus-orientations of the assessment—whether it is process- or product-oriented—and the rigour of the content—the depth and scope of the assessment. In this way, planning for assessment content attends to what is intended for the learners to 'take home' (Moon, 2004).

Disciplinarity. I use the term disciplinarity to describe the intellectual and behavioural aspects relating to the discipline of mathematics. This may include specific mathematical content knowledge, mathematical competencies or proficiencies (Alberta Education, 2008a, 2008b,

2017), or mathematical habits of mind (Cuoco et al., 1996) transferrable skills associated with a mathematical disposition—often referred to as 21st century skills (Griffin & Care, 2015; Griffin et al., 2012). In this way considering disciplinarity would be to consider the alignment between what students are expected to know and do on the assessment and what mathematicians[9] (loose definition) know and do.

Much of the literature on alternative assessments in mathematics draws a focus on transferable skills (Griffin & Care, 2015; Griffin et al., 2012). If we want our students to value growth and to embody orientations and dispositions reflective of doing mathematics, we need to communicate this importance not only through instruction, but through our evaluations of learning (Beesley et al., 2018; Wyatt-Smith & Gunn, 2009). Some of the competencies and proficiencies indicated in government documents and in the literature as important to cultivate include problem-solving, critical thinking, visualisation, mental math and estimation, communication, collaboration, reasoning, managing information, creativity and innovation, personal growth and well-being, cultural and global citizenship, and use of technology (Alberta Education, 2008a, 2008b, 2017; Griffin, et al., 2012).

Even more, some literature suggests fostering mathematical habits of mind, which are said to include behaviours reflective of what it means to know and do mathematics (Cuoco et al., 1996) with the purpose of developing discipline-specific dispositions in students; these include seeking patterns, performing thought experiments, tinkering or experimenting with possible lines of solution, describing (both qualitatively and quantitatively), inventing (which connects to the

[9] Here, I use the term mathematician to describe any person that either acts mathematically or does mathematics.

idea of creativity and innovation mentioned above), visualising (as mentioned above), and making conjectures (Cuoco et al., 1996). If it is important for students to cultivate these skills and habits of mind, and if assessment is what communicates that which is important to learn, it follows that assessments—namely their content—would address these behavioural elements of mathematics.

Unfortunately, when it comes to testing, often what is covered in the content of the assessment is simply the specific outcomes from the program of studies (Alberta Education, 2008a, 2008b) which may seem to be considered a more tangible source of evidence—as compared to a teacher observation of a mathematical disposition. On the other hand, proponents of alternative assessment claim that alternatives to testing address less tangible, yet still important elements of learning such as the behaviours and skills involved in doing mathematics (Ben-Hur, 2006; Griffin et al., 2012; Horn, 2012; Stenmark, 1991); these foster collaboration, meta-cognition, persistence, making connections (Boaler, 2016; Paterson & Sneddon, 2011), as well as flexibility and adaptability during problem solving (Star & Rittle-Johnson, 2008). Assessments of this nature may include performance tasks, which involve productive struggle (Boaler, 2016; Horn, 2012); reflective journals and self-assessment, which focus on personal growth; and peer-assessment and group projects, which foster collaboration and collective growth.

In the same vein, having assessment content (that which is to be assessed) include students' skills or traits signals concerns that including behavioural components to assessments risks inferences being made that conflate the behavioural and cognitive aspects of learning (Tveit, 2009). Although, mathematical habits of mind are behavioural aspects of learning, and yet, are important indicators of mathematical competence which ought not to be ignored during

an assessment task (Cuoco et al., 1996). In this sense, Tveit is likely referring to classroom management related behaviours; to mitigate risks associated with conflating classroom management behaviours with mathematical competence, one could implement transparent and co-created expectations for the purpose of assessment, or have colleagues check whether the inferences one has made are being tainted by assumptions about proper behaviour or not (Mason, 2002). For teachers wary of transitioning away from current standard testing, one might begin with fostering collaboration by having students complete a test in groups (Berry & Nyman, 2002). While testing only content outcomes avoids this conflation between behaviour and content, alternatives provide a basis for addressing skills that continue to be relevant beyond the day of the test. Even so, research suggests that one tread very carefully.

Focus-Orientation. Related to the notion of addressing disciplinarity, is the focus-orientation of the assessment. I use the term focus-orientation to characterise the intent of the assessment in terms of being process-oriented or product-oriented. In line with developing assessments that facilitate the development of transferable skills and habits, many researchers have indicated that current standard assessments tend to value the product of learning (Rapke et al., 2018) over solutions and processes, and suggest a shift towards assessments that value processes of learning (Ben-Hur, 2006; Boaler, 2016; Horn, 2012; Pai, 2018; Stenmark, 1991). One critique is that "all too often what is assessed is what is easiest to assess, such as manipulation of symbols or an application of a formula, rather than what is more complex but which more closely resembles the important process of doing mathematics, such as problem solving or reasoning and proving" (Suurtamm, 2018, p. 478). Process-based assessments of this nature are shown to increase students' sense of value, growth, struggle, persistence, reflection,

peer-support, collaboration and flexibility (Ahern et al., 2006; Alberta Education, 2017; Kooken et al., 2016) which enables a move away from the memorization-reproduction model.

One example of a process-focused assessment that is situated within the testing paradigm in Rapke et al. (2018) study where students completed a test within the current standard testing environments and the instructor selected student responses for students to review. Students then gave feedback on their peers' solutions after which the original tests were returned to the respective students for an opportunity to review their own answers; summative assessments were then graded with extra points for the revisions. This may be a good starting point for teachers wishing to implement more process-oriented assessments in their classroom, but may not feel ready for the fundamental shift in practice involved in switching to alternative assessments.

Methodical Productive Struggle. Initially, I had titled this subsection Rigour, which may be a more familiar term used to describe the way in which students might engage deeply with difficult mathematical content and procedures. However, in my investigations into the word rigour, I found myself questioning its usage for describing the phenomenon in terms of assessment. I begin this section by first explaining my reasoning for moving away from the term rigour; I then suggest *methodical productive struggle* as a more apt term, following up with a synthesis of the literature on alternative versus current standard assessment in terms of methodical exertion.

The term rigour is the British spelling of the word rigor, coming from the Latin *rigorem* meaning having the quality of being numb, rude, stiff, hard, or rough (Harper, n.d.b). In other words, it is a term historically rooted in qualities of inflexibility and rigidity, which when applied to the human character are metaphorically cold. Current definitions of the word rigour are largely characterised with these same qualities; Collins, Oxford and Cambridge English Dictionaries

include definitions of rigour as a strict, harsh, severe, and cruel treatment or circumstance (Cambridge University Press, n.d.b; Collins, n.d.a; Oxford University Press, n.d.b) with only two exceptions: rigour as in "logical validity or accuracy" (Collins, n.d.a), and rigour in terms of being "detailed, careful and complete" (Oxford University Press, n.d.b). Rigorous, as an adjective, is used to describe something that follows a strict meticulous procedure that is systematic (Oxford University Press, n.d.c; Collins, n.d.b). I find the current usage of the word rigorous problematic given the definitions and etymology above.

Mathematics, the way I approach and have experienced it, involves deep contemplation, logical argumentation—which may require creative deviation from procedure; it involves hmming and hahing, a bending and wavering throughout the thought process. In this sense, doing mathematics in a deep and conceptual way involves a thorough yet flexible approach to reasoning and argumentation, and it is in no way a cruel treatment of the mind. For this reason, I propose, instead, methodical productive struggle.

I define methodical productive struggle using two notions: the quality of being methodical, and what is termed in the literature as productive struggle (Boaler, 2016). The term methodical has some overlap with rigour; it describes careful and ordered action (Cambridge University Press, n.d.a). A mathematical task, used for assessment purposes, that is methodical, is one that requires a purposeful attention to detail and procedure; that is, procedural fluency (Kilpatrick et al., 2001). This is not, in itself, enough to describe the depth of mathematical competence I seek in my assessment practice, thus is added the notion of productive struggle.

As I mentioned above, I draw from the term productive struggle in order to propose an alternative term to rigour. Productive struggle is a level of mental exertion that is enough to cause pause and confusion, but not yet to the level of frustration and abandonment of the task

(Boaler, 2016; Horn, 2012). A mathematical task that elicits productive struggle will necessitate persistence and flexibility in approach. One may need to tackle the problem from another angle, thus necessitating flexibility; however, this requires persistence, as it may take several attempts in problem solving.

I use the term methodical productive struggle to describe the level of mathematical engagement within an assessment task; an assessment task that elicits methodical productive struggle is one that involves not just conceptual understanding and procedural fluency, but the adaptive reasoning and productive dispositions (Kilpatrick et al., 2001) necessary for complex mathematical thinking and doing[10]. This is what is described in conversations about rigour and it tends to be a great point of contention in the alternative versus current standard assessment debate. On the one hand proponents of alternative assessment suggest that math class (and testing) more often involves recall and retrieval tasks (Ben-Hur, 2006; Berry & Nyman, 2002; Corrêa, 2018; Rapke et al., 2018; Roicki, 2016; Suurtamm, 2018), and state that alternative assessments address higher levels of thinking through the use of open-ended collaborative tasks (Bennett & Gitomer, 2009; Swan & Foster, 2018; Roicki, 2016). These are robust mathematical tasks that help teachers track the meaning-making processes of students and identify misconceptions, which may not otherwise have been identified (Ben-Hur, 2006; Corrêa, 2018; Horn, 2012). On the other hand, some argue that lacking teacher expertise in mathematical

[10] One important note, here, is that evaluating the level of rigour of an assessment task necessitates a sensitivity and awareness of cultural biases and their effect on how one perceives rigorous mathematical doing.

content knowledge and assessment literacy means that there is a high risk that alternative assessments are not rigorous (Aitken et al., 2011; Duncan & Noonan, 2007).

There are arguments to be made that methodical productive struggle is, at least to some extent, implicit to alternative assessment given its multimodal focus. This is because, part of deeply understanding a math concept is being able to explain concisely and clearly, being able to represent content in multiple ways, being able to use similar strategies appropriately across multiple contexts (Roicki, 2016). Similarly, exposing students to various situations and having them express themselves in multiple ways can foster their ability to have positive reactions to ambiguous situations (Hesse et al., 2015). While questions of methodical productive struggle remain, alternatives to testing would be beneficial—at least to the extent that the assessment practice, itself, has variation.

An example of alternative assessment that fosters rigorous mathematical thinking could be having students examine a situation and pose their own problems, particularly in ones that challenge normative societal thinking such as in Pai's (2018) chapter where he discusses having his students explore gender norms through a notice and wonder activity. These activities tend to "be rooted in the contexts of [students'] lived experiences" (Pai, 2018, p. 500). Another example might include having students complete a standard test but refrain from giving a mark, and instead providing qualitative feedback for students to reflect on (Suurtamm, 2018). Having students reflect on mathematical processes (either verbally or in written form) values mistakes, allows the students to develop mathematical process skills and allows the teacher to see into the deeper thinking of students (Pai, 2018) which provides a better picture of their mathematical competence and maintains methodical productive struggle.

To summarise the dimension of both structure and content of assessment design, assessment practice includes tasks that "(1) address genuine situations, (2) demand mathematical curriculum knowledge, (3) are challenging, (4) require students' autonomy and decision making, (5) focus on reasoning, (6) acknowledge mathematics worthiness, and (7) are engaging" (Corrêa, 2018, p. 455). The above quotation succinctly describes the important elements in planning and executing assessments; thus, reasons to use varied assessments include: enabling students the opportunity to express themselves in multiple (and preferred ways—or ways that play up their strengths in communication), providing multiple opportunities to express the learning from one outcome, and to represent the multiple complex facets of mathematics (Suurtamm, 2018). The last thing to consider is the question of what comes next? This brings me to the final dimension of assessment: inference and reflection.

2.3.3 Inference and Reflection

The final element regarding the technical aspects of assessment is what I refer to as inference and reflection. Inference and reflection refer to the processes and enactments that occur after an assessment when the teacher (or student, in the case of self- or peer- assessment) makes an inference about the evidence of learning, and communicates this information to the relevant person. Any information gleaned from a given assessment task should be purposefully reflected upon as part of the assessment process. "Assessment involves making inferences about student achievement on the basis of the evidence available" (Matters, 2009, p. 210), and that communicating these inferences to parents and students is part of the assessment practice. Given that parents and many stakeholders perceive tests as unbiased, fair and objective measurements of student learning (Graue & Smith, 1996), teachers using alternative assessments ought to consider how they might translate inferences made from these assessments to parents in a way

that engenders confidence. For example, in Norway, changes to assessment reform were met with parent and teacher protests because the directives and definitions were unclear (Tveit, 2009) suggesting that clear communication of the assessment structure, assessment content, and measures used to make inferences are clearly communicated.

Feedback and Reporting. Sharing results and evidence of students' progress with students and parents regularly can help students (and parents) feel confident in their progress and address what needs to be worked on (Pai, 2018). As mentioned before, particular attention must be paid to translating non-test forms of feedback in a way that engenders trust between parent, teacher and assessment can be complicated. Some examples might include standard quantitative records or qualitative comments and reflective feedback. This would mean that interactions during instructional time for the purpose of assessment can be noted by the teacher and later logged in a reflective journal or comment sheet by the teacher (Mason, 2002; Pai, 2018) to be shared either in real time or periodically throughout the year.

Alternative assessments may be used for reporting purposes by using tools such as checklists, anecdotal records, or rating scales such as rubrics (Cornett, 1982; Stenmark, 1991; Suurtamm, 2018). Similarly, Suurtamm (2018) suggests that a teacher could record (audio or audio-video) students as they work in groups in order to have some evidence of learning. In other words, evidence does not need to come in the form of a written or produced artifact. In the same vein, a multimodal communication of learning involves planning for what is expected to be learned, and have that broken down into descriptors of the criteria that need to be met for that learning to occur (Holm, 2018; Suurtamm, 2018).

Haraway (KIASualberta, 2014) speaks of abstractions as holding together questions of problems of the world; these are stories which lure us but are mortal and fragile. These

abstractions can be broken to create new desires and stories. Though applied to a much narrower conception of ‘a world’ or ‘problem of the world,’ I see this phenomenon of breaking apart as analogous to assessment. What I mean is that assessment may be the ‘problem of the world’ while this research intends to break the abstractions of this problem and create new stories. The appeal of neat and tidy evidence of learning (one abstraction that lures us), seems to be, in some assessment philosophies, becoming fragile, and a new abstraction—that of the appeal of complex conceptions of assessment, being reborn. Even more considerations regarding the evaluation of validity, reliability and trustworthiness of the assessment, while perceived as important, may also be abstractions to be challenged. Each of the three dimensions of assessment design has implications for the quality of assessment.

2.4 Evaluating Assessment

The purpose of this section is to discuss issues of validity, reliability, trustworthiness, and equity that frame the theoretical basis for various forms of assessment. There is “a call for a considerably expanded understanding of assessment, how it is enacted in particular contexts and its dynamics with learning and teaching” (Wyatt-Smith & Gunn, 2009, p. 86). This involves contemplating equity (Gipps & Stobart, 2009), and the alignment with theory (Tveit, 2009). Equity includes notions of fairness, accessibility and relevance (Gipps & Stobart, 2009; Pai, 2018), while alignment with theory includes validity, reliability and trustworthiness (Gipps & Stobart, 2009; Tveit, 2009; Worthen, 1993).

2.4.1 Equity

Assessment ought to be used in equitable ways (Suurtamm, 2018). Equity means taking into consideration students’ social and cultural contexts as they pertain to access to curriculum and curriculum resources (Gipps & Stobart, 2009). In the same vein, equity is not equality

(sameness) but it is fairness; in this respect expected outcomes of performance may be different but fairness is still achieved (Gipps & Stobart, 2009). Whether a pedagogical enactment (assessment or otherwise) is equitable or not, is contingent on access to necessary resources before and during said enactment, and the impact of, inferences made as a result of and the characteristics of the enactment (Gipps & Stobart, 2009; Lewis & Diamond, 2015).

2.4.2 Alignment with Theory

Alternatives or adaptations to testing typically involve more interpretation and inference on the part of the teacher (Gipps & Stobart, 2009), and as a result, carry the risk of teacher bias (Gipps & Stobart, 2009; Tveit, 2009; Worthen, 1993). In the same vein, these alternatives, when varied and done frequently, can increase validity of student data and potentially provide a measure of reliability (Gipps & Stobart, 2009). Here, reliability refers more to the predictability of the assessment and the related inferences (Mason, 2002). Gipps and Stobart (2009) suggest that validity is "not simply the way in which [an assessment] functions, but depends on what it is used for and the interpretation and social consequences of the results" (p. 110); this includes how effectively the assessment is addressing the target domain. In order to address reliability, Moon (2004) suggests following a predictable and incremental revision and revitalisation cycle of curriculum (and assessment) in order to increase reliability.

There seem to be points of contention surrounding the use of current standard versus alternative approaches to assessment. Those in support of varied assessment practice that goes beyond the testing model suggest that validity is increased through variation and frequency and that the goal of alternative assessment is to foster more rigorous mathematical thinking through robust tasks and collaboration. They claim that testing, by design, is situated in a memorisation and reproduction model (Ben-Hur, 2006; Boaler, 2010; Horn, 2012; Stenmark, 1991). In

contrast, those in favour of testing, tend to suggest that alternative assessments lack validity due to the bias nature of subjective inferences (Maclellan, 2004; Ruthven, 1994). Even more, some argue that collaboration is seen to foster cheating (Berry & Nyman, 2002; TODOS, 2020) and claim that anything other than a tried-and-true test with well-designed and reliable questions is unrepresentative of rigorous mathematics.

Teachers' interpretations of students' expressions of learning in order to determine whether they had met the standards is a subjective interpretation; as such, teachers should collaboratively judge student evidence for consistent interpretations and allow someone to critique assessments (Wyatt-Smith & Gunn, 2009). This is in agreement with Mason's (2002) suggestion to have colleagues observe one's practice in order to strive for a more objective perspective. In addition, Tveit (2009) suggests providing opportunities for teachers to develop their assessment expertise and confidence (Tveit, 2009).

There is something to be learned here: (1) no singular method is the 'best practice' or is perfect (Gipps & Stobart, 2009; Pai, 2018; Tveit, 2009); (2) assessment structure, design, and related inferences are subjective and contextual (Pai, 2018; Wyatt-Smith & Gunn, 2009); and (3) each assessment design, regardless of where it falls within the alternative-current standard space, has both affordances and disadvantages. Neither of the above four assertions are surprising but they carry implications for the variation in promising[11] assessment tasks that collectively define a

[11] This term, promising, is one that was suggested to me by Dr. Elaine Simmt, and it resonated with me. Promising practices, for me, imply not only elements of hope, but of purpose.

teacher's[12] assessment practice. "The best defence against inequitable assessment is openness" (Gipps & Stobart, 2009, p. 116) to design alternatives, scoring alternatives and grading alternatives.

2.5 Affective Dimensions of Assessment

Assessment, as a process, includes the affective domains of student interactions with mathematics (Pai, 2018); this consideration of student affect is demonstrated through attention to student identity and relational ethics during the planning phases of an assessment. These two elements help characterise the individualistic considerations, and the communal considerations of affect in assessment.

2.5.1 Student Identity

Students bring all aspects of their identities (context and psychological elements) with them to the test including motivation, level of anxiety, engagement, gender, race, ethnicity, educational experiences, and social experiences with them when they complete test items, and this influences the way they interact with those test items (Matters, 2009). "Assessment processes naturally involve moments in the classroom: observations, conversations, and interactions" (Pai, 2018, p. 497). This importance of the consideration of students' identities in pedagogy is reflected in Chronaki and Kollosche's (2019) piece, which showcased a refusal of mathematics discourse, as presented in the classroom. In their case study, Chronaki and Kollosche found that the student's active disposition and social nature competed with the independent and physically stationary nature of instruction and assessment in mathematics. This

[12] Here, I might argue that implying a teacher owns their assessment practice is erroneous; especially given that assessment is a collaborative dance.

suggests that assessment practice ought to be holistic, not in the sense of assessing students' identities but in a sense of acknowledging and honouring that students are influenced by and interact with the assessment with their whole selves (Aitken et al., 2011; Pai; 2018); it signals that there may be deeper considerations to assessment practice than the technical aspects such as structure, content and inferences.

2.5.2 Relational Ethics

The second aspect of affect involves attention to relational ethics, which means considering the complex and unpredictable nature of interaction, both between people and with the environment (Nicol, 2018). Nicol suggests that educators would be wise to think deeply and reflect on different problem contexts as they contemplate using them in their classrooms, knowing that with any particular problem context comes deeply complex issues that "may not be easily resolved" (Nicol, 2018, p. 434). This assertion implies that there is a certain responsibility to anticipate discomfort with content. As well, teachers' expectations are what shape their teaching enactments and expectations, which in turn influence how they interact with students and parents, and how the students interact with them (Lewis & Diamond, 2015). Thus, throughout the planning, executing and reflecting processes of assessment, teachers engage in deep reflection on the sensitivities or preconceived notions they have, attend to students' sensitivities that may surface as a result of the presented assessment, and are mindful of unexpected or unintended resistance as a result of emerging conversations, and productions of knowledge throughout the assessment task. In other words—and particularly in the context of trying assessments that may be met with resistance or discomfort by the teacher, the students or the parents—it is important to practice checking in with one's self and one's students to attend responsibly to those sensitivities.

In conclusion, when it comes to contemplating assessment practice in terms of student affect, some questions that educators might engage in or ask their students to engage in, could include: “What kind of thinking was involved: concrete, conceptual or personal? What abilities were required: verbal, numerical or spatial? What emphases were placed on the treatment of the stimulus material: Did the student need to absorb it, operate on it or transform it into something new? Is it possible that a student’s (or the student group’s) perception of success on the item was influenced by features of the stimulus material such as context” (Matters, 2009, p. 215)? These questions help to attend to the technical aspects of assessment as well as the affective and emerging aspects of assessment.

3 Theoretical Framework

The research on teacher identity, also referred to as professional identity within educational research, provides a theoretical framework for understanding my own identity space, while the Dynamic Systems Model for Role Identity (DSMRI), conceptualised by the work of Kaplan and Garner (2017), provides a strategic model for detangling my professional identity and the associated roles, conceptions and assumptions regarding assessment and imagined future enactments. However, this is not a study *on* my professional identity; rather it is a study that *uses* professional identity as a tool (Beijaard et al., 2004) to make sense of autoethnographic data. In this way, the theoretical framework I use is meant to situate the data within a process of 'identity work' (Beijaard, 2019; Clarke, 2009; Darragh, 2016). Throughout this section, I weave in personal examples in order to situate my identity work, and I pull from literature pertaining to novice teachers as well as in-service teachers because this literature on novice teachers' identity development is particularly relatable and relevant to my context.

I begin the chapter by providing a general overview of teacher identity and role identity. This scaffolds the discussion around the DSMRI which is outlined the following subsections. The DSMRI is comprised of four dimensions: self-perceptions and self-definitions, ontological and epistemological beliefs, purpose and goals, and perceived action possibilities (Kaplan & Garner, 2017, 2018; Garner & Kaplan, 2019). Thus, this section begins with an overview of teacher identity and related role identity, followed by the characterisation of each of the four dimensions of DSMRI including personal examples, and concludes with final commentary and considerations regarding the use of this model in the context of identity work.

3.1 Overview

3.1.1 Overview of Literature on Teacher Identity

Many researchers note that identity is a poorly defined phenomenon (Bekerman & Zembylas, 2018; Darragh, 2016; Lutovac & Kaasila, 2018). This is reasonable given the complexity of identity and identity work; it makes sense that researchers would focus only on specific aspects of identity or identity development, rather than attempt to define it. Nonetheless, Darragh (2016) and Beijaard et al. (2004) note the importance of characterising the specific approach taken by a researcher. For this research, I situate identity and the process of identity development all at once as a positioning and a performance which results from dynamic interactionism—an approach to identity work that situates identity within a complex dynamic interaction between person and environment (Ashforth, 2001; Beijaard et al., 2004; Clarke, 2009).

Context-dependence. As mentioned earlier, teacher identity is heavily context-dependent. In other words, identity is an enactment within social, cultural and historical frames of reference, and individuals and their contexts mutually affect one another. This is what Ashforth (2001) calls “dynamic interactionism” (p. 20). Hence a teacher’s enactments within a particular circumstance are influenced by this dynamic interactionism (Ashforth, 2001; Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018). Hong et al. (2018) support this notion stating that “identity is developed through practices and activities that are situated in historically contingent, socially enacted, and culturally constructed frames of social life” (p. 247), and teacher identity is “linked strongly with self-concept and the social systems within which the teacher experiences what it means to be a teacher” (Edwards & Edwards, 2017, p. 192). Teachers’ identities are in continuous flux and development through the dynamics of interaction with others and with one’s

environment (Beijaard et al., 2004; Boylan & Woolsey, 2015; Clarke, 2009; Schaefer & Clandinin, 2019). Identities are both socially and individually constructed based on what is individually and collectively relevant to teaching at any given time (Clarke, 2009; Beijaard et al., 2004). Thus, identity development is both temporally and spatially dependent.

Emergent and Stable. Teacher identity is characterised as both relatively stable and emergent (Boylan & Woolsey, 2015). Bekerman and Zembylas (2018) noted, identity can be used to define the whos and whats of people taking a more psychologically situated approach to defining the essence of a person (Darragh, 2016), which remain relatively stable over time. Most researchers, however, take a sociological approach to characterising identity (Darragh, 2016). This situates identity within frames of "when, where and how one is" (Bekerman & Zembylas, 2018, p. 64), and imply a continuous emergence of different elements of the self. As well, "teachers have multiple sub-identities that emerge as a result of different interpersonal relationships and contexts, which "more or less harmonize" (Beijaard et al., 2004, p. 122) and become stable. In essence, certain aspects of identity, such as the psychological whos and whats (Bekerman & Zembylas, 2018), tend to remain stable, while others, such as the sociological positioning and performances (Clarke, 2009; Heffernan et al., 2017; Langer-Osuna & Esmonde, 2017), may emerge as a result of the interaction with the environment (Ashforth, 2001; Boylan & Woolsey, 2015).

Predictable and Unpredictable. Identity—be it teacher identity or otherwise—is a process of internalisation, experience, change, and making of a self (Clarke, 2009). Clarke suggests that "identity is at once a complex matter of the social and the individual, of discourse and practice, of reification and participation, of similarity and difference, of agency and structure, of fixity and transgression, of the singular and the multiple, and of the synoptic and the

dynamic" (p. 189). He defines identity work as a type of continuous critical reflection—what Aoki (2011b) would term as reflexive praxis—that guides an investigation into one's identity, and which leads to identity development. As such, different sub-identities may emerge while others remain stable, and the dynamic interactionism between teacher and environment provides some level of predictability but identity work in and of itself is rather unpredictable; thus, identity is context-dependent, at once predictable and unpredictable (Boylan & Woolsey, 2015), and at once both emergent and stable (Beijaard et al., 2004). This may contribute to the difficulty in defining teacher identity, and suggests that a model for understanding teacher identity would be characterised as a complex dynamic system. Where a complex dynamic system is a system in which the elements "are reciprocal and interdependent, so that change in any one element will reverberate throughout the system" (Kaplan & Garner, 2017, p. 2037); this continuously dynamic interaction between interdependent elements defines the system's behaviour.

3.1.2 Overview of Literature on Role Identity

This research is meant to both speculate about and interrogate future assessment practices within the mathematics classroom context, but my speculations are influenced by multiple dimensions of myself as a teacher, which is formed from the whole of my multiple identities the respective roles and their interactions. I use the term teacher identity and professional identity[13]

[13] Ashforth (2001) describes professional identity in terms of the identities of people in professions using profession as a general term not necessarily connected to teaching. On the other hand, it would seem that much of the research on teacher identity uses professional identity interchangeably with teacher identity. This is likely by convenience and seems reasonable,

synonymously and characterise them as a collection of roles that teachers enact or perform as they position themselves within different professional contexts as educators (Ashforth, 2001; Beijaard et al., 2004; Boylan & Woolsey, 2015; Schaefer & Clandinin, 2019). However, the roles I enact within my life as a teacher influence and are influenced by the roles I adopt and enact in my personal life, as well. For this study, I focus on teacher identity and the external influences on it as I unpack my role as math educator.

The Dynamic Systems Model for Role Identity, characterised by Kaplan and Garner's (2017, 2018) work, provides a basis for interpreting, understanding and making inferences about expected and unexpected findings of this research. The aim of the DSMRI is to "capture the holistic and rich content, structure, and process of identity and its formation within social-cultural contexts, with anchors in established theoretical constructs" (Kaplan & Garner, 2017, p. 2040), and is meant to characterise role identity development of actors within the social-psychological and social-cultural contexts (Kaplan & Garner, 2017). The DSMRI enables us to understand the influences on learning and the adaptations which are enacted by teachers as part of their role (Garner & Kaplan, 2019; Kaplan & Garner, 2018). I draw on this conceptual framework for teacher identity as a means to organise and discuss the relevant scholarship on identity work, and to organise my own identity work which forms a basis for investigating future assessment practices.

To begin, I briefly overview of the nature of roles; following this discussion, I characterise the DSMRI framework and provide personal examples. A role, to me, implies a set

---

however, it is important to note that this statement for Beijaard et al. (2004), Boylan and Woolsey (2015), and Schaefer and Clandinin (2019) is stated in terms of teachers.

of responsibilities which, in turn implies action or inaction. Even more, these responsibilities and (in)actions, as they manifest or become salient in unique contexts, preface the argument that roles and identities are deeply tied; as such, a particular identity within a person's identity network carries with it a particular set of roles, and those roles in turn shape that person's identities. Some examples of roles could be role of professional (Mentis et al., 2016; Ruohotie-Lyhty & Moate, 2016), role as a member of a particular nationality (Bekerman & Zembylas, 2018) and intersections thereof, or role of student (Chronaki & Kollosche, 2019). As mentioned above, an individual often has multiple identities, each manifesting differently based on the context in which they find themselves and the roles they enact. These can be defined as role identities, and different role identities become salient within different temporal or physical contexts.

Roles are situated in social and cultural contexts, and people typically inhabit several role identities within any given context; particular roles, then, elicit particular enactments and dispositions (Ashforth, 2001). These different role identities are continuously emergent, negotiable and fluid. Of importance in this particular research is micro role transitions, which Ashforth defines as being transitions between simultaneously held roles. In contrast, macro-transitions are those role changes that occur as a result of changing employment or changing positions within the same institution (Ashforth, 2001). This research occurred within the context of my full-time immersion in graduate studies, thus, I experienced a macro-transition into the role of graduate student. Simultaneously, my role as a mathematics educator continues to be firmly rooted as part of my network of identities, and as I progress through the program, I enact micro transitions between these respective identity roles. My identity as 'graduate student' emerges temporally in the present and physically in the university environment. On the other

hand, while my identity as ‘mathematics educator’ is presently relevant, it is situated in a more abstract psychic space of a K to12 classroom environment that I intend to inhibit in future. Nonetheless, throughout the graduate program, I have seamlessly transitioned between roles as I contemplate my philosophies, goals, enactments and responsibilities.

Ashforth (2001) argues that the greater the difference in social and cultural contexts of each role identity, the less smoothly the transition between roles is enacted. In the same vein, the more important the role is to someone, or the more prominent it is within their role identity system, the more elements of that role identity transcend across all roles (Ashforth, 2001). Different role identities become salient based on the audience receiving the performance or the environment in which they are situated (Ashforth, 2001) including the interactions occurring with others within that context (Beijaard et al., 2004). There are multiple interrelated and interdependent elements of a role identity, "such as the teacher’s purpose and goals in teaching, self-perceived attributes regarding teaching, world view as a teacher, and perceived possibilities for action as a teacher" (Garner & Kaplan, 2019, p. 9). These four elements interrelate with one another and each role identity can be conceptualised using these elements. As such, tensions can arise as a result of inter-role identity tensions (tensions between elements of one identity) (Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018) or intra-role identity tensions (tensions between multiple role identities) (Ashforth, 2001).

The DSMRI framework has implications for micro and macro transitions between roles, however, the focus in the following sub-sections intend to characterise the four dimensions of the DSMRI rather than focus on these transitions. As mentioned above, and as will be showcased below, the unique and multiple identities that comprise my whole self are intertwined as a

complex dynamic system; thus, examples of each dimension in the following sub-sections include both the personal and the professional elements of my multiple identities.

3.2 Self-Perceptions and Self-Definitions

3.2.1 Characterising Self-Perceptions and Self-Definitions

The first element of the DSMRI is *self-perceptions and self-definitions.* This element includes self-identified attributes, characteristics (physical, cognitive, social or psychological), interests, personal identifiers, values, beliefs about oneself, and beliefs about one's competencies or value pertaining to the role (Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018). Heffernan et al. (2017) describe identity work, using the term identity exploration, as being the act of "experimenting with social roles and self-perceptions, questioning previously held identifications, values, goals, and convictions about the self, and seeking information about oneself and one's environment" (Heffernan et al., 2017, p. 54). Self-perceptions and self-definitions would include perceptions or self-narratives, as well as perceived or defined memberships (Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018). These self-perceptions and self-definitions heavily impact identity work.

Important to note is that, in the case of novice teachers, this aspect of self-identity tends to be deeply tied to the role of teacher (Day et al., 2006). In other words, perceptions and definitions of the self as a person deeply influences and, at times directly translates to, professional definitions and perceptions. This includes personally held values, morality and beliefs in regards to human relations (Boylan & Woolsey, 2015; Clarke, 2009; Cross Francis et al., 2018) because they shape our perceptions of others and relations of care within the context of our roles as educators (Boylan & Woolsey, 2015; Cross Francis et al., 2018; Hong et al., 2018). This deep tie between the personal and the professional is both influenced by and influences the

level to which teachers' professional lives overlap with their personal lives, which means that personal definitions would also influence professional identity.

Perceptions of self involve personal identity and sense of self or self-narratives (Beijaard et al., 2004; Clarke, 2009; Cross Francis et al., 2018; Curtis, & Curtis, 2017; Hong et al., 2018; Schaefer & Clandinin, 2019); what stories do we tell about ourselves relevant to the roles we take on? This would include elements of professional-efficacy and competence (Cross Francis et al., 2018; Hong et al., 2018), professional credibility (Connolly et al., 2018) and pedagogical expertise (Duncan & Noonan, 2007). For example, Huang et al. (2019) found that teachers, as they struggled to develop their identities at the beginning of their careers, tended to have a lesser sense of self-efficacy which impacted the confidence they had in themselves as professionals.

Similarly, self-definitions, both in terms of personal and professional, heavily influence identity work and identity roles. Defining oneself may come in the form of memberships or similar physical, psychological, social or cultural identifications (Beijaard et al., 2004; Boylan & Woolsey, 2015; Clarke, 2009; Bekerman & Zembylas, 2018). For example, one's nationality, one's ethnicity and cultural background or one's gender (Bekerman & Zembylas, 2018) with the associated political and social definitions that may be adopted (Bekerman & Zembylas, 2018; Zembylas, 2018). Self-definitions also include one's interests and dispositions; an example that comes to mind is how hobbies such as sports or a disposition of being active might influence enactments within educational settings (Chronaki, & Kollosche, 2019).

Our ability to self-narrate includes the unconscious discursive and socio-political influences on our self-definitions and self-perceptions (Chronaki, & Kollosche, 2019) which limits our ability to tell our stories objectively. Even more, we cannot know how others see us, nor are we aware of subconscious thoughts and ways of doing that shape our identities but that

are not brought into the forefront of our attention (Clarke, 2009). Our socio-cultural context affords a sense of belonging to a community, and a situatedness or role within the community or community of practice (Cross Francis et al., 2018; Edwards & Edwards, 2017; Hong et al., 2018) which then shapes our self-perceptions.

3.2.2 Situating Self-Perceptions and Self-Definitions in Personal Context

In order to showcase self-perceptions and self-definitions I use my own personal and professional context (**Figure 5**), and map out the account of my self-perceptions and self-definitions. Adapted from Khan's (Khan & La France, 2019; Khan et al., 2019) transphenomenal framework for identity, I organise my self-definitions and self-perceptions within the following categories: physiological, psychological, and sociocultural. These self-definitions and self-perceptions influence my role identity as mathematics educator to different extents, some tangentially and some directly, and some have emerged as relevant despite me previously perceiving them as unrelated to my role.

Physiological. The physiological self-definitions are those biological characteristics that validate or imply a membership to particular populations. My age, skin colour, sex, and medical identifications fall within this category of self-definitions and influence my role identities to varying extents. For example, I identify as a young Caucasian female with epilepsy. In this way, I self-identify as belonging to the category of white, female, epileptic and young adult, though not necessarily in that order of relevance. I perceive each to be relevant to my role as educator as they influence my enactments within that role, but not necessarily my role as assessor. This is by no means an extensive list of physiological definitions, but they are memberships that come to mind when I contemplate my roles and responsibilities as an educator.

Psychological. I use the term psychological self-definitions and self-perceptions to encompass perceived dispositions, temperaments, and interests that I consciously recognise as having. For example, I am inclined to describe myself as sensitive and contemplative (psychological definitions); this may serve as an influence on the expectations I have for student behaviour and classroom dynamics, as well as the inferences I might make in regards to interpersonal and professional interactions, and the ways in which I reflect on my roles and enactments. Not only does this showcase the affective influences on self-perceptions and self-definitions (Boylan & Woolsey, 2015; Cross Francis et al., 2018; Hong et al., 2018), it indicates that our self-narratives are heavily impacted by psychological factors.

Within the psychological also dwells my perceived capacity as an educator and assessor. To what extent do I see myself fit to make decisions about student learning and assessment of student learning? It is in this space that I remain in conflict. Logically, I know that my training and experience make me a trained professional capable of taking on innovative projects in my pedagogy. However, as I alluded to in my introduction, I continue to lack the confidence necessary to proceed in divergence to my school's common practice. I refrain from rocking the boat, mainly because I am not confident that my ideas are based in professional judgment or naïve opinion. I have not been confident in my capacity as a professional to make informed decisions about assessment in mathematics.

Social. My social self-defined memberships are broad and varied; I include in this category, the familial self, professional self, and other socially constructed notions of self. For example, in regards to my familial self, I have no children. and this influences the way I perceive myself and enact my role as educator. In addition, as a cisgender female, there are self-perceived sociological factors that have influenced the ways in which I enact my role as mathematics

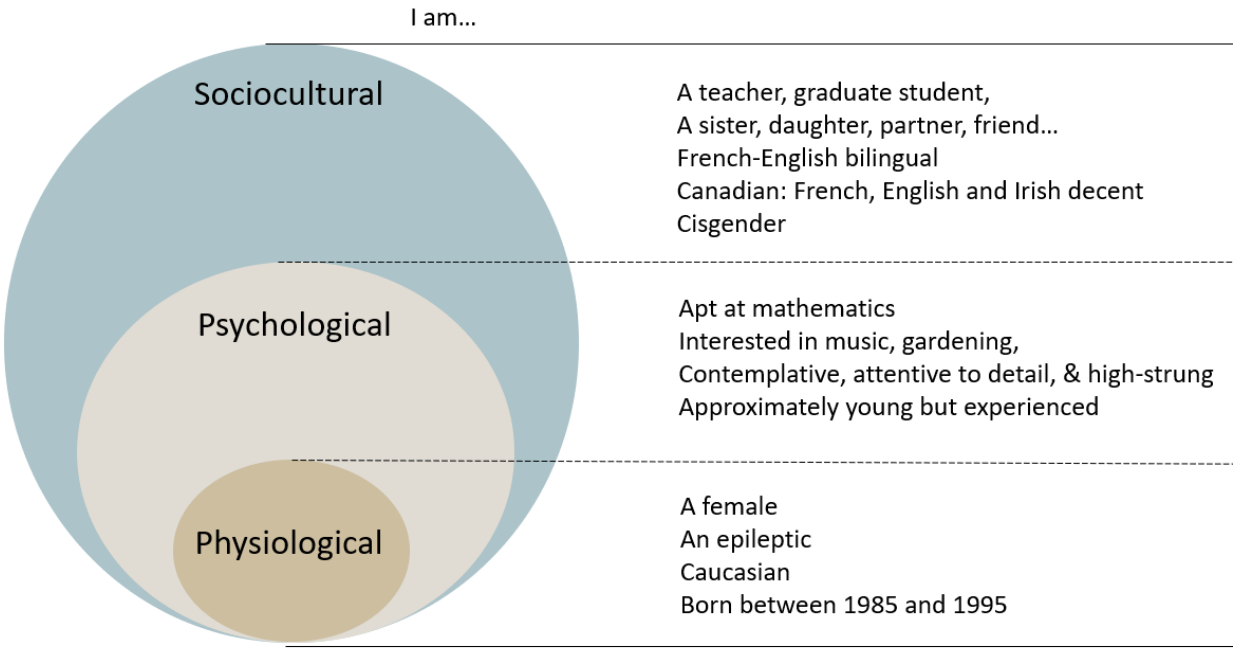
educator. A final example of a social self-perception is that I perceive myself as belonging to the mathematics education community and self-define as a mathematics educator. These are only some examples of self-definitions and self-perceptions that fall within the sociological influences on my role identity.

As I reflect on the times in my life when I felt well with mathematics and well with the assessment of mathematics, I realise that my relationship with mathematics has generally become more positive over time; it only began to truly flourish in university and has continued to be cultivated since. I attribute this mainly to my physiological development, which is closely tied to my psychological development. On the other hand, my relationship with assessment in mathematics has followed a not-so-linear path. I remember dreading tests in my later K to 12 years as a student, but felt more or less at peace with the assessment in my university mathematics courses—even the test-like assessments. Later, as I transitioned between student and teacher, I found my relationship with assessment deteriorating, once again, as I defaulted to the assessment resources I was given. I can only speculate that this wavering is attributed to the social role I held at those times. In my K to 12 education, I was both a minor and a student, and my responsibilities, as I perceived them, was to do well as a student. My role as a student in university, as I perceived it, was distinctly different from this because I was then responsible for taking charge of my future; I was a professional in training and explorer of possibilities. When I became a teacher, I was no longer responsible for my own education, but for the education of others. I wonder if seeing my students as versions of my younger self was the reason for reverting back to my former distain for testing; perhaps I projected my own schooling experiences onto them.

Cultural. Closely connected to the sociological and physiological self-definitions and self-perceptions are the cultural self-definitions and self-perceptions. Following Zembylas' (2018) discussion regarding assigned memberships, I begin by acknowledging my nationality as Canadian, as is indicated on my passport and birth documents. While this is an externally assigned membership, it has become internalised in a sense that I was born and have been raised in Canada, I self-define myself as being French Canadian, and have been exposed to particular cultural practices related to that nationality. I am of European decent; my ancestors having come mainly from France and England were part of a people who developed institutional systems that displaced, separated and committed cultural genocide against First Nations, Métis an Inuit peoples. The legacy of this colonisation pervades in current educational institutions which carries with it particular implications for how I perceive and define myself as an educator. My cultural roots influence my role identity as mathematics educator and the responsibility to be reflective and particularly attentive to ensuring I not colonise the students I intend to serve, including in my contemplations and speculations that follow in this research.

Figure 5

Graphic Situating My Self-Definitions and Self-Perceptions



Note. A brief outline of my self-perceptions and self definitions. As a disclaimer, it is my choice to label myself an epileptic (as opposed to a person with epilepsy). The impact that epilepsy has had on my self-perceptions as teacher and my fitness to teach is significant; at the same time, I feel a sense of belonging in the support groups for people with epilepsy, so epilepsy is not just part of my life. Rather, being epileptic is a sub-identity but it is important to note that within the disability theory community, it is more common to use the latter language around disability.

As a final note, I recognise that language restricts our ability to narrate our lives and express ourselves in a way that encapsulates the full intended meaning (Clarke, 2009); that is, using language to describe an experience, does not accurately translate the full meaning of that experience (Jardine, 2008). In this sense, as I sit here and attempt to convey to the reader my own identity, I am limited by my subjective interpretations, my unconscious dispositions and

influences, and my language. As a result, the descriptions of my self-perceptions and self-definitions are incomplete and biased to a significant extent. Even so, these self interpretations heavily influence how I enact my role as a mathematics educator.

3.3 Ontological and Epistemological Beliefs

3.3.1 Characterising Epistemological and Ontological Beliefs

The second element of the DSMRI is *ontological and epistemological beliefs.* This element refers to what the teacher believes to be true and the knowledge or beliefs they hold about teaching and what it means to be a teacher. Where epistemological beliefs are the "collective beliefs about the origin and acquisition of knowledge" (Schraw & Olafson, 2008, p. 31), “ontological beliefs are beliefs about the nature of reality." (Schraw & Olafson, 2008, p. 31). Thus, for a mathematics educator, epistemological beliefs are those beliefs that guide a teachers’ thinking around pedagogy and the teaching and learning of mathematics. In the same vein, ontological beliefs are those beliefs that shape a teachers’ understanding of what it is to be a mathematics educator. Epistemological and ontological beliefs morph and develop over time (Schraw & Olafson, 2008) and are deeply intertwined with emotion (Boylan, & Woolsey, 2015; Cross Francis et al., 2018; Pelini, 2017; Van Galen, 2017). They encompass the temporal relevance of causal situations, the level of control and certainty the teacher has over situations, the sense-making process of evaluating and responding to situations relevant to the role, and the related emotional aspects of the situation (Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018). Given that a teachers’ level of control over, experience with, and knowledge about any given situation is dynamic, so are their epistemological and ontological beliefs.

Kaplan and Garner (2017, 2018) characterise teachers’ epistemological and ontological beliefs and knowledge as being acquired through formal or informal training. Here, informal

training would include professional experience and networking, personal histories, experiences with logical reasoning and cause and effect relationships, and experience with policies or initiatives. Formal training is characterised by pre-service or in-service training. Both informal and formal training influences the epistemological and ontological beliefs of teachers.

Formal pre-service teacher training and professional development tend to be situated within a framing of identity development (Boylan & Woosley, 2015; Mentis et al., 2016; Schaefer & Clandinin, 2019). Schaefer and Clandinin (2019) inquired into novice teachers' identities in order to shed light on different elements of teacher identity that ought to be attended to in preservice teacher training. Even more, Huang et al. (2019) found that novice teachers' identities are informed mainly by the negotiation that occurs between their initial teaching experience and the epistemological beliefs they develop through teaching experience. Similarly, many other studies use teacher identity development as a framework for professional development. For example, Mentis et al.'s (2016) interprofessional networking within a professional development program aimed at building professionals' cultural responsiveness was framed around identity work. Similarly, Boylan and Woosley (2015) took a compassionate inquiry approach that focused on repositioning teachers' identities as a professional development activity aimed at investigating teachers' conceptualisations of social justice education. This identity development, as a form of professional development and/or training, shapes teachers' beliefs about teaching and learning, as well as their beliefs about what it means to be a teacher.

Another element of formal training would be content knowledge and beliefs about learning mathematics, which tend to serve as driving forces in teachers' identities (Beijaard et al., 2004; Cross Francis et al., 2018; Darragh, 2016; Hong et al., 2018). As a result, content knowledge and expertise acquired through formal training impacts their epistemological and

ontological beliefs. These content- or discipline-specific epistemological and ontological beliefs shape the ways in which teachers "attend to both the academic and socio-emotional needs of students" (Hong et al., 2018, p.248). For example, in mathematics, teachers may attend to students' personal and mathematical identities and challenge normative beliefs within the discipline of mathematics as it pertains to what it means to teach or learn mathematics (Aikenhead, 2017; Chronaki & Kollosche, 2019). Similarly, Cross Francis et al. (2018) noted that teachers' relationship with mathematics, and their self-perceived competence in mathematics carried significant weight in the formation of their identities. Both of these examples suggest that content-specific knowledge and expertise, in connection with confidence in content and related pedagogy, shapes the way in which teachers enact their roles, as well as what they believe to be true about their roles.

In contrast to formally acquired beliefs, informally acquired epistemological and ontological beliefs are influenced by teachers' aversions or inclinations towards specific pedagogies (Beijaard et al., 2004; Connolly et al., 2018; Darragh, 2016; Edwards & Edwards, 2017). These beliefs, inclinations or aversions are largely formed within communities of practice to which teachers find themselves belonging (Edwards & Edwards, 2017). Here, community of practice could be school-based, community-based (Edwards & Edwards, 2017), or based on the subject area taught (Day et al., 2006). This is an example of informal professional development and identity formation through community building (Connolly et al., 2018; Mentis et al., 2016). The influence of professional communities of practice on teachers' identities is further influenced by the fact that teachers often feel a sense of isolation in their first years due to lacking networking, but as they begin to form networks within and outside of the school context, they begin to develop increased confidence and risk-taking (Connolly et al., 2018). As a result,

teachers can conceive of their roles within the educational system and develop confidence in their roles as well as shape their epistemological and ontological beliefs.

An extension of informal training is the influence of communities of practice, such as the mathematics education community, the discipline and division level taught (Cross Francis et al., 2018; Duncan & Noonan, 2007), or the school (Edwards & Edwards, 2017); all serve as sources of normative culture that influences beliefs about pedagogy, and as a result teachers' role identities. In fact, Clarke (2009) suggests that "recognizing that our identities, like our pedagogical practices, should not be predetermined, but need to be continually renegotiated within specific contexts, leaves open the possibility that our pedagogical certainties might be transformed by encounters with others and by exploration of others' ideas" (pp. 194–195).

A final piece included in the epistemological and ontological beliefs of teachers is the connection between roles and emotion. Much of the research on teacher identity indicates that teachers' beliefs about teaching and what it means to be a teacher, are deeply emotional (Boylan, & Woolsey, 2015; Cross Francis et al., 2018; Pelini, 2017; Van Galen, 2017). This makes sense given "teaching demands significant personal investment" (Day et al., 2006, p. 603). However, professional experience and the beliefs about teachers' roles tend to also influence their ontological and epistemological beliefs. For example, teachers in the beginning of their careers find themselves attempting to make sense of their multiple roles and responsibilities within the school, district and classroom context as well as what those roles entail (such as relational aspects of teaching) (Beijaard et al., 2004; Schaefer & Clandinin, 2019). These roles are based on normative beliefs which define particular accepted and unacceptable actions and interactions (Ashforth, 2001). As a result of this complexity and convergence of the personal and

professional, teachers' ontological and epistemological beliefs necessarily are influenced by emotional bonds with teaching.

3.3.2 Situating Ontological and Epistemological Beliefs in Personal Context

In this subsection, I briefly discuss my experiences in mathematics as a student (I remain a learner for the rest of my life), my experiences as an educator, and my professional development through the MEd program.

Past Experiences and Beliefs Around Mathematics. What I remember most fondly about the assessment in university—the time at which I felt most at peace with assessment— are the assignments; this is the way in which I came to learn concepts. By this time, my self-definition as a 'math person' was firmly rooted as part of my identity. I was married to the sciences in a sense, which was influenced by my perception that the sciences were for the elite, and that they were generally hated by everyone outside that elite group—a perception that frustrated me deeply. I believed that mathematics could be loved by everyone if it were just presented with enthusiasm, and if students in these disciplines were given opportunities to persevere through challenging problems without the stress of time limits. This belief was further solidified with the nature of the course assignments. There were some specific elements about the assessments in university mathematics courses that further developed my love *of* mathematics[14].

---

[14] It is strange to reflect and discover that the assessments, in and of themselves, could have a positive influence on my relationship to mathematics because, as a student in secondary school and as a teacher after post-secondary, I found the assessments either hindered or damaged

I admit that I have not always loved mathematics. In fact, I did not see myself as competent in mathematics until my twelfth year of schooling, and it was not an identity I embraced until my university years. I base this judgement, not surprisingly, on the assessments I encountered as a student. I was perfectly average as a math student for a very long time, and while I remained interested in the subject, I was not particularly good at it within the school environment. Once I began my university career, something changed. I saw the way the professors came alive when they spoke about mathematics. Many of them even came alive when they observed my own growth in the subject. Even more, many of the courses had weekly assignments that pushed me to think and slowly digest mathematical content. It was meditative and almost soothing. I even continued to do mathematics problems out of my university textbook in my second and third years of teaching. I would do it before bed to decompress from the day. I came to know mathematics through discovering my own solutions and practicing the skill of mathematical argumentation.

Experiences as an Educator. I spoke in depth about my distress over testing in the introduction of this thesis. However, I did not discuss my beliefs around how learners come to know and love mathematics, or how I come to know the learning that has occurred in my mathematics classroom. I would love to do weekly assignments with my students, or projects that spanned a long period of time—ones that mimicked the assignments I had in university—but with students of the middle school age, it is a challenge for them to keep organised and not lose their assignments. I know there are solutions to this; but they seem inefficient. Even so, I remain

---

my relationship with mathematics. This to me, indicates that assessment has the potential to inspire the development of a positive relationship with mathematics.

convinced that mathematical argumentation, and not content, is how students come to truly know mathematics. With that said, my instructional methods are based on Peter Liljedahl's work on vertical non-permanent surfaces (VNPS; Liljedahl, 2016).

The premise of VNPS work is this: students work in small groups to solve an open-ended problem, which then leads to a gallery walk and discussions where my students and I discuss the differences and similarities in solutions, as well as why they work. While students are working in groups, I walk around and observe their conversations and progressions. It is in these moments that I have historically come to know the most about student learning. Even more, on several occasions there were massive discrepancies between student performance on the test and student performance during the VNPS lessons. When I first started this instructional method, I was worried that I was just delusional and that I could not trust my observations. With time and practice using this method, I came to realise my observations were, in fact, on point.

Master of Education and Current Research. The Master of Education (MEd) program, while a relatively short-lived experience, has shaped my professional and personal identity in unimaginable ways which, in turn, shapes my multiple roles within the profession of education. Langer-Osuna and Esmonde (2017), in describing identity in the context of mathematics, note that identity is "fundamentally linked to learning because learning is conceptualized as the process of becoming a certain kind of person in relation to mathematical activity, including its varied skills, knowledge base, and social practices" (p. 637). This can be applied to the context of professional learning as well, in a sense that role identity is a process of becoming a certain kind of person in relation to a specific role. In fact, "teacher professional learning refers to changes in knowledge, orientation, and skills that pertain to the person's conception of teaching and actions as a teacher" (Kaplan & Garner, 2018, p. 8). Thus, my epistemological and

ontological beliefs are being influenced as a result of the formal professional development I am experiencing through the MEd program.

Specifically, the full immersion in the program combined with a temporary sabbatical from teaching temporarily places me on more of a philosophical and spiritual journey in order to contemplate and interrogate my teaching, and more specifically, mathematics assessment practices. Andersson and Palm (2017) and Cross Francis et al. (2018) indicate that providing sufficient and structured support is crucial for influencing teachers' pedagogical practice. This support could come in the form of professional development (Beesley et al., 2018) or networking within a community of practice (Mentis et al., 2016). I feel that the program has offered all of these elements, and I consider the MEd program to be a significant source of identity development and professional development which is situated in an environment that engenders the ability to contemplate and speculate about future practice.

3.4 Purpose and Goals

3.4.1 Characterising Purpose and Goals

The third element in the DSMRI is *purpose and goals* which refers to what the actor (teacher) believes to be important, relevant and worth pursuing within the context of their role, as well as their overall purpose as a professional; this includes intrinsic and extrinsic, individual or collective, short-term or long-term goals defined with varying levels of broadness and orientations (Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018). Clarke (2009) described a similar notion as the *telos* of ourselves as teachers; it is the end-point or purpose of our identities as teachers and it shapes our goals and motivations for and in teaching.

Purpose and goals can be either collective or individual. An example of a collective goal could be a school district's initiative, priority or area of focus. In this sense, the collective is

composed of all of the members of the district. Collective goals, however, can be to a smaller scale such as within a school or as a mathematics department. Collective goals and purpose could result from any collective goal within a community of professionals (Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018). In contrast, individual goals stem from emotional ties to how a teacher perceives their role and purpose (Edwards & Edwards, 2017; Pelini, 2017; Van Galen, 2017). As mentioned earlier, aspects of identity relating to the regulation of teaching-related emotional experiences become salient parts of teachers' role identities, and they "serve to influence how [teachers'] come to perceive teaching and who they should be as teachers" (Hong et al., 2018), which in turn would influence their individual goals and purpose.

Purpose and goals may also be extrinsic or intrinsic, however, these two characteristics are difficult to separate. Affective elements, which are experienced uniquely for each teacher, fuel intrinsic motivation (Edwards & Edwards, 2017; Pelini, 2017; Van Galen, 2017) and goal setting. However, Clarke (2009) suggests that self-practices of teacher identity refer to "the techniques and practices we use to fashion and shape our teaching selves" (p. 191). This in combination with Ashforth's assertion that role identities are often developed within the context of an organisations' normative beliefs and enactments and influenced by a longing for belonging and membership (Ashforth, 2001) indicates that our purpose for teaching, while intrinsically motivated, are heavily influenced by external factors.

The relationship between epistemological and ontological beliefs (discussed in the previous sub-section), and purpose and goals is interdependent. This is partially due to the notion that intrinsic goals cannot be fully separated from the extrinsic. Any identity development happens as a consequence of renegotiation in or response to environmental tensions (Darragh, 2016; Hong et al., 2018). These tensions are not necessarily negative; in fact, Ruohotie-Lyhty

and Moate (2016) suggested that teachers approach tensions in three different ways: reductive, where a teacher may "resist practices or ideas that were present in their environment and to create boundaries for their future teacher identity" (p. 323); expansive, where the teachers' experience leads to the adoption of new ideas; and attentive, where the teacher partially accepts new perspectives which they find relevant to their context. This process is relevant as it showcases the dynamic nature of teacher identity development as it pertains to the presentation of new information and new situations. For example, in Edwards and Edwards (2017), a teacher's transition from preservice teacher to first- and second-year teacher is followed. It was found that, originally, the teacher's goal was to present students with oral assessments, but changed to a more balanced approach between written and oral. This example showcases the relationship between personally held ontological beliefs and the norms within communities of practice as they related to the element of purpose and goals; it also showcases the link between purpose and goals, and self-definitions and self-perceptions. Even more, "individuals develop a sense of who and what they are—their goals, values, beliefs, and normative ways of thinking, acting, and even feeling" (Ashforth, 2001, pp. 25–26)—through group memberships (Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018) that may be socially, culturally or politically defined. Thus, there are implications for pedagogy (ontological and epistemological beliefs) as well as self-perceived efficacy (self-perceptions and self-definitions).

3.4.2 Situating Purpose and Goals in Personal Context

In this section, I discuss personal examples of purpose and goals. It is important to note that these examples are heavily influenced by my epistemological and ontological beliefs, my self-perceptions, as and my perceived action possibilities (discussed in following section). I begin with examples of collective goals and follow up with examples of individual goals.

An example of a collective goal is related to my membership to the collective of people who work at my school, and more specifically the math department. At my school, the math department has made it a goal to align all of the assessments amongst grade level. In other words, we have implemented a common assessment practice (as mentioned in the introduction). Beyond my membership to the school collective, I belong to an online group of mathematics educators. I am part of a community of mathematics educators, whose aim is to share tasks that elicit deep mathematical thinking and that provide opportunities for multiple solution pathways. This collective goal may also have been influenced by an individual goal, as it was an individual goal that led me to seek out like-minded educators in an online community.

In the same vein, my purpose for teaching is to create more (com)passionate environments in mathematics where students do not feel so isolated, and where they feel connected to and curious about mathematical content; this drives my individual goal of seeking out professional development related to this purpose as well as pursuing a MEd related to alternative assessment. I would be remiss if I did not acknowledge the influence of my past experiences as a student, the positive interactions I have had with mathematics professors, and the philosophical discussions I have had with my colleagues (in multiple departments), all of which have shaped and influenced the curation of my goals and purpose for teaching. In other words, the collective and individual purpose and goals are often indistinguishable.

3.5 Perceived Action Possibilities

3.5.1 Characterising Perceived Action Possibilities

The final element of the DSMRI model is *perceived action possibilities* characterises an actor's perceptions regarding possible actions, behaviours or purpose, goal pursuits, and the related affective nature of these perceived elements. These perceptions would define what an

individual perceives as appropriate, effective and possible to achieve which are relevant to the role they hold in terms of epistemological and ontological beliefs, self-perceptions and self-definition, and purposes and goals (Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018). This particular element of identity is what Clarke (2009) denotes as the authority-sources of teacher identity, which includes the perceived power structures, level of agency, and external factors that shape what teachers believe to be important, their attitudes, and their behaviours. In other words, the perceived action possibilities are what determine the ultimate actions and enactments of teachers.

I understand these perceived action possibilities as falling within three themes; they can be politically situated, socio-culturally situated, or psychologically situated[15]. I characterise politically situated boundaries as barriers that surface in the teacher's external environment that restrict certain actions either through government or institutional mandates and policy; these are barriers that are not easily side-stepped or ignored. I characterise socio-culturally situated boundaries as barriers that teachers face as a result of societal or cultural factors that do not immediately dictate teachers' actions, but that cause enough tension to influence their behaviour. Finally, I characterise psychologically situated boundaries as tensions or barriers that arise as a result of an inner conflict of some sort, or a threat to identity. Each of these categories of perceived action possibilities have direct implications for teacher agency and are not mutually exclusive.

---

[15] This is the way I have come to thematisise and understand the limiting factors that influence perceived action possibilities, and these are the names that I have come up with to describe my understanding of them.

Teacher agency is found to be one of the more salient components of identity development (Beijaard et al., 2004), and is described as "one's ability to pursue the goals that one values" (Day et al., 2006, p. 602) and have "a sense of control over one's teaching context" (Hong et al., 2018, p. 244). In this sense, the impediments to agency can be both internal and external (Hong et al., 2018), and "professionals use their autonomy to make informed decisions by applying a specialised body of knowledge to specific situations" (Mentis et al., 2016, p. 67). For example, "student agency in identity formation is exercised *re*actively as student resist, negotiate, or come to identify with normative academic roles" (Heffernan et al., 2017, p. 54). When this autonomy is perceived to be threatened, the perceived action possibilities are subsequently limited, and, as mentioned above, I organise these perceived action possibilities in three categories: politically situated, socio-culturally situated, and psychologically situated.

Characterising Political Influences. Political influences on perceived action possibilities are top-down mandated or required actions that have direct implications for teacher agency. For example, mandated curricula, funding and resource constraints or lacking administrative support (Hong et al., 2018; Van Galen, 2017) and other hierarchical power imbalances (Bekerman & Zembylas, 2018; Edwards & Edwards, 2017; Hong et al., 2018; Van Galen, 2017). These imbalances are exemplified by policies and directives which delegate to teachers, specific expectations for their roles as professionals (Grootenboer, 2013; Hong et al., 2018; Van Galen, 2017). The above examples are barriers that directly dictate teacher action by political means and are not easily overcome or negotiated thus, they often result in acceptance of or compliance to the situation. However, the perceived action possibilities that result from these political influences are dependent on how the teacher perceives their level of agency in the

interpretation and implementation of these policies. Thus, teachers may comply or choose not to comply based on how they perceive their action possibilities.

A popular example of politically situated influences on perceived action possibilities in the literature is the notion of accountability and performance-driven culture and accountability-based policy (Cross Francis et al., 2018; Hong et al., 2018; Van Galen, 2017)—a politically situated barrier. Elements of teachers' identities are heavily influenced by these accountability measures (Buchanan, 2015; Hong et al., 2018). Even more, in their study about elementary teacher's mathematical identity, Cross Francis et al. (2018) noted that pressures to increase performance and numeracy skills, in the form of policy and administrative demands, served to decrease professional agency and influence decision making. In this sense, accountability measures do not directly dictate to teachers what they should do, however, the resulting pressure for student achievement tends to influence teachers' perceived action possibilities in instruction and assessment.

Characterising Socio-Cultural Influences. The second category of influence on perceived action possibilities is that of socio-culturally situated boundaries. An example of a socio-culturally situated influence on perceived action possibilities would be that of societal beliefs about teaching often showcased in the media or reflected in communities (Pelini, 2017). For example, Morgan (1999) argues that parental or student opposition to change, for instance in the case of the 'New Math' initiative, could have a powerful and negative influence on teacher autonomy. Teachers may find themselves changing, shifting or ignoring certain beliefs—and, as a result, action possibilities—in response to these societal tensions. Similar to societal beliefs would be tensions faced as a result of differing cultures. For example, in Edwards and Edwards' (2017) study, a teacher held strong beliefs about oral assessment which were influenced by his

bi-cultural identity as a learner and professional, but when he was confronted with conflicting beliefs within the western school culture, he renegotiated his actions and shifted his beliefs about assessment. Thus, both common societal and cultural beliefs that conflict with a teacher's perspectives and goals impacts their perceived action possibilities. Thus, the socio-cultural boundaries refer to those environmental challenges that provide some level of freedom to choose actions within limits (Clarke, 2009). Important to note, however, is that the level to which a teacher is influenced by these socio-cultural factors is dependent on how they perceive the barrier, itself. In other words, different teachers will perceive the level of difficulty in negotiating a boundary in unique ways, potentially based on their level of expertise and experience, their epistemological and ontological beliefs, or their purpose and goals.

Characterising Psychological Influences. The final barrier that acts to influence teachers' perceived action possibilities would be psychologically situated influences. Huang et al. (2019), found that, in the first years of teaching, lacking agency to construct their preferred identities lead to great internal conflict in teachers. Individuals typically want to reduce the conflicts between their professional identity and the collective identity of the community of practice in which they reside in order to maintain positive interpersonal relationships (Pelini, 2017). Similarly, Schaefer & Clandinin (2019) find that novice teachers favour belonging over negotiating the professional landscapes of their teaching philosophies which translated to "not being able to live out the story of teaching that they are expected to live out as well as not being able to live their imagined life as a teacher" (p. 60). In this way, a psychological barrier to enactments would be a longing for belonging to a professional community or network. An extension of wanting to belong would be longing to be seen as a competent professional. For example, Day et al. (2006) found that teachers' perceptions of not meeting expectations and not

being able to keep up with workload made it feel like their teacher identities were in conflict with reality; a perceived feeling of inadequacy is a form of lacking agency (Hong et al., 2018; Van Galen, 2017) with significant affective consequences such as feelings of shame (Van Galen, 2017). Given the emotional nature of teaching, and the fact that professional identities and personal identities are deeply tied, it follows that perceived action possibilities are heavily influenced by psychologically situated barriers.

Unfortunately, Beijaard et al. (2004) suggested that striving for uniformity actually impedes identity development and formation. However, while membership and belonging to a professional network challenges agency in some ways, it engenders a greater sense of agency (Connolly et al., 2018), competence (Mentis et al., 2016) and ability to navigate tensions in others (Connolly et al., 2018). Teachers negotiate between their own ontological and epistemological beliefs and the socially situated beliefs about teaching thus putting a teacher's purpose and goals at risk as they contemplate ethical dilemmas (Reeves, 2018); however, it is within these environments of tension that teachers do have some level of choice and freedom to decide which ethical pedagogical choice to make (Clarke, 2009). Clarke (2009) suggests that when we form fixed notions of identity that are defined and taken for granted as being constrained by external sources of power, our identities become fragile; on the other hand, "this fragility is also a source of potential freedom" (Clarke, 2009, p. 196) that may manifest into alternative perceived action possibilities.

3.5.2 Situating Perceived Action Possibilities in Personal Context

I wish to briefly discuss some external and internal influences on perceived action possibilities as it pertains to this study. However, I include only examples for the political and psychological influences; this is because certain socio-cultural influences are showcased in depth

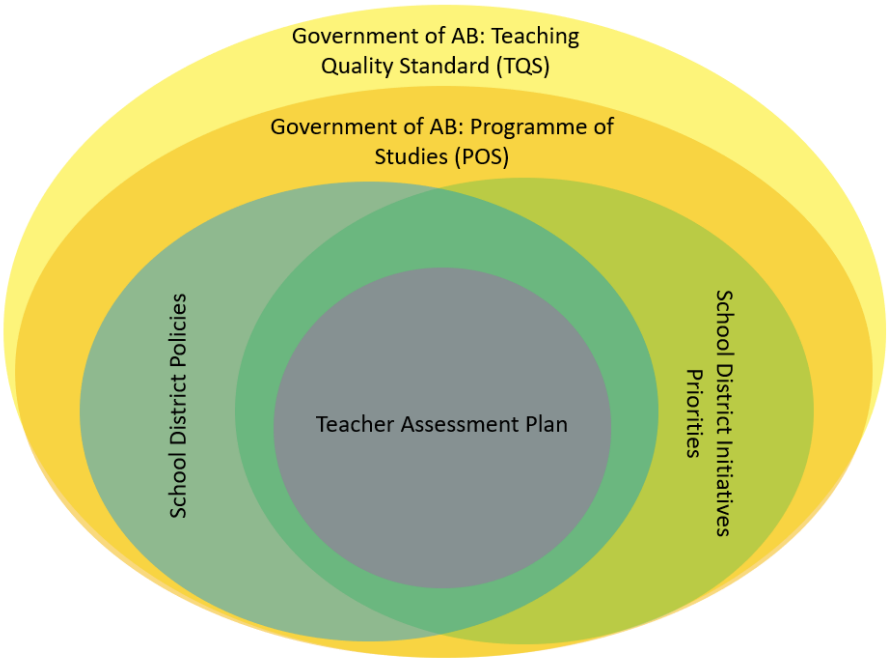
in the first chapter where I explain my personal school-based context. Recall that the purpose of the study is to speculate about a future of assessment in mathematics which necessarily overcomes many of the current perceived restrictions. Even so, external and internal perceived barriers shape my thought processes as I attempt to make sense of the state of assessment currently, and future directions in assessment in mathematics. Each of the influences described below are perceived influences. They are an attempt to account *for* certain enactments and include only speculations as I attempt to detangle the multiple strings of my own role identity and practice. In addition, I leave this dimension—perceived action possibilities—to last, as it is a culmination of the prior three dimensions in a sense that role enactments that seem possible are heavily influenced by self-identified dispositions, beliefs about teaching and what it means to be a teacher, and my purpose and goals within teaching, in addition to the level of agency I perceive to have.

Political Influences on Perceived Action Possibilities. I begin by discussing the political factors that influence perceived action possibilities. These structures include the Alberta Program of Studies (Alberta Education, 2008a, 2008b, 2016), the Teaching Quality Standard (Alberta Education, 2018), and a brief policy review. Curriculum guides, teaching standards documents, and policies, while periodically updated, continue to be firmly established structures within education. As with any politically oriented phenomenon, there are certain elements that are particularly problematic, and other more progressive elements which inspire change. In the following paragraphs, as I discuss the Alberta programs of study for 7–9 and 10–12, the Teaching Quality Standard, and various policy and district initiative documents, it may become clear to the reader some of my epistemological and ontological beliefs; this is intentional.

In Canada, it is the provincial governments that design the program of studies and curriculum content, and broadly outline the roles and responsibilities of teachers. School districts design and implement policies that align their initiatives with the governmental mandates in a way that meets the needs and philosophies of stakeholders within the district. In turn, teachers use these government mandates, and district policies and initiatives to guide their pedagogical decisions in which they have a certain level of freedom (**Figure 6**). The level of freedom a teacher perceives themselves to have in response to these mandates and policies would be unique to each teacher and dependent on the multiple dimensions of their role identities and the interactions of these dimensions. In the following sections, I discuss the nature of impact of these mandates, policies and initiatives on my perceived action possibilities.

Figure 6

Visual Representation of Structures That Influence My Role-As-Assessor



Alberta Program of Studies. The Alberta program of studies (Alberta Education, 2008a, 2008b, 2016) has a chronic influence on my perceived action possibilities. Here, I use the term chronic as a means of discussing the deep-seeded, firmly-rooted and contentious nature of the program of studies which seems to perpetually restrict my action possibilities via political agendas. Teachers in Alberta are mandated to teach the program of studies (2008a, 2008b, 2016); I perceive this as meaning, while I may add content, I do not have the power to 'leave out' parts of the program in my curriculum.

In the mathematics program of studies for secondary levels (grades 7–12), it is expected that the mathematical processes be woven into instruction and assessment. The processes to which the documents are referring include reasoning, technology, visualization, communication, connections, mental mathematics and estimation, and problem solving—skills that I discussed in the literature review. The specific outcomes are designed, to a certain extent, to elicit the use of these processes. They are intended to "identify the specific skills, understanding and knowledge that students are required to attain by the end of a given grade" (Alberta Education, 2008, p. 11; Alberta Education, 2016, p. 9). In other words, the content of the curriculum is focused around specific outcomes and mathematical processes.

In addition to the programs of study, the Alberta Government provides a document for teachers that outlines the achievement indicators for the specific outcomes found within the program of studies. That is, for every specific outcome at every grade level, samples of evidence and suggestions for criteria are provided to guide teachers in assessing whether a student met the outcome or not. These are found in a set of separate documents, and they provide a rubric-like description of different levels of student achievement including an acceptable standard or a standard of excellence. In this way, between the program of studies (Alberta Education, 2008a,

2008b) and the achievement indicators there is a great amount of elaborate content prescribed as I attempt to build a curriculum aligned with government standards, a prescription I often feel compelled to take with a spoonful of sugar[16] (i.e., alternative interpretations of the SOs).

The Alberta program of studies (Alberta Education, 2008a, 2008b) presents me with a perceived hard boundary that, not only restricts my perceived action possibilities, but carries with it several problems. First, the sheer volume of elaborate and fragmented content (Freisen & Jardine, 2012) that is intended to be covered each year threatens teacher and student autonomy to pursue areas of interest beyond the program of study. Even more, there is no acknowledgement in the program of studies that the content is culturally situated, just as Aikenhead (2017) suggested. Reference to cultural values and beliefs is done only in terms of students' diverse backgrounds, and the (rather short) section on *First Nations, Métis and Inuit Perspectives*[17]. Compounding these issues, is the fact that the SOs represent abstract and fragmented content making it difficult for students to see themselves in the curriculum and see any relevance to it (Aikenhead, 2017; Freisen & Jardine, 2012). Thus, the wording of the content in the POS may be worth re-interpreting in the speculative fictions on assessment.

---

[16] This is a reference to a film that came out in 1964 called Mary Poppins, which had a song with the lyric "just a spoonful of sugar helps the medicine go down." See (Stevenson, 1964) for movie and (Belmondo, 2017) for music video of song.

[17] It is pretty clear to me that this section was added separately as part of a revision which may explain why First Nations, Métis and Inuit perspectives are not referenced anywhere else in the document. Perhaps, the revision should have woven these perspectives throughout rather than simply inserting an extra section.

Alberta Teaching Quality Standard. In addition to the program of studies (Alberta Education, 2008a, 2008b, 2016), there is a document that outlines expectations for teacher's roles and responsibilities as professionals; it is called the *Teaching Quality Standard.* This document mirrors the program of studies and many policies (discussed below), stating that teachers are to use a variety of assessments. The main justification for this seems to be that using a variety of assessment strategies will "help build upon the diverse knowledge, cultures, communication styles, skills, attitudes, experiences and learning styles of the students" (Alberta Education, 2008a, p. 3) and to honour cultural diversity (Alberta Education, 2018). This statement may not contradict the program of studies directly, but the beliefs I hold about what it means to "honour cultural diversity" engenders a great deal of tension in relation to the SOs in the program of studies. As I currently interpret them, the SOs act as a barrier to fulfilling the above responsibility—at least in mathematics. In fact, where the program of studies focuses on abstract Platonist mathematics (Aikenhead, 2017), the Teaching Quality Standards suggest placing importance on our students' cultural identities, which to me, means exploring more culturally relevant and contextualised mathematics. This clash of cultures is well represented in the literature (see Little Bear, 2000), and it presents a challenging negotiation when I contemplate perceived action possibilities.

While mathematical knowledge may provide a source of content, both the program of studies (Alberta Education, 2008a, 2008b, 2016) and the TQS (Alberta Education, 2018) documents agree, teachers ought to "provide a *variety* [emphasis added] of methods through which students can demonstrate their achievement of the learning outcomes" (Alberta Education, 2018, 3(c)), and assessments ought to "help build upon the diverse knowledge, cultures, communication styles, skills, attitudes, experiences and learning styles of the students" (Alberta

Education, 2008a, p. 3). This further supports a necessary negotiation in content outcomes, just as Aikenhead (2017) suggests which continues to shape my own ontological and epistemological beliefs. The perceived conflict between the two mandates elicits tension within my own role identity; I find myself continually contemplating: *how bad would it really be if I did not cover all of the content in the program of studies?*

In line with attending to students' identities and cultural backgrounds, and as a result of the shifting awareness towards more culturally appropriate and reconciliatory practices, Alberta's education system includes mandates in the TQS (Alberta Education, 2018) to attend to the needs of First Nations, Métis, and Inuit students. This important shift carries with it, responsibilities for educators to diversify their teaching practices and content in a way that honours and reconciles with the cultural traditions of Indigenous peoples. Just as a section on First Nations, Métis and Inuit perspectives is part of the revised version of the program of studies (Alberta Education, 2008a, 2008b), there is an added standard added to the revision of the TQS. This addition is as follows: "A teacher develops and applies foundational knowledge about First Nations, Métis and Inuit for the benefit of *all* [emphasis added] students" (Alberta Education, 2018, p. 6). Below, I have noted some achievement indicators of relevance for this quality standard (**Figure 7**); one of which states that teachers demonstrate this standard by "using the programs of study to provide opportunities for *all* [emphasis added] students to develop a knowledge and understanding of, and respect for, the histories, cultures, languages, contributions, perspectives, experiences and contemporary contexts of First Nations, Métis and Inuit" (Alberta Education, 2018, 5(c)).

Figure 7

Teaching Quality Standard

5(b)	Supporting student achievement by engaging in collaborative, whole school approaches to capacity building in First Nations, Métis and Inuit education
(c)	Using the programs of study to provide opportunities for all students to develop a knowledge and understanding of, and respect for, the histories, cultures, languages, contributions, perspectives, experiences and contemporary contexts of First Nations, Métis and Inuit; and
(d)	Supporting the learning experiences of all students by using resources that accurately reflect and demonstrate strength and diversity of First Nations, Métis and Inuit

Note. The content of this table is re-typed verbatim from the Teaching Quality Standard document (Alberta Education, 2018, p. 6)

For me, this official acknowledgement through government policy is a powerful source of hope, yet there is more to be done in order for the above philosophy to truly be represented in school curricula and teacher assessment practice. How we might honour and represent First Nations, Métis and Inuit ways of knowing and ways of doing mathematics within daily mathematics education, and, in particular, assessment practices? The way I interpret this document and the mathematics programs of study (Alberta Education, 2008a), I see that the program of studies presents a significant threat to TQS#5(c), and because both documents are mandated, I find there is a tension within my role identity that continues to force negotiation. Namely, I need to resolve this perceived conflict and align my purpose and goals with the resulting perceived action possibilities. This has implications for the current research project as I attempt to speculate about a future assessment practice in mathematics education.

Examples of District Policy. Using the above government mandates and policies, school districts create policies and initiatives that, in turn, impact the choices teachers make about their

practices. The following discussion outlines the multiple policies and initiatives representative of school philosophies within three school districts in my spatial context. These policies and initiatives guide my assessment practices, as I live and work as a teacher within the greater Edmonton area in Alberta, Canada. I choose to include several districts in my investigation of policy and initiatives rather than only my own school district because, in my motivation to pursue a deeper understanding of assessment, I find that each shapes my thinking around assessment and interpretation of policy in different ways. Here, I begin by discussing general themes within these district policies, growth plans and initiative documents that carry relevance to assessment. Following the general, I present policies and initiatives specific to mathematics and assessment as they shape my own role identity as math educator and assessor of knowledge.

Within documents that outline district initiatives and policies, I found there was mention of increased cultural diversity within the student body. The term diversity was used to describe a perceived ongoing increase of English Language Learners (ELLs) and First Nations, Métis and Inuit students (Edmonton Public Schools, 2018b), or in other terms, increasingly complex and diverse classrooms[18] (Edmonton Public Schools, 2018b; St. Albert Public Schools, 2017). As a result, many districts have explicitly addressed the need for a culturally relevant curriculum that

[18] I find myself disagreeing with the rhetoric used to describe student bodies that include students of multiple nationalities, cultures, languages, and in general, unique identities is inappropriate because, at times, within these documents, it seems like ‘diversity’ and ‘complexity’ are conflated with ‘non-white’ or ‘non-western’ students, which in turn carries with it an indication of othering certain students. I choose to acknowledge this discomfort while simultaneously recognising that this is my perception and others bring different perceptions.

supports and meets the needs of diverse learners (Edmonton Catholic Schools, 2019; Edmonton Public Schools, 2018b; St. Albert Public Schools, 2017). For example, one of the district's priorities is to commit to "ongoing communication, participation and engagement that enhances public education and respects the diversity of our community" (Edmonton Public Schools, 2018a).

A second theme within policy and initiatives is the effort to increase numeracy and literacy—though these terms are ambiguously defined within the policy and initiative documents. For example, St. Albert Public explicitly states that they intend to "increase literacy and numeracy skills of students in Preschool to Grade 12 through a district Enhancing Instructional Practice project" (St. Albert Schools, 2018, p. 5). Similarly, Edmonton Public School's first priority is to increase the number of students that "demonstrate growth and achieve student learning outcomes with a specific focus on literacy and numeracy" (Edmonton Public Schools, 2018a). The terms 'skills' and 'demonstrate' indicates to me that numeracy skills, like those mentioned in the literature review, ought to be considered in the design of assessments.

In fact, school policies indicate specific characteristics of assessment, mostly in regards to assessment structure, but with some implications for content and inferences. The main theme seems to be variety in assessment practice (Edmonton Catholic Schools, 2000; Edmonton Public Schools, 2014; St. Albert Public Schools, 2018) both in terms of format and function. For example, districts suggest providing multiple means of expression, while ensuring flexibility (St. Albert Public Schools, 2019) validity and reliability (Edmonton Catholic Schools, 2000). Two districts mention specific formats of assessment including observations, discussions or conversations, questioning, products, conferences, demonstrations, projects, portfolios, performances, peer and self-assessments, reflections, student writing and tests (Edmonton

Catholic Schools, 2000; St. Albert Public Schools, 2019). In addition, districts suggest using professional judgement keeping in mind the frequency of formative and summative assessment (Edmonton Catholic Schools, 2000; Edmonton Public Schools, 2014; St. Albert Public Schools, 2019). Thus, across the districts investigated, there seems to be a consensus on the need for variety in function, timing, and format.

Interestingly, each district has a specific focus when it comes to content. For example, Edmonton Catholic Schools explicitly emphasise deep conceptual knowledge and cross-curricular content (Edmonton Catholic Schools, 2019), while Edmonton Public Schools focus on assessments that "meet the standards of education set out by the Minister of Education" (Edmonton Public Schools, 2014, p.1)—a slightly broader directive. In contrast, St. Albert Public Schools is "engaged in ongoing professional learning opportunities to build First Nations, Métis and Inuit cultural competence and culturally-responsive instruction and assessment strategies" (St. Albert Public Schools, 2017, p. 35) indicating that inclusion of First Nations, Métis and Inuit perspectives were of focus in assessment content. Despite these differences, each of the three districts have clearly used the POS and the TQS to guide their policies on assessment content.

Finally, all districts, in some form or another, indicated that assessment was to be equitable for and attend to diverse student populations (Edmonton Catholic Schools, 2000; Edmonton Public Schools, 2014; St. Albert Public Schools, 2019) and that feedback and reporting was to occur periodically and transparently (Edmonton Public Schools, 2014; St. Albert Public Schools, 2019). Important to note is that none of the assessment policy or initiative documents indicated that teachers were to use accountability testing as a guide for their instruction and assessment; rather, teachers' focus was on using assessments that meet the needs of the students and provide clear, valid and useful information to the parents.

Psychological Influences on Perceived Action Possibilities. In this sub-section, I intend to showcase some examples of psychological influences on perceived action possibilities. These influences are internal to the mind and entirely subjective. In this sense, they are accounts for that may not necessarily be objectively valid, but are nonetheless felt or perceived. First, I provide a particularly relevant inner dialogue that I have which showcases inner conflict which, in turn, influences my perceived action possibilities. I then move on to attempt to provide some accounting for in regards to self-perceptions and self-definitions. These two examples are only some consciously identified psychological influences which are intended to help bring the reader into my world of thinking and perceiving.

First, consider the narrative excerpt below:

> My teaching practice and my professional pursuits are rooted in doubt, inner-conflict, passion, love, experience, hope, and tension. "Should I do this or should I do that? What will my colleagues think? What will the parents think? I feel like this would be better, but it seems like everyone else is more comfortable with that." I am tired. I want to know if what I believe in—my philosophies about teaching mathematics—*are right* [emphasis added]. So, here I am, in a graduate program, ready to explore *the truth* [emphasis added]. I am here, not only to grow professionally in my knowledge, but to resolve the seemingly never-ending doubt of wondering if I am doing the right thing for the students and to figure out precisely who I am as a mathematics educator—to define my resolve.

The above is an excerpt from what I wrote initially as an introduction to myself as an educator and the context from which I initially entered the program of MEd. I thought it important to include for a few reasons: first, the aspect of doubt is one of the more pervasive elements of my identity that influences many of my perceived action possibilities; second, it is in

direct conflict with the part of the literature review that discusses how ‘best practice’ is an erroneous construct; finally, the indication of inner-conflict transcends my own experience, and is well-represented in the literature on teacher identity. These three elements provide a strong basis for discussion about how the MEd program has inspired significant shifts in my psychologically situated perceived action possibilities.

Secondly, I provide some speculative accounts for in relation to some self-definitions and self perceptions. Accounting for my enactments as educator and the emergence of particular aspects of professional identity over time using these physiological, psychological, sociological and cultural self-definitions and self-perceptions is purely speculative. In other words, the reasons I attribute to particular performances as educator are perceived and can only be speculated. An example of such a speculation could be that my whiteness and Frenchness[19] (physical and cultural definitions) affords me the privilege of having a relatively smooth educational experience catered to my cultural identity, which subsequently led to a quick transition between preservice teacher training and full employment. This quick transition engendered a sense of confidence and belonging within the community of practice I became a part of which led to the development of my self-definitions as mathematics educator, and as mathematics inclined. In addition, my disposition that compels me to mimic the professional

---

[19] I use the term Frenchness to refer to the bilingual environment in which I was raised being the daughter of a French Canadian. This bilingualism afforded me greater professional opportunities and put me at an increased advantage for transitioning from student to professional. This has to do with the increased privilege as a person who speaks both official languages of Canada.

behaviours of my more experienced colleagues, as well as have elaborate justifications for my pedagogical choices may be attributed to my self-perception as being a young teacher relatively new to my career. Finally, being unmarried, being epileptic, and having no children (sociological and physiological), may drive concerns that others—specifically parents—may not see me as a person fit to act *in loco parentis*[20]. Again, these accounts for are purely speculative and are based on how I define and perceive myself, and my identity roles. As in my case above, "historical, sociological, psychological, and cultural factors may influence the teacher's sense of self as a teacher" (Schaefer & Clandinin, 2019, p. 113).

3.6 Concluding Commentary for DSMRI

The dynamic system, characterised by the above four elements, can either be in harmony or there can be tensions between elements of the role identity (Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018). When beliefs (about teaching or about oneself as a teacher) are challenged by contextual factors, professional identities become unstable (Huang et al., 2019; Schaefer and Clandinin, 2019) or cause conflicts and inconsistencies (Ashforth, 2001) within and between role identity elements. However, in order for one to freely develop oneself professionally, it is necessary to participate in identity work; that is, to deeply reflect on one's identity and contexts in which our identities are formed (Clarke, 2009). Identity work involves an exploration and deep reflection on both the individual and social engagements, "an awareness of the contingent and constitutive nature of our histories" (Clarke, 2009, p. 196) which enables an ethico-political

---

[20] *In loco parentis* is outlined in the Alberta Teachers' Association's *Teachers' Rights and Responsibilities and Legal Liabilities* document as a term to describe teachers' role as "a caring parent, as an unofficial guardian" (ATA, 2019, p. 27).

enactment of self, and an acceptance of the inevitable ambiguity within our identities (Clarke, 2009). In this sense, I use the DSMRI model as a lens through which to understand my own self-exploration, or as Clarke might put it, identity work.

To summarise, "the Dynamic Systems Model of Role Identity (DSMRI) reflects the intuitive understanding that a teacher acts in order to achieve goals on the basis of [their] beliefs about the situation and about [themselves] as a teacher in that situation" (Kaplan & Garner, 2018, p. 70). The four elements described above and their characteristics, as well as the multiple roles represented within teachers' identities are interdependent and interrelated forming a complex and dynamic system situated within temporal and contextual frameworks affected by content, structure and process of identity development (Kaplan & Garner, 2017, 2018).

The DSMRI model pertains to the characteristics of professional identity as per their roles that goes beyond professional knowledge changes towards characterising a holistic change within the lived context of professional learning (Kaplan & Garner, 2018), I feel it well suited to conceptualise and situate the current research. I must admit that this research is all at once painful yet cathartic, uncomfortable yet reassuring, and leaving many unanswered questions yet existentially affirming. I suppose this is the nature of identity work that is necessary for professional growth (Clarke, 2009) as I come to terms with inner tensions (Curtis & Curtis, 2017; Ellis, 2012) within and between the elements of my role identity causing shifts, "some of which may seem minor, [which] reverberate throughout the system and could, under certain conditions, lead to sudden radical change in the system's next iterations (i.e., a 'butterfly effect')" (Kaplan & Garner, 2017, p. 2038).

4 Methodology

4.1 Introduction to Methodology

Educational research is meant to add to knowledge and improve practice for a particular audience (Creswell, 2012). Creswell notes that, for something to be considered research, it must follow the following process: pose a question, collect data to answer the question, provide an answer to the question. My study intends to take an open inquiry approach exploring a central phenomenon of interest using qualitative data that is generated through autoethnography and speculative fiction. This exploration, which involves a unique form of data generation analysed through a particular theoretical frame, broadens the scope of research in mathematics education. In this instance, the central phenomenon is the process of conceptualising a preferred assessment practice, and the main audience is teachers like myself; however, the dissemination of the research contributes to the field by providing a unique methodology and theoretical framework combination and a relatable text which intends to inspire the reader's own ponderings.

For Mason (2002), methodology is what frames and characterises the way in which methods conform to standards of research. These standards vary depending on the methodology used. For Hughes and Pennington (2018a) methodology is "the established and evolving approach to and foundation of a research study" (pp. 10–11). Here, I use a mix of autoethnography and speculative fiction to guide my methods and approach to answering my research question. Research in the mathematics education community, specifically in regards to assessment, typically revolve around in-service training for formative assessment methods (e.g., Aitken et al., 2011; Bennett & Gitomer, 2009), professional reflections or explorations of various assessment methods (e.g., Ben-Hur, 2006; Frey, 2014; Pai, 2018; Stenmark, 1991), impact of large-scale testing on in classroom assessment choices (e.g., Frey, 2014; Suurtamm et al., 2016),

or analyses of different assessment methods and how to implement them (e.g., Frey, 2014; Suurtamm, 2018); in essence, they are research of past or present explorations of assessment. Recall the research question: If assessment is to be a continuous and dynamic process and practice of sitting beside one-another and *co-creating* evidence of learning mathematics in a way that contributes positively to the strength, wellness, value and worth *of the student*, the students learning, and the discipline of mathematics, then *what might I come to know about my future assessment practice?* This involves characterising future practice; however, the answer to this question is processed, conceived of, and interrogated through a lens of identity work using autoethnographic approaches. This lens is situated in the superimposed contexts of a MEd program and the teaching and learning of mathematics in K–12 classrooms. Conceiving of a future involves speculative fiction, while the reflection and interrogation of this conception involves the deep inner exploration of the self that an autoethnography methodology stimulates.

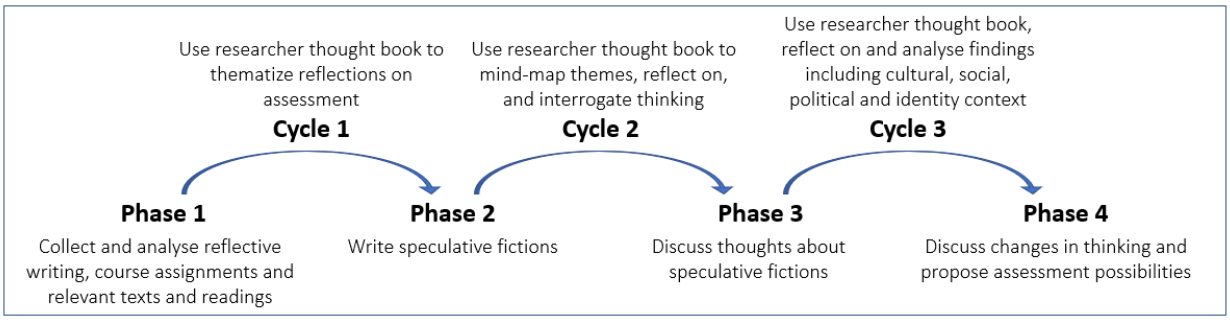
The first step to this research is conceiving of a speculative fiction that characterises my future assessment practice in my secondary mathematics classroom. In order to do this, I first evaluate and reflect on my current beliefs and what I perceive to be the norm beliefs regarding assessment in mathematics. As such, the planning phase for this speculative fiction involves a review and meta-reflection of assignments, personal reflections and texts that have influenced my thinking throughout the MEd program; these will be used to situate my speculations. Following the speculative fictions, I draw from autoethnography to deeply reflect on and interrogate the cultural, social, political and practical implications of my speculative fictions as they pertain to my identity, my practice, and my assumptions around normative practice.

This research can be organised into four phases (**Figure 8**). The first phase involves reviewing and reflecting on the writing I have done as part of my graduate studies; the second

phase is the writing of two speculative fictions on mathematics assessment; the third is an interrogation of the speculative fictions to elucidate the cultural, social, and political contexts that are most salient within the narrative as it relates to my professional identity; the fourth and final phase is a process of discussing what was learned from this research in terms of themes found as well as contextual elements that became evident. There are two dimensions of the methodology and methods; namely, the nature of the research and the nature of the writing.

Figure 8

A General Overview of the Research Process



4.1.1 Nature of the Research: Methodology

In this section, I discuss the literature that I draw on from each methodology as it pertains to the nature of the research. I use the term nature of the research to describe the reflective and analytical processes involved in and between the four phases. Starting with autoethnography, I briefly review the nature of this methodology and the elements of it that play important roles in the research. Following autoethnography, I do a review of speculative fiction methodologies with a specific focus on the elements relevant to this research. I end this subsection with a comparison of the two methodologies and an integrated description of the nature of my research.

Autoethnography as a methodology. In general, autoethnography, as a methodology, is a single-case study (Curtis & Curtis, 2017) that situates the researcher within the cultural, social, and political contexts through which to analyse the self (Ellis, 2012). In this sense “the

researcher is both the principal investigator and the subject of the study" (Hughes & Pennington, 2018a, p. 4). There are many variations of autoethnography as it encompasses a broad range of approaches to self-study. Autoethnography varies in emphasis on three main elements: process (graphy), culture (ethnos), and self (auto) (Ellis, 2012). The researcher, as the single participant, purposefully designs their research with this ratio of the three elements in mind, in order to examine a particular meaningful phenomenon and its cultural, social, and political relevance through a process of identity work. I share Richardson's (2000) sentiment when she says "the aim of writing autoethnographically for me was to demonstrate that by reflecting on some of my own life stories about my identity, I came to a deeper understanding of the research and myself" (p. 826). My research is centred around assessment in mathematics, which I intend to understand more deeply through reflecting on my own ideations and interrogating my assumptions about ideal assessments, and by bringing my own identity into consciousness.

Showcase subjective lived experiences. Autoethnographic research showcases lived experiences; it acknowledges the many lenses through which to interpret experience and the world, and is situated in and driven by subjectivity (Hughes & Pennington, 2018a). The researcher's identity and thinking are central to the narrative inquiry process, and, as a result, generalisability is sacrificed in order to allow for greater subjective interpretations (Le Roux, 2017; Richardson, 2000). As part of this process, "the motivations and assumptions of the author have to be exposed, explained and their limitations assessed" (Curtis & Curtis, 2017, p.268) in order to disrupt the researcher's sense of authority of their perspective and narrative. It is important to be critical of one's own assumptions and how those assumptions may be causing or perpetuating complicity in problems of teaching and learning (Hughes & Pennington, 2018a). Asking the question "what am I learning by examining my identities, power, privileges, and

penalties within one or more cultural contexts?" (Hughes & Pennington, 2018a, p. 6) enables the researcher to interrogate their lived experience and the resulting narrative, by showcasing the subjective nature of it, and engage in deep reflection about positions of power that influence alternative subjective interpretations.

Reflexivity. The deep and rich inquiry centred around the self and one's subjectivity necessitates researcher reflexivity, which is a salient characteristic of autoethnography. Each autoethnography "involves locating a meaningful phenomenon of interest and considering a critical reflexive approach to thinking and writing" (Hughes & Pennington, 2018a, p. 16). As this thinking and writing progresses, the researcher becomes influenced by or resistant to emerging ideas (Ellis, 2012) through reflexive thinking (Curtis & Curtis, 2017; Le Roux, 2017). The researcher interrogates their thinking through constructive critique, questions, analyses the efficacy of thinking and learning, engages in purposeful inquiry, and becomes aware of the thinking pathways and their efficacy (Curtis & Curtis, 2017). Thus, the researcher's identity continues to emerge throughout the research process as a result of this critical reflexive narrative inquiry (Hughes & Pennington, 2018a), and the investigation "[focuses] directly on the research and personal experiences of the researcher" (Ellis, 2012, para 1).

Contribution to the Mathematics Education. A final important aspect to consider in autoethnographic research is the contribution of the inquiry to the greater field of research. Curtis and Curtis (2017) suggest that autoethnography must have significance beyond understanding the self (i.e., contributes to the literature in the area of study) and is relevant in the training of teachers. The research must provide a clear purpose and relevant contribution to the field with a hook of sorts to elicit interest and relevance in and for others (Curtis & Curtis, 2017). Part of the relevance and purpose comes from the storying of a subjective yet relatable experience, but using

existing research and literature to situate and justify assumptions is also an important part of autoethnography (Curtis & Curtis, 2017; Hughes & Pennington, 2018a). The contribution of this research to the field of mathematics education lies in the blending of autoethnography and speculative fiction which explores a thought experiment about assessment in mathematics followed by an interrogation and evaluation of that thought experiment. This blending of two methodologies provides a future-oriented, yet realistic and critical approach to assessment in mathematics which has the potential to overcome common barriers and yield unexpected avenues to pursue in assessment. Even more, experimenting with these assessments carries no immediate risk to students, and provides a less restrictive and lower risk[21] environment for exploring the connection between professional identity and assessment practice.

Speculative Fictioning as a Methodology. In contrast to autoethnographic methodology which focuses on lived experiences that have been, speculative fictioning is a methodology focused on writing lived experiences that could be (Reid, 2009). Thus, there is a difference in temporal relevance; where autoethnography is centred on (but not exclusive to) past and present, speculative fictioning involves an exploration of potential futures. However, both methodologies present opportunities for exploring discomforts of non-normative relations; in fact,

> we might see speculative fiction as the pattern for all fiction and for the literary experience more generally: it asks us to come to terms with otherness, to leave the

---

[21] Here, I note lower risk rather than no risk because this thought experiment and self-exploration involves a certain affective risk to myself such as discomfort, disappointment, and potential identity threat. However, these are also benefits to the methodology of investigation.

> comforts of sameness behind (though in view) in order to explore difference (Patell, 2015, p. 110).

In this sense, the term speculative fiction is an umbrella category that includes science fiction and speculative fabulation.

Philosophy and Foci of Speculative Fiction. Speculative fiction is a broad genre of writing that has developed different meanings over time; these definitions have included speculative fiction as

> a subgenre of science fiction that deals with human rather than technological problems, a genre distinct from and opposite to science fiction in its exclusive focus on possible futures, and a super category for all genres that deliberately depart from imitating "consensus reality" of everyday experience (Oziewicz, 2017, para 1).

The meaning of speculative fiction continues to expand and transcend multiple non-mimetic genres (Oziewicz, 2017), and it is for this reason that I have chosen to use it. For the purpose of this study, I choose to adopt the meaning of speculative fiction as being an umbrella term for non-mimetic genres, including science fiction, that challenge normative conceptions of reality and propose alternative futures. I draw on science fiction philosophies along with scholarship on speculative fiction to shape the nature of my own proposals. Important to note, is that, in combination with autoethnography, these realities that are challenged are beliefs as perceived by me, and the proposed futures are situated within my own identity framework. Oziewicz references Waggoner's concept of speculative fiction as being a mode of showcasing "what we *do not know* and thereby can only speculate on" (para 25), and because what I know is limited to my experience and the research of the literature that I have done to date, what I do not know and can only speculate on, is both subjective and interpretive. Thus, the purpose of using speculative

fiction is to "[strategically re-story in order to] reposition the binary between self and other, and in this case name the ways in which mathematics education participates in the production of that which is other to the discipline" (de Freitas, 2008, p. 288) in terms of assessment.

Suggesting Alternative Futures. A first element of speculative fiction involves suggesting alternative futures; this is similar to autoethnography which can also be used as a means for proposing alternatives. Science fiction is a thought experiment partially situated in histories yet imagining a reconstructed alternative to what was. They involve asking 'what if?' questions and thinking about alternative histories (Patell, 2015). Much like autoethnographers, speculative fiction writers often situate their work within the dynamic contexts of their times (lived experiences); "accordingly, whatever it is they imagine, they are departing from and building in their own assumptions, criticisms, and idealizations of how the world works and of how it might be different" (Passell, 2013, p. 60). For example, speculative fiction texts are often historically situated yet suggesting an alternative historical progression into a future, with a focus on social and political issues including colonialism, post-colonialism, gender and sexuality and societal structure in general (Brooker & Thomas, 2009; Oziewicz, 2017; Thomas, 2013). This bridging of past, present and potential future involves wondering "what was it like?" (Patell, 2015, p. 88) which is heavily influenced by lived experience and the way the writer perceives the world around them. In this sense, proposing alternative futures demands a level of reflexivity, which is another commonality between speculative fiction and autoethnography.

Interrogating and Challenging Status Quo. A second element in the philosophy of speculative fiction is the exploring and challenging of status quo (Oziewicz, 2017; Passell, 2013); this involves probing specific aspects of normative beliefs and questioning their virtue (Brooker & Thomas, 2009). Speculative fiction texts are usually situated within rationally

explained believable, yet divergent, worlds that plant suggestions for change and by powerfully challenging the social and political[22] (Brooker & Thomas, 2009). In order to challenge the status quo or to interrogate normative practice, it makes sense that the writing is partially situated in historical or current real contexts. However, there are a few ways in which speculative fiction expands on this reality in order to engage in questioning and challenging; thus, there are elements of fiction that act to showcase the relevant ethical dilemma. One type of speculative fiction is science fiction, which often focuses not on the danger of science itself but in the power relations of control and use of science, as well as the reason (Thomas, 2013). For example, science fictions can be used to challenge definitions of scientific truth (Reid, 2009) including what is and is not considered 'true' science. Postcolonial speculative fiction provides a situated fiction that challenges colonial histories and imagines what could be if the colonial influences were to be disrupted and is focused on relations of power and dominance (Reid, 2009). In this example, speculative fiction is being used to question the virtue and the social and political hierarchies of power, particularly in terms of scientific pursuit. In other words, one of postmodern speculative fiction's "enduring features are its destabilization of hierarchies and the versatility of its critical practices. In its self-reflexivity, postmodern criticism wants to interrogate boundaries and make presumptions unstable" (Jorgensen, 2009, p. 279) by dismantling hierarchies and re-imagining worlds of plurality. Extending on this, "through fiction we are able to hear the voice of the underdog, the unknown thoughts of the perpetrator, the power relations

[22] Interestingly, one of the consequences of this philosophy is that speculative fiction can be—and historically has been—used as a way of side-stepping censorship (Brooker & Thomas, 2009)

between two apparently innocent protagonists, the other path not taken, and all the other ways by which otherness is lived" (de Freitas, 2008, p. 288). These are elements of speculative fiction that I draw on for my study[23].

Focus on Ethics. Finally, speculative fiction includes undertones of ethics either through interrogation of lacking ethics (Thomas, 2013) or proposition of more ethical futures (Passell, 2013). This focus on ethics is a continuation of the previous two elements of speculative fiction which are, challenging the status quo and suggesting alternative futures. For example, interrogating the colonial power structures by proposing a different mythology would carry undertones of human ethics. Similarly, challenging definitions of science—or mathematics—and proposing potential futures, would carry undertones of ethical scientific practice. There are different ways to convey these ethical considerations, a writer could "suggest an optimistic future in which systems of difference and inequality have lost much of their force, [or] exaggerate aspects of our current condition in ways that highlight precisely how damaging they are" (Passell, 2013, p. 62). This is the difference between speculative fiction utopias and speculative fiction dystopias, which are both situated in an ethical questioning of what is and what could be by providing a thought experiment to play out ethical futures (Passell, 2013; Thomas, 2013).

4.1.2 Nature of the Writing: Methods

In this section, I describe the nature of my writing including the speculative fictions and the autoethnographic interrogations of the speculative fictions that follow. There are two distinct

---

[23] Speculative fiction is not exclusive to western thought but does tend to be dominated by it. Critical speculative fiction then is an entry point into acknowledging this and re-innovating (Thomas, 2013)

genres of writing in the second half of this thesis: first, there are the speculative fictions, which aim to propose alternative futures that challenge my current conceptions of normative reality, and second, the reflexive writing, in the spirit of autoethnography, that is used as a tool for challenging the integrity and assumptions made within the speculative fictions. In this sense, there are two waves of interrogation. Recall the following phases of the research with writing components.

Short Speculative Fictions. I refer to the productions and processes that occur within the speculative methodology as phases (where the cycles are the analyses and processes that occur as part of the autoethnographic approach). The phase 2 short speculative fictions are planned for and conceptualised through the deep reflection and self-study that occurs in phase 1 of the research. The final speculative fictions are created in the spirit of speculative fictioning, yet are conceived as a result of autoethnographic study. This deviates slightly from autoethnography in a sense that autoethnographic data includes a recounting of experiences that have already happened followed by an analysis of the researcher's thinking about that experience. This study, on the other hand, narrates a proposed future experience, which is then followed by the same self-study and analysis of one's thinking (phase 3&4).

The phase 4 interrogation of the speculative fiction writing is a result of an autoethnographic-style analysis of the speculative fiction (phase 3), and is written in the spirit of the autoethnography, where the researcher discusses the results of their self-interrogation of their thinking and assumptions in order to discover unexpected realisations about themselves and the meaningful (to them) phenomenon of study. In this case, this meaningful phenomenon is, assessment in mathematics education. The purpose of this phase is to question my own thinking from the speculative fictions.

In contrast to the previous section, the nature of autoethnographic and speculative fiction writing are not discussed separately; rather, the following discussion of the writing is described as a bricolage of the two. Autoethnography and speculative fiction, while different, seem to hold similar philosophies of questioning, challenging and shifting normative assumptions. As well, they both necessitate great reflexivity as they aim to propose alternative perspectives to meaningful phenomena. Context, be it political, cultural or social, tends to be central to this exploration. Where autoethnography is a recounting of past experiences, speculative fiction narrates alternative present or future experiences, yet both are situated in historically relevant mythologies. Phase 2 of this research includes an important fictional writing element to it that acts to provide data to interpret and interrogate. In Phase 4, I use this speculative fiction writing to expose and narrate my own thinking about assessment. Both speculative fiction and autoethnography have unique writing styles, however, there are shared qualities between the two. As such, I draw on literature from both writing styles to provide a full description of the nature of the writing in this research process.

Fiction-Factual. There are both fictional and factual elements to the writing in this research; however, important to note is that this 'factual' element is not equivalent to objective factual given the subjective and single-person interpretation of the context and data. As such, the fictional elements would be those texts that purposefully explore imaginative contexts and assessment practices, while the factual elements include those texts that discuss reflections within my perceived real contexts or lived experiences. These two are not necessarily written as separate entities. For example, the speculative fictions, while intended to convey imagined futures, are situated to a certain extent within believable contexts. In a sense, the current perceived reality provides a seed from which to grow an imagined future. These speculative

fictions attempt “to draw readers and viewers to that other world that is close enough to the real world that the audience can see reality, not distorted, as it is in the work, but more clearly” (Thomas, 2013, p. 18), so there is a blending of realism and thought experimentation (Thomas, 2013). The scientific prevents delusional narratives and provides context with normalised stories (KIASualberta, 2014) creating a space of practicality and relatability, whereas the literary situates the reader and researcher in an environment that enables new disruptive stories to shape new possible futures (KIASualberta, 2014). Similarly, autoethnography, in its intent to propose alternative perspectives, incorporates these thought experiments into the writing, but uses current literature to support the intended factual claims and literary truths (Richardson, 2000). There is a “blurring of genre, the complexity of writing, the shaggy boundaries between “fact” and “fiction,” “subjective” and “objective,” “true” and “imagined” (Richardson, 2000). Both the speculative fictions (phase 2) and the autoethnographic writing (phase 4) that follow, blend both the factual and the fictional. This blurring of truth and fiction, is a result of the fact that “whatever it is [we] imagine, [we] are departing from and building in [our] own assumptions, criticisms, and idealizations of how the world works and of how it might be different” (Passell, 2013, p. 60).

Estrangement. The writing in this research has elements of estrangement; that is, it provides an outlet for challenging knowledge, norms and actions of the status-quo by purposefully going counter to dominant discourses and cultural ways of thinking and being (Hughes & Pennington, 2018a), and embrace different versions of reality that are used to “dismantle the traditional Western cultural bias in favor of literature imitating reality, and as a quest for the recovery of the sense of awe and wonder” (Oziewicz, 2017, para 2). In this sense, the writing in the spirit of autoethnography “enlists a rewriting of the subjective self and the

cultural context replete with hidden and explicit rules and norms for sustained participation" (Hughes & Pennington, 2018a, p. 9), while the writing in the spirit of speculative fiction provides examples that threaten the preferred individual agency, where agency "is the power to act effectively on one's intentions" (Patell, 2015, p. 93). The purpose of estrangement, as it pertains both to autoethnography and speculative fiction writing, is intended to place the researcher and the reader within a world that deviates from current reality to pursue alternative perspectives in order to provide a fresh take on the nature of our current realities (Brooker & Thomas, 2009; Hughes & Pennington, 2018a). In a sense, estrangement is a tool used to explore multiple conceptions of reality by contemplating futures that conflict with current perceived realities and assumptions.

Idling in Discomfort and Incomplete Notions of Truth. Extending on this, challenging notions of reality require the researcher and writer to idle in discomfort and incomplete notions of truth (Haraway, 2016). This notion of idling in discomfort stems from several paradigms including postmodernism, which aims to celebrate the multiplicities and "critical receptivity to difference" (Jorgensen, 2009, p. 280) and the inclusion of micro-narratives and partiality (Jorgensen, 2009), as well as posthumanism, which aims to create alternative creations of self (de Freitas, 2008; Haraway, 2016). In order to do this, one must sit with discomfort; I suggest even attempting to savour the discomfort and engaging with it in a way that one loses track of notions of truth—if only temporarily. Part of autoethnography is to explore the cultural, social and political contexts of the researcher's experience through a deep inner exploration (Curtis & Curtis, 2017; Ellis, 2012; Le Roux, 2017) that elicits vulnerability, intertwined and interrelated with the cultural interpretations. In other words, to focus outward in providing context and then focus inward on the personal journey of meaning making and personal experiences as they shape

the researcher's narrative and identity (Curtis & Curtis, 2017; Ellis, 2012; Jorgensen, 2009; Le Roux, 2017). For example, with speculative fiction, there is no requirement for accuracy or alignment with reality; "this denial endows it with a potential for challenging consensus reality, besides making speculative fiction politically scrappy, cognitively empowering, and affectively stimulating" (Oziewicz, 2017, para 40). Similarly, in autoethnography, the text intends to focus on the journey though the process delving into intimate and affective domains (Ellis, 2012) of professional identity. The speculative fiction approach challenges notions of truth through a destabilisation of self and an idling of sorts within the resulting discomfort of incomplete multiplicity (Jorgensen, 2009). Implied within this notion of idling in uncomfortable incomplete notions of truth (and reality), is an element of emotion. Autoethnographic research elicits often visceral sensations in both the reader and the researcher (Ellis, 2012) stemming from deeply vulnerable experiences. The use of narrative is to "evoke emotion, and to take the reader to depths of personal feeling and sympathetic understanding" (Le Roux, 2017, p. 199) in order to create truths of their own. Similarly, as Oziewicz (2017) suggests, speculative fiction intends to elicit affective stimulation; that is, emotionally charged narratives that challenge the status quo (Oziewicz, 2017). Thus, the level to which I find myself affectively engaged can be one indicator of how deeply I am engaging with my own discomfort.

Reflexivity. The intimate and vulnerable nature of the writing as well as the deep situatedness within identity necessitates strong researcher reflexivity. Reflexive writing includes a critical dialogue with the self that brings the researcher's awareness to perspectives that may otherwise be overlooked (Curtis & Curtis, 2017; Le Roux, 2017). As well, reflexive writing includes an interrogation into the influences (contextual, situational, and personal) on one's own perspective and how that perspective is given value or authority over another (Curtis & Curtis,

2017). Part of this reflexivity involves paying special attention to accounting of and accounting for (Mason, 2002). That is, being particularly mindful not to conflate the explanation of an event with the meaning or assumption we associate with it (Mason, 2002). Reflexive writing showcases the intimate nature of thought and experience in a way that brings the reader into the world of the researcher (Hughes & Pennington, 2018a), but also acts as a method to hold the researcher accountable to alternative perspectives. In essence, reflexive writing simultaneously enables the reader to be privy to vulnerable thoughts of the researcher, and enables the researcher to become aware of assumptions (accounts for) so as to explore alternative perspectives that have not yet been given authority.

4.2 Method

The four phases of the research involve a strategic and disciplined production and analysis of texts, and of the thinking throughout the process of the research. In this way, there are specific techniques, tools and means used to collect and analyse data (Hughes & Pennington, 2018a), as well as ensure the integrity of the research. The methods used vary between phases in the representation and presence of each methodology. I use the term autoethnography to describe my method in a sense that it is a meta-analysis of my own speculative writing and learning experiences within the MEd program (Curtis & Curtis, 2017; Ellis, 2012) that has shaped my understanding, awareness and attention to both broad and intricate cultural, social and political influences on assessment in secondary level mathematics. These influences, in turn, continuously and dynamically situate the development and emergence of my professional identity as it relates to imagined assessment futures. Autoethnographic methods include reflective journaling, videotaping, interviewing and fieldwork, descriptions of personal experiences and the analysis of these descriptions (meta) (Hughes & Pennington, 2018a). For this research, I use journaling,

descriptions of experiences and analyses of these experiences, as well as literature and conversations with third persons about the assumptions or my accounts for (Mason, 2002). I use the method of assemblage to weave these data and analyses together so as to "represent a multilayered moment…[that] relies on literature, items, and accounts assembled in a unique form" (Hughes & Pennington, 2018a, p. 25).

While autoethnography is the main method in this research study, phase 3 and its planning use speculative fiction as a method for producing text. This text intends to narrate the environment in which I would place myself if I were using uniquely autoethnography. There are a few reasons for using speculative fiction rather than narrating past experiences. First, my intent with this study is to explore my own notions of "ideal" assessment practice, a practice that goes beyond what I have experienced before, yet influenced by different elements of assessment experiences. The second reason for using speculative fiction is that, because of the current pandemic as well as my status of leave, I am not in a position to fully immerse myself in a classroom environment (be it in-person or online). At the same time, the present global and personal context continue to significantly impact my thinking around assessment. Speculative fiction offers an opportunity to use my current thinking about assessment in mathematics, and what I would like it to look like in my classroom, and explore it as a thought experiment. The complementary autoethnographic methods enable me to investigate inconsistencies and contingencies in my own thinking and further develop my ideas around assessment practice.

4.2.1 The Process

In autoethnography, the collection and analysis of data is ongoing and recursive throughout the research process (Curtis & Curtis, 2017) as the researcher continues to gain more perspectives and explore their own identity. Similarly, the data include personal accounts,

personal reflections and reflexive narration in which changes in thinking and conceptualising are openly discussed alongside the context and other environmental or relational influences (Curtis & Curtis, 2017). Note that cycles are these autoethnographic analyses and processes that occur between phases. I use a reflective journal, which I refer to as my research thoughtbook to organise and interrogate my thinking, reflect on tacit knowledge in order to make said knowledge explicit to the reader, and note ongoing analyses of data (Curtis & Curtis, 2017). As well, I use this research thoughtbook to reflect on the writing of my thesis including the first to last chapters; thus, I started writing in this journal long before the central investigation and research protocol began. As mentioned before, this research is recursive and follows three cycles which I outline below.

First Cycle. The data for the first cycle include assignments I have written for courses within the MEd program, personal reflections I have kept throughout the program, and relevant entries from my research thoughtbook which include recollections and reflections of past experiences as learner and teacher regarding assessment and reflections that have surfaced as a result of the thesis writing process. The analysis of these data includes reflective journaling with focus on social, political and cultural contexts, mind mapping themes that become salient, and sketching out assessment ideas. Synthesis of this analysis results in speculative fictions aimed at showcasing particular themes. These speculative fictions intended to reposition the stories of mathematics that are not traditionally told into the forefront of my mathematics assessment practice, which Lunney Borden et al. (2020) note is a first step into re-telling, re-shaping and re-vitalising mathematics curricula. Thus, the first cycle uses autoethnographic methods of analysis to plan and organise thoughts around assessment, and speculative fiction methods to synthesise this information.

Second Cycle. The data for the second cycle are the thematic speculative fictions that are synthesised in cycle 1. The analyses of these speculative fictions involve reflective journaling focused on interrogating assumptions and evaluating the proposed assessment practice, and mind mapping main themes. This analysis pays particular attention to personal assumptions, as they relate to my own dispositions in order to identify pervasive liberal philosophies morph and recentre themselves as a solution to new problems, blocking our ability to imagine alternatives. (Donald, 2020). As a result of the analysis, an organised reflective discussion regarding the speculative fictions is synthesised.

Third Cycle. The third and final cycle combines the data from cycle 1 with the reflective discussion synthesised in cycle 2. This cumulative data is then analysed using reflective journaling, mind mapping, and thematic analysis, with a specific focus on unexpected findings, changes in thinking and any emotional discomforts that surfaced throughout the process. This focused reflection and analysis is synthesised to produce a discussion about the connection between identity and assessment practice. This may involve defacing the self or presenting multiple selves that disconnect and are in conflict (de Freitas & Paton, 2009).

4.2.2 Affordances, Limitations and Delimitations

Speculative fiction is a form of critical inquiry that engages in appreciation of diverse modes, mediums and content, that challenges the normative conceptualisations of reality (Oziewicz, 2017); thus, its purpose is not to plan, but rather to propose and explore. In this way, its deviation from reality is both a limitation and an affordance. It is a limitation in a sense that the resulting ideas may not easily be implemented in current constructs of reality. In contrast, it is an affordance in a sense that it enables a flexible pursuit of ideas beyond current institutional or political constraints. This concern over pragmatism is ignored for this study, as the purpose is

not to propose an immediately implementable assessment practice as is defined within current institutional or political frameworks and related constraints—though still set within a plausible future reality. In fact, it is to speculate on assessment practice that would exist outside my current conceptions of realistic practice; this is a vehicle through which to imagine.

One of the main critiques of autoethnography is that it is limited to one case (Ellis, 2012), and it lacks generalisability. In the same way that lacking realism is foregone, generalisability is not aligned with the paradigm in which this research operates. Limiting the study to one case facilitates a more in depth understanding and investigation of the self and the subjective experiences of the researcher, which, if written well, is showcased in a way that others can relate to and that troubles normative practices. Critiques of autoethnography mainly centre around the idea that it does not stand up to the "standard scrutiny of the academy" (Hughes & Pennington, 2018a, p. 26), but it is argued that lacking ability to generalise may be ignored because it is not the purpose of autoethnography and should not be used as a measure of its quality in research and for scholarship (Ellis, 2012; Hughes & Pennington, 2018a).

A concern that is relevant and cause for attention is that the investigation into one's self and one's thinking carries with it the risk of rumination, narcissism, and "it's all about me" lines of thinking (Curtis & Curtis, 2017; Ellis, 2012; Le Roux, 2017). Proposed delimitations within the literature include reflexivity as a necessary component to analysis (Curtis & Curtis, 2017; Ellis, 2012; Le Roux, 2017), and Mason's (2002) notion of disciplined noticing to attend to and discuss elements of accounting of and accounting for. I use these notions to mitigate the risk of presumptuous accounting for, attempts to generalise, and rumination and narcissism by continuously reflecting on my writing, using a thoughtbook, and conferring with others. However, despite the challenges, there are immense benefits to this spiraling inwards of studying

the self including challenging potentially erroneous assumptions that I have developed, exploring alternative dispositions, and discovering the unexpected in order to continuously reflect on my future assessment practice. As a practitioner, this research is about overcoming barriers that limit my assessment practice from being aligned with my role identity, and even more, to engage reflexively in a critical refraction of my current conceptions around what assessment can be and may be. The result, which includes a narrative of the emergent thinking, speaks to others in the field, and to provides researchers who study practitioners the opportunity to hear inner thoughts from a practitioner.

A final important limitation is that, despite reflexive thinking, my perception of the cultural, political and social context which I use to conceptualise 'reality', is subjective. In other words, what I believe to be true or to be real, may not be real for the reader. In turn, the texts I produce are subjective perceptions of the speculative and the fictional in a sense that they intend to explore what I do not yet know to be reality. I can only know, to a partial extent, what I do not know; as such, as much as I aim to provide a text that is considered speculative in general—through the use of particular reflexive methods—I am constrained by my own experiences and perceptions of truth and fiction, and current and future. As such, I remain uncomfortably in contemplation of incomplete notions of truth.

4.3 Some Additional Considerations for the Research

This research and the suggestions it yield, are situated in and influenced by the interaction of my multiple identities which, in turn, define the parameters of my interpretations, reflections, perceptions and creations (de Freitas, 2008). Not only is assessment and assessment practice situated in an already complex systems of interaction within educational spaces, my own identity is complex and dynamic, emerging in unexpected ways (Kaplan & Garner, 2018). This

research is intended to be and is implicitly irreproducible, and contribute to the richness of research of human experience in the field of mathematics education.

The purpose of this inquiry requires that I engage in a deeper understanding of myself by which my resolve in imagining an alternative future assessment practice might change; as such, I am engaging in "a reality-altering, channeling state of mind, through which [I] ultimately gain more critical self-understanding and more self-determination than typically experienced" (Hughes & Pennington, 2018b, p. 96). This is done, first, by focusing on reflexivity; I continuously reflect on and question my own work as well as the logic behind it (Curtis & Curtis, 2017). Secondly, I draw on peer reviews and peer conversations to further interrogate and check my own thinking (Curtis & Curtis, 2017; Mason, 2002). Third, I use multiple sources of data to enrich my work (Curtis & Curtis, 2017; Le Roux, 2017). The purpose of using speculative fiction in this research is to challenge myself to explore beyond the influence of my cultural roots— and beyond the institutional structures founded on it—in order to pursue a suggestion of what I might consider a better future for mathematics education. If not better, then at least a future that disrupts and challenges the status quo; one that makes my current western notions of privilege feel threatened. In this way, I purposely attempt to make myself feel uncomfortable in my pursuits of pedagogies that challenge what I have come to know as mathematics education.

4.4 Rigour and Research (E)valuation

Rigour is characterised by credibility, transferability, dependability, and confirmability (Le Roux, 2017). The research practices used to optimise rigour include using thick descriptions (Mason, 2002; Le Roux, 2017), contemplating alternative truths and interpretations (Mason, 2002) by attending to cultural, social and political context (Le Roux, 2017), questioning "the soundness of the research approach, its conceptual depth, the accuracy of the finding and the

integrity of the assumptions made and the conclusions reached" (Le Roux, 2017, p. 203), and honouring the ethic of honesty toward self and reader (Le Roux, 2017).

This research is continuously evaluated based on the following criteria of reflection: impact of the contribution to current research body, impact and resonance of research for readers' interpretations and contemplations, influence and assertion of research on the multiplicity of subjective truths, demonstration of researcher reflexivity, and research credibility (Le Roux, 2017; Richardson, 2000)—some of which are noted above. Hughes and Pennington (2018a) propose five themes common among all autoethnographies: "critical reflexivity, educative experiences, privilege-penalty experiences, ethics and supported-salient narratives" (p. 16) where critical reflexivity involves the critical interrogation of the self and assumptions made, and how the researcher comes to realise how these dispositions make them in some part complicit in the problems they intend to address (Hughes & Pennington, 2018a); educative experiences, on the other hand, refers to an exploration of the lifelong learning that occurs relevant to the current problem of study (Hughes & Pennington, 2018a); privilege-penalty experiences: "the deception, contradiction, ignorance, and denial of interlocking systems of oppression" (Hughes & Pennington, 2018a, p. 21) which has to do with intersectional identities and the ways in which privilege is not a dichotomy; relational ethics involves being cognizant of the problems their research presents (problematising the research), acknowledging the subjectivity and limitations of inferences, protecting the privacy and safety of those directly part of the research (including stories with those characters), being careful not to generalise and being mindful of how the work will be interpreted (Hughes & Pennington, 2018a); and supported-salient narratives involves supporting one's narratives with scholarship (Hughes & Pennington, 2018a). In summary, attention must be paid to who is really suited to represent these contextual

elements (Hughes & Pennington, 2018a). Autoethnography is about continuous questioning of the self (Hughes & Pennington, 2018a); it includes “sensory and emotional experience...from an ethic of care and concern” (Ellis, 2012)—in this case, for my students and their experience in mathematics.

5 Two Speculations About Assessment

There are two speculative fictions to present within this chapter. The first speculative fiction is presented as a model for an assessment practice using three themes which intend to act as my guide for reflection: What ought I attend to in my assessment practice? The second speculative fiction is meant to provide a concrete example of an approach to an assessment task that is likely to be familiar to the reader. However, before I begin, I share with the reader the planning and reflective process that form a basis for the speculative fiction.

I have come to understand assessment practice as distinct from an instructional practice only in that it is meant to glean information for future use and reporting. If it is for future use, it would be deemed formative; if an assessment task is ultimately used for reporting, it would be summative. It is this understanding that guides my speculations about my future assessment practice. Thus, the reader may find that both speculative fictions presented seem almost indistinguishable from an instructional method. While both the example of an assessment task and the theoretical qualities of assessment practice discussed below lend well to a formative purpose, I encourage the reader to think about how these speculative fictions may suggest alternative futures for classroom tasks intended for reporting on and evaluating learning in more summative terms, as well. This is something I continue to contemplate, myself and includes interrogating modes of communication defined as “reporting”.

5.1 Reflecting on the Process of Creating a Speculative Space

Recall that one of the functions of speculative fiction is that it acts to challenge the status quo, and to narrate an alternate reality of sorts that might have happened or could happen if certain elements of the current reality were removed or flipped around (Passell, 2013; Thomas, 2013). The benefit of this challenging and changing status quo practice is that it sheds light on

many of the value systems and ethical implications woven into current realities, and is written as and to inspire a thought experiment. As such, planning for speculative writing involves choosing certain realities to remain so, and deciding on others to ignore or re-write. For the two speculative fictions to follow, I keep the following current realities constant. Note that these are purposefully chosen by me, but that I could very well have chosen different realities to keep constant.

1) assessment must exist as part of institutionalised education
2) assessment is a valuable practice used to push learning forward, gather data on student learning and report data to students and parents
3) The data gathered is meant to target the level of mathematical knowing and knowledge of students, which includes content and processes.

These assertions set my speculative fictions within a context that resembles current realities, however, the second part of planning for a speculative fiction is deciding on certain current realities to challenge. I noted in my theoretical framework some challenges I face in regards to perceived action possibilities—that which defines what I perceive as appropriate, effective and possible to achieve and relevant to the role I hold in terms of my epistemological and ontological beliefs, self-perceptions and self-definition, and purposes and goals (Garner & Kaplan, 2019; Kaplan & Garner, 2017, 2018). I have decided to discard some specific realities that I think have prevented me from pursuing certain actions. The following is a list of current realities I am choosing to challenge and the suggested alternative. Note that the following list of realities are not objective realities, but felt realities that I am choosing to challenge.

Removing Barriers of Relevance in Planning for Speculation. The program of studies defines the ultimate goal for learning and assessment; the learning outcomes within must all be

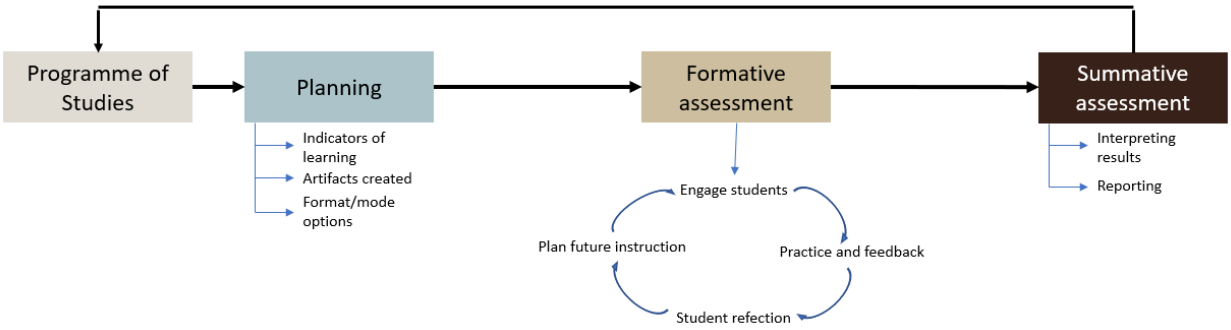
addressed and assessed in one year's time. As a corollary, all assessment tasks must be developed to target these learning outcomes; as such, the standard way to plan for assessment is to start with the program of studies learning outcomes which one intends to measure student to mastery of (AAC, 2017; Holm, 2018), and develop mathematics problems or tasks that target those outcomes either for the purpose of formative feedback or summative evaluation. I suggest that this planning strategy, while efficient in its ability to ensure coverage of the program of studies, fails to provide opportunities for valuing a multitude of mathematical engagements; this is because current programs of study are limited to western academic mathematics (Aikenhead, 2017; Pinxten, 2016) despite mathematics being a human, thus multi-perspective, endeavour. I instead suggest that the learning outcomes within the program of studies are simply suggestions for content and process outcomes, and that assessment tasks may be developed to target more or less difficult, or expanded content outcomes. In other words, I ignore the restrictions of the program of studies content and suggest what assessment planning and executing might look like when the program of studies is no longer the central goal of the assessment task.

Before beginning the speculation, I first present the current recommended process for assessment which has defined my assessment practice at the beginning of this research process and presented barriers to deviation from it (**Figure 9**). The AAC (2017) suggests assessments—both summative and formative—be rooted in the program of studies, the platitude being "planning with the end in mind," where the end one has in mind is the program of studies learning outcomes. Following the planning phase, one engages in formative assessment, using it as a litmus test of sorts to determine where the students are in their journey to that end, which one uses to determine any further instruction that is necessary. With these two speculative fictions, I suggest that, instead of looking at assessment planning as a means to an end or race to

the finish line, one looks at assessment planning as an engagement in possibilities in a way that makes the assessment process be more of a continuous dance between teacher and student.

Figure 9

Adapted Diagram of the Cycle of Assessment



Note. Based on the Alberta Assessment Consortium (AAC, 2017) Key Visual to describe the interconnected process between the program of studies and assessment.

Qualitative Assessment Measures. By the end of each school year, all students are held accountable for knowing the same content and process outcomes, and teachers are held accountable for teaching and evaluating student learning of them. In this current institutionalised education system, accountability testing both exists and imposes pressure on teachers to produce higher student achievement. As a result, historically, I have not only refrained from alternative assessment tasks in my practice, but used assessments that mimic the accountability testing: they consist of items designed to elicit prescriptive student responses for which students receive marks. These marks are then tallied and translated into a percentage grade. The formative test marks are labelled as practice, while the summative test marks are averaged across the year to produce a final grade. I suggest that, while this system of accountability may afford some coherence and consistency across classrooms, schools and school boards, it dehumanises the

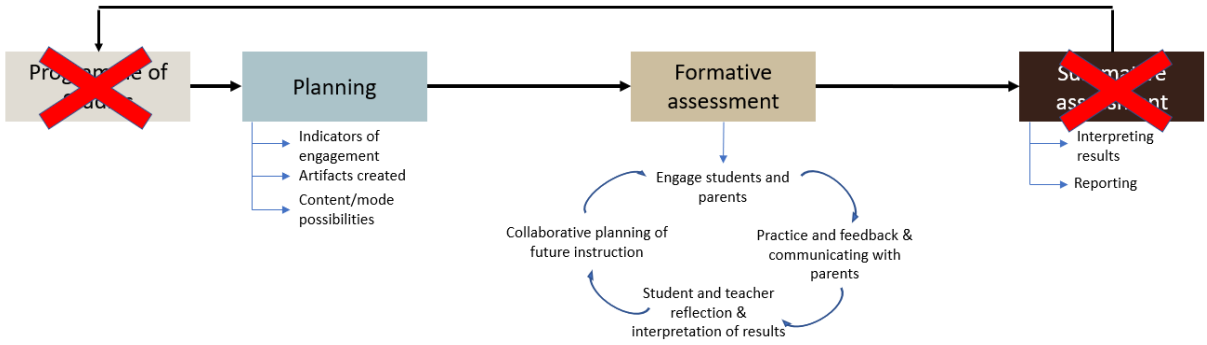
evaluation process, limits students' ability to communicate the depth and breadth of their learning, and infringes on the teachers' ability to design valid and holistic assessment tasks.

For the purpose of speculation, I propose that the alternative reality be that student accountability testing is not standard practice, nor is it used to pressure and critique teacher efficacy; as a result, it no longer guides or affects classroom assessment practice. Similarly, summative assessment is no longer a practice aimed at determining a quantitative grade for reporting purposes. Instead, all students encounter the same contexts and formative assessment tasks, but each may demonstrate competence of different content outcomes and different mathematical processes afforded by these assessment tasks so that, by the end of the school year, students may have a different competence portfolio.

Summary of Alternate Reality. Summarizing these moves to alter reality, I have removed the influence and role of a program of studies, accountability testing and summative grading practices. Instead of looking at reporting as being a quantitative measurement and finale, I see opportunity to communicate with and involve students and parents throughout the assessment process. For me, if reporting is a mode of communication, and that communication is to be meaningful, then the information that is communicated needs to be meaningful—rather than be a grade—and the communication needs to occur before it is too late for the student and parent to do anything with the information shared. This thinking led me to reconceptualise formative assessment in a way that enables parents to be involved as part of the feedback loop depicted in **Figure 10** that frames formative assessment. With this reconceptualisation, I concluded that summative assessment—as a means of handing out grades—was not a necessary component of my classroom assessment.

Figure 10

Corrected Diagram of the Cycle of Assessment



Note. This describes the starting point from which my Speculative Fictions were conceived. Rethinking these assumptions represented a move towards aligning my epistemological and ontological beliefs—which have both shifted and crystallised over the course of graduate studies—with my perceived action possibilities. Removing the influence of the program of studies and grading in the learning-assessment process helped me to expand my perceived action possibilities by removing the political barriers, as I had come to understand them in writing my theoretical framework. The second effect it had, was it removed what I perceive to be the larger colonial influences on the way I think about assessment tasks and assessment practice, so that I could begin to contemplate what I imagine assessment practice ought to be.

5.2 First Speculative Fiction: A Guide for Assessment Practice

The following is not meant to describe any one assessment, but rather the assessment practice as a whole. No single assessment task would attend to all of these elements; however, the following serves as a guide for contemplating a range of dimensions of an assessment practice. I see this speculative fiction as a characteristic of an assessment practice to work on and strive for, be it in the span of an academic year or as a multi-year project. As mentioned in the methodology chapter, the planning and drafting of the following speculative fiction involved

analysing assignments and reflections written or recorded as part of course work in my graduate studies. In so doing, three themes emerged which shape the three dimensions of the assessment practice: (1) taking a holistic approach to assessment practice; (2) engaging in a pluralistic assessment practice; and (3) sharing responsibility. This first speculative fiction is meant to outline an assessment practice as a whole that attends to these three dimensions. In other words, this speculative fiction takes these three themes that emerged for me and suggests the ways in which I might bring attention to these dimensions within my assessment practice.

It is important for me to note that the literature presented is literature that inspires the themes that coalesced, and helps to characterise them; the point is not to analyse the literature or present the themes in the form of a literature review, but rather to present themes of relevance that inspire questions for contemplation. Recall that the purpose of this research is to speculate about my imagined future assessment practice in mathematics, the response to which is the narrowed topic of study. The response to my research question, presented in the speculation below is situated within a broad range of theory and philosophy, and as a consequence, a broad range of inspiration. In the speculative fictions, I curate specific pieces and use them to suggest a possible future for my own assessment practice *based on* how my role identity as researcher and mathematics educator has changed over the course of my graduate studies.

5.3.1 Situating an Assessment Practice

Gipps and Stobart (2009) state that "assessment is a socially embedded activity that can only be fully understood by taking account of the social and cultural contexts within which it operates, alongside the technical characteristics" (p. 106). Combining this statement with Suurtamm's (2018) assertion that assessment tends to be the measure by which students determine what is important, one could argue that an assessment practice is a vehicle for

communicating to students what social and cultural contexts are most valued. It is for this reason that it is important to situate my assessment practice within carefully curated social and cultural environments.

As with any of my professional development activities, my learning is driven by the questions that arise as a result of the information I come by, rather than the information itself. I notice that no matter what I read, no matter what I listen to, and no matter what interactions I may have in a day, I always seem to land on the question *how might this apply to mathematics education?* And, in particular, *how might this shape what assessment in mathematics could be?* Each course in my program brought with it texts and conversations that began to answer these burning questions. In the same way, this section is written as a personal reflection—an internal dialogue of sorts—which includes the information that has influenced my thinking as well as the resulting questions that surface. These questions are not my research question, rather, they are the questions that guided my thinking *towards* my research question and my formal—yet uncertain—response to it.

5.3.2 Informing Holistic Assessment Practice

I remember watching a recorded talk given by Donald (Donald, 2020) about the nature of curriculum studies and how schooling is the starting place where students are exposed to particular ways of being; it is through schooling that one learns specific mythologies and ideologies about how to be in the world (Donald, 2020). He noted that pedagogy is about how we tell stories and why we tell them that way, and that understanding curriculum means understanding the specific types of humans and humanity that we value. If each assessment task is a chapter in a story that, together, make up my assessment practice, what story am I telling? What story do I want to tell? What type of human are my assessments teaching students to value,

and how are these assessments teaching students to value certain types of humans relations? This first part of my speculative fiction is about seeking out the type of human and human relations I *want* my assessments to value.

Assessment is a practice; more than that, it is a human constructed practice and it is experienced by humans. What I mean by practice is that it is constantly evolving with multiple fluid points of focus. It involves everchanging intermingling of human relations between people and the physical environment in which the assessment is situated. As I reflect on my current assessment practice which includes only testing, I note that it is not a practice designed for the complex human being but instead, seems to be designed for a complicated but trivial machine. "Trivialisation is a dangerous panacea when [the human] applies it to [the self]" (von Foerster, 2003, p. 204). Thus, applying an assessment method applicable to trivial machines risks significant destruction that trickles into the many domains of self as learner. As I mentioned in the first chapter, it is sterile—clean cut with a prescriptive plan and little to no potential for witnessing students' knowing and skills on their own terms. As such, it must be reimagined, and part of this work begins with contemplating what it means to be human and what it means to be well with one another, then pivoting to what that means for a mathematics assessment environment.

A holistic assessment practice honours and welcomes students' whole selves the way they are at the time they complete assessment tasks. More than that, it functions dependently on their flourishing and well-being[24]. If the assessment philosophies that drive my assessment

---

[24] My interest in and understanding of flourishing in terms of assessment is influenced by work I have done with Dr. Steven Khan and Ms. Hang Thi Thuy Tran around multispecies'

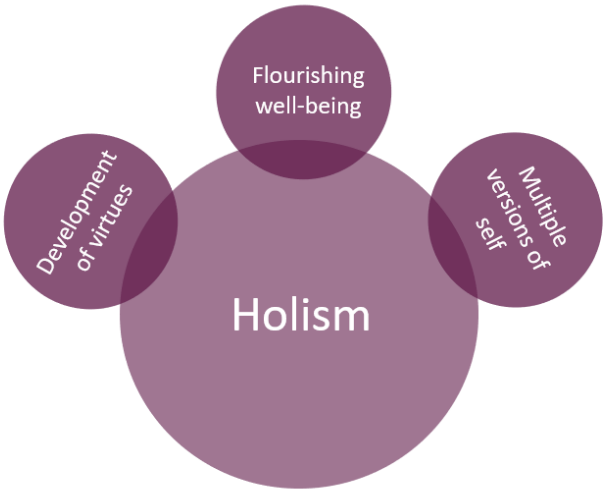
practice are framed in terms of honouring the whole student and communal unit, then it begins to rewrite the story about what type of student is valued in mathematics education, and the type of student for whom the task is worthy. I choose my language purposefully in using the term communal unit; what I mean to reference and acknowledge, here, is the notion that the group of learners is more than the sum of the students put together. Each student breathes life into the community of learners when they come as they are, and this community of learners engages in a communal practice—one that is meant both for the individual student and the collective of students that make up the community of learners. In this way, an assessment practice is one that framed in terms of welcoming the whole student—a holistic assessment practice. This notion of holism means that the assessment practice attends to and values the development of virtues, flourishing and well-being and multiple versions of self (**Figure 11**).

---

flourishing in terms of pre-service teacher curriculum implementation (Tran et al., 2020), the conversations and literature I engaged in as a result of the collaboration shaped the way I think about flourishing in terms of K-12 assessment.

Figure 11

Beginning to Conceptualise Holistic Assessment Practice



Doolittle (2006) quotes Chief John Snow when he says "we have survived, but survival by itself is not enough. A people must also grow and flourish" (p. 25). There are a few texts that shape how I conceptualise flourishing; one is from the field of business (Ehrenfeld & Hoffman, 2013), one is from the field of psychology (Seligman, 2011), and one in terms of mathematics (Su, 2020). For Ehrenfeld & Hoffman "flourishing is the result of acting out of caring for oneself, other human beings, the rest of the "real, material" world, and also for the out-of-the-world, that is, the spiritual or transcendental world" (Ehrenfeld & Hoffman, 2013, p. 17), suggesting that the dominance of the rational and objective ought to be disrupted to make way for a more spiritual and transcendental form of knowledge to be valued. I argue that it begins with honouring multiple versions of self. My students offer their learning to me, and it is my responsibility to be worthy of witnessing their knowledge and skills. For me, this means creating the proper atmosphere (not just the proper environment) for welcoming multiple versions of the self—spiritual, physical, rational, psychological, self-in-relation to others or otherwise. The

assessment practice welcomes the student, as they are in their entirety, as a dynamic person, into a space of sharing for the purpose of assessment.

For Su (2020), “human flourishing refers to a wholeness—of being and doing, of realizing one’s potential and helping others do the same, of acting with honor and treating others with dignity, of living with integrity even in challenging circumstances" (p. 10). Su extends this to involve the development of virtues such as wisdom, morality and patience, among others, noting that this can be done with and through mathematical tasks and interactions. Thus, an assessment practice aimed at enabling flourishing involves actions and activities like *acting out of caring, acting with honour, treating others with dignity,* and *living with integrity* in relation to ourselves, our fellow learners, and our learning environment. What virtues ought to be valued with and through my assessment practice? Do I prefer the efficiency of silence, compliance and order, or do I prefer conversation, integrity and authenticity, which may be messy and unpredictable? Certainly, I want my students to be virtuous even (if not especially) during assessment tasks; virtues that come to mind in addition to the ones above include honesty, appreciation of beauty, empathy and love. How might students develop and model virtues like morality, wisdom, patience, honesty, appreciation of beauty or love with and through assessment in mathematics? What environments are conducive to this and how can I plan for assessment tasks that are situated within them?

Seligman (2011) suggests that flourishing is experienced by attending to the elements of his PERMA framework: Positive emotion, Engagement, positive Relationships, Meaning, and Accomplishment. Here, positive emotion refers to happiness, satisfaction, enjoyment or gratification. Engagement is achieved when one loses track of time and is in a state of flow (Liljedahl, 2016). Does my assessment practice include assessment tasks that invite students to

lose track of time? The notion of positive relationships is well described in Ehrenfeld & Hoffman's (2013) definition of flourishing, and is about peaceful and appreciated communal human relations. Does my assessment practice include tasks that invite students to live harmoniously together and with themselves and their classmates? The element of meaning refers to one's sense of a calling to something, it dwells in a sense of purpose. What purpose is felt by students as they engage with various assessment tasks? Does my assessment practice give students an opportunity to engage purposefully? Finally, the element of accomplishment is about persisting through challenge, and developing a practice in a sense of mindful slow contemplation as well as repetitious action. Does my assessment practice provide opportunities for students to demonstrate disciplined practice as well as challenge unfamiliar mathematical territory?

For flourishing to occur, each of the five elements above must be present, and attending to them, as Su (2020) suggested, would involve nurturing certain virtues. The virtues nurtured could include gratitude and appreciation (Hart, 2019; Seligman, 2011), patience, resilience and persistence (Paterson & Sneddon, 2011; Seligman, 2011), loving kindness (Khan & Armstrong, 2019), as well as curiosity and awe (Hart, 2019). These virtues cannot be forced, but rather enabled through the assessment environment, so when I plan for any given assessment task, I am keeping in mind the virtues it is promoting—consciously or unconsciously. The environment of the assessment task is one which promotes connectedness and communal development of the above virtues. Even if it may not be the central goal, it is a critical piece of planning for assessment, and in my mind, a piece more critical than the content outcomes.

One of the most significant shifts for me, and one that stands out as the driving force in enabling an environment of flourishing, is the move towards more relational practices. The relations I refer to are relations between person and self, person and person, person and

environment, and person and mathematics. Donald notes that colonialism is “an extended process of denying relationships” (Donald, 2020). In his talk he speaks mainly of relationships to land and to mythologies of place; I extend on this and suggest that a colonial assessment practice denies relationships between self and task, self and environment, and self and mathematics by forcing students to deny parts of themselves in order to perform the task. For example, denying their sense of connectedness to others by writing a test independently in silence, or working only with fragmented abstract mathematical content that bears little resemblance to the human experience. The colonial project of school mathematics is denying students opportunities to have and develop relationships between content and themselves, between school and community and between mathematics and the world. Thus, the obvious next step towards a holistic assessment practice would be to contemplate how we might nourish and heal—not just attend to—those relationships *within* and *through* mathematics assessment.

Earlier in this thesis, I asked the question: why must student grades be based solely on their ability to produce written information independently within an arbitrary time-frame and without access to other tools or resources? I return to this question, now, and note that there is nothing honourable about forcing students to convey their learning in a single format within a confined space and time alone. There is nothing caring about the isolative nature of the assessment environment created from forcing students to work independently. And, there is no respect for the dignity of the students or myself when I impose the belief that intellectual purity is an independent pursuit, rather than a collective one (not to mention the problematic nature of intellectual purity in and of itself).

I now pose the question: in what ways does the assessment practice enable an environment of flourishing? Note that, with this question, I am not investigating how to mitigate

risks to wellbeing in assessment—a deficit approach—I am investigating a complete reframing of the assessment environment: how might an assessment practice promote flourishing? Holistic assessment practice, is rooted in notions of relationality and assessment that contributes to wellbeing. This theme describes an assessment practice that nurtures the whole student, develops a sense of connectedness and community, and enables positive relationships with mathematics. In essence, it is centred around an assessment practice that attends to all elements of wellbeing of a student, the wellbeing of the learning community, and the relationship developed with mathematics with and through assessment as a practice. This is not to say that one is assessing the wellness of students; rather, a holistic assessment practice is about enacting assessment tasks that provide a space for multiple student identities to be well.

A holistic assessment practice is one situated in an environment that fosters relational wellness between students and with the community. There is a necessary shift to valuing the connection and relationship between communities' mathematics and school mathematics so that the mathematics that emerges as a result of honouring this relation is valued as a central role rather than as an add-on to school math curriculum (Lunney Borden et al., 2020). Importance, then, must be placed on connectedness and relational ethics when planning and executing (Nicol, 2018) any assessment task. The environment of the assessment practices continues to be centred around "the love one might have for another human being through and because of mathematics" (Su, 2020, p. 205). Again, while it is not the relationality itself that is the focus of the assessment, the assessment tasks are designed in a way that facilitates these positive relations and love for others.

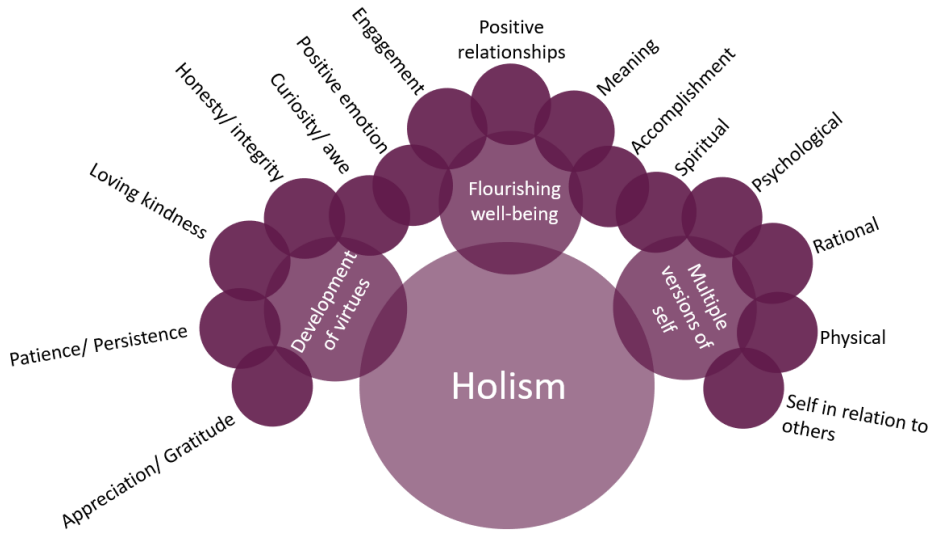
As well, a holistic assessment practice (**Figure 12**) is one that is situated in an environment that fosters relational wellness between those being assessed and that which is

being assessed. That is, it develops a more positive relationship between the student and mathematics. Doolittle (2006) suggests that if we think of mathematics as a type of medicine, something with healing powers, we might be able to reframe how we approach the content and teaching of it in more equitable and ethical ways, and as an extension, the assessment of mathematical learning. However, part of developing a relationality with mathematics involves honouring the learning of mathematics that emerges as a result of the assessment task prompt, and honouring mathematics (and assessment in mathematics) as a human endeavour, one that is communal. So, in the end, it is a cycle of relationality because being well with others with and through mathematics involves respecting and validating the multiple productions of mathematics, which in turn, develops relational wellness with mathematics.

In summary, a holistic assessment practice attends to the positive psychology of wellbeing and relational wellness. It is an assessment practice that nourishes both the individual and the collective of students with and through mathematics assessment. This means that the design of the assessment attends to more than just the purpose of the assessment. The definition of assessment is changed to be more than providing feedback, gathering information for future instruction or evaluating student learning—all intellectual-centred. Instead, an assessment practice is a fluid collection of assessment tasks, which are planned and designed in a way that they foster wellness of and honour all elements of the self within the assessment environment.

Figure 12

A Fractal Representation of Holistic Assessment Practice



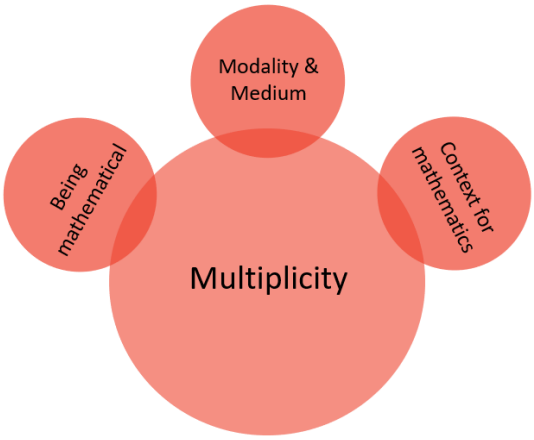
5.3.3 Engaging in Multiplicity in Assessment Practice

When the theme of multiplicity emerged, it seemed to transcend multiple parts of assessment including the ways of interacting with an assessment task, ways of knowing mathematics within the assessment task and the contexts in which we might find opportunities to engage with mathematics for the purpose of assessment. The theme of multiplicity is meant mainly to address how we might honour and represent the ways of knowing and doing mathematics from and with multiple cultural perspectives, and value these perspectives with and through assessment. Moving towards a pluralistic assessment practice involves disrupting colonial logics (Glanfield et al., 2020); it means not "valuing one way of knowing over another, but rather about valuing multiple worldviews for their contributions to each other" (Lunney Borden et al., 2020, p. 94). In this way, I would value not only multiple ways of knowing and doing mathematics, but also multiple ways of assessing student knowledge. With this in mind, I discuss the theme of multiplicity in terms of three parts: re-imagining what it means to be

mathematical, what contexts might provide spaces for being mathematical, and what modes and medium one might engage with mathematically (**Figure 13**).

Figure 13

Beginning to Conceptualise Multiplicity



In the summer term of 2019, I took a course aimed at exploring mathematics and science from Indigenous perspectives. One of the ideas in that course that I found revelational was the idea that abstract mathematics is not the only type of mathematics. Abstract mathematics is also noted in the literature as academic mathematics (Pinxten, 2016) or Euro-American Mathematics (Aikenhead, 2017); this characterisation of mathematics is largely Eurocentric[25] and includes approximating models, using symbols and symbolic representations, and rational argumentation. This course catalysed for me an entirely new view of mathematics both as a discipline and as a

[25] I find this term problematic, as much of the math termed 'Eurocentric,' is historically from thinkers around the globe, particularly within algebra where concepts can be traced back to various Arab countries; this is but one example (Joseph, 2011). With that said, I can see why the term arose because the North American countries, colonised by various European nations continue to focus on abstract mathematics within mathematics schooling.

school subject. Much of what I contemplated in that course frames the part of this theme of multiplicity, yet at the time, it felt wildly difficult to imagine; it felt almost speculative—fictional—and yet I was fixated on how I could implement the ideas immediately. Thus began my present contemplations about what it means to be a mathematical being, what contexts invite us to think and act mathematically and what modes or mediums we might engage with while doing so with and through assessment.

As a result of the course, my definition of mathematics began to fracture, finding discomfort in the uncertainty and instability of potential new definitions. I found myself striving for a singular universal characterisation of mathematics—what it means to do mathematics or be mathematical—but I now rest in discomfort at the idea that, perhaps, there are multiple, simultaneously existing definitions and that there is no way to construct a universal conceptualisation of mathematics. Engaging in multiple ways of knowing mathematics means opening the mathematical content of the assessment to include and value a plurality of mathematical ways of being. The assessment practice, then, reframes mathematics not in terms of content, but in terms of action. In order to reframe definitions of mathematics, I contemplate the multiple ways of mathematising: playing, measuring, designing, explaining, counting and locating (Bishop, 1988). Are students engaging in those actions during assessment tasks? Then, I expand to include multiple mathematical dispositions such as performing thought experiments, explaining patterns, hypothesising, formulating arguments and making inferences (Cuoco et al., 2010; Pyper, 2018). What would it look like if my assessment practice included tasks that opened up opportunities for students to demonstrate multiple ways of being mathematical? Part of this second theme, engaging in a pluralistic assessment practice, describes an assessment practice that engages with multiple, simultaneously existing definitions of mathematics.

Engaging in multiple ways of knowing mathematics means opening the mathematical content of the assessment to include and value a plurality of mathematical dispositions, fluencies, competencies and ways of mathematising.

Engaging with a pluralistic and contextualised mathematics can occur, not as an add-on, but as a starting place for pedagogical planning. What might an assessment task rooted in context look like?[26] How might I address or weave in the multiple histories of the mathematics discipline into my assessment practice? This, in part, means contextualising fractured mathematical content so that it extends beyond the abstract western mathematics to which I am accustomed (Aikenhead, 2017; Pinxten, 2016), and the other part involves engaging with unfamiliar and potentially uncomfortable contexts from which mathematics might emerge. Here, when I say uncomfortable, I am referring to the reactive feeling one gets when one is met with an idea or phenomenon they have trouble believing, digesting or experiencing; for example, being challenged on one's definition of mathematics versus pseudo mathematics[27] or pure mathematics versus applied mathematics (Fowler, 2004). Engaging in a pluralistic practice, then, means enabling students to express their own mathematical truths using their own experiences, the knowledge they learn from the community, thus creating new emergent mathematical ideas (Hunter et al., 2020; Lunney Borden et al., 2020), or might involve planning a mathematical task using the context as a guide rather than learning outcomes that are situated in western abstracted mathematics. What is my definition of mathematics and how might it differ from my students'

---

[26] See second speculative fiction

[27] The mention of these contrasting versions of mathematics is inspired by a comment made by Dr. Mijung Kim during a course I took.

definitions of mathematics? How might I design assessment tasks that provide an opportunity for my definition of mathematics to be challenged? What assessment environment would enable a space for multiple definitions of mathematics to co-exist?

Aikenhead (2017) argues that school mathematics is assumed to be culture-free when, in fact, it is simply rooted in a culture of privilege and thus the conceptualisation of mathematics touted as obvious or common sense, is not so; it is the privileged notions of mathematics. Extending this idea to assessment practice, I might conclude that if I continue to only assess Platonist mathematics content—including only the plurality of perspectives in instruction—then I commit to perpetuating conflation between school mathematics and mathematics in general and risk recolonising my students (as Aikenhead has warned against). Assessing only for mathematics that is far-removed from any context and often seem disconnected from each other. This fragmentation and abstraction of mathematical content are often in conflict with Indigenous ways of knowing and doing mathematics (Aikenhead, 2017; Little Bear, 2000) creating and perpetuating a culture clash between student and school math content (Aikenhead, 2017; Little Bear, 2000). As such, students are faced with feelings of alienation and a felt sense that they need to detach themselves from their identities in order to 'do' school math (Aikenhead, 2017); in other words, this environment is non-conducive to a holistic assessment practice. How might I design assessment tasks in a way that encourages connectedness and contextualisation of mathematical content and processes?

For this theme, as I have come to understand it, contextualising mathematical content can mean putting the mathematics into a cultural context, which involves the acknowledgement of a plurality of cultural histories that contributed to what is now known as mathematics, and disrupting the dismissal and forgetting of cultural contributions to mathematics that were ignored

during the colonial period (here, I note that the colonial period is ongoing). For example, Joseph (2011) notes that there were various meeting places for the sharing of mathematics over time based on geographical accessibility. This suggests that place has meaning, just as Donald (Donald, 2020) mentioned that mythologies of place have meaning. What temporal and geographical meeting places hold mathematical mythologies, and how might those be incorporated into an assessment practice? Reconnecting the histories of contribution of different mathematical phenomena to place. However, contextualising mathematical content can also mean finding the mathematical content in personal, social or interdisciplinary contexts as well. The overarching theme in developing an assessment task that is contextualised is setting the context first, and finding the mathematical connections to or dimensions of it.

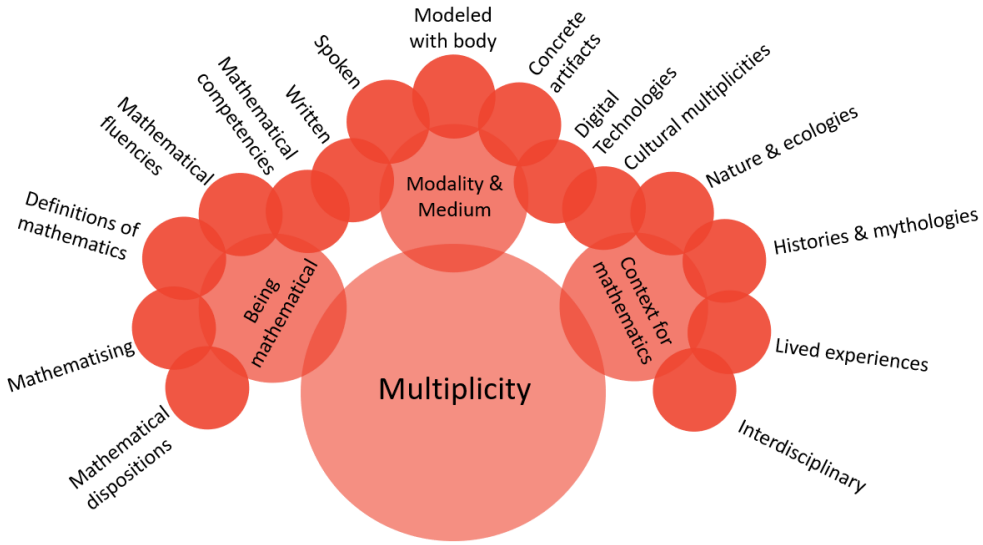
The final piece of an assessment practice situated in multiplicity is engaging with multiple ways of communicating and representing. At a rudimentary level, the act of assessing a student is an exchange of information involving the communication between participating parties. With any given assessment task, there is some form of interaction between the assessee(s) and assessor, which means that a multiplicity of modes of representation and expression (Kress, 2009) and mediums with and through which one interacts in order to represent and express mathematical knowing can be used. In this respect the theme of multiplicity, as it pertains to assessment practice, involves broadening and varying the ways in which myself or the students gather and evaluate information on students' mathematical knowing and doing. In what ways do humans communicate with one another and how might this be reflected in an assessment practice? Perhaps writing and drawing, speaking and singing, listening, and using the body to understand, model and encode mathematics (Sinclair & de Freitas, 2019; Gerofsky, 2011). The mediums used to interact could vary from psychic to

environmental, artificial to natural, and span multiple states of being (physical, spiritual, corporeal). In what ways might I design assessment tasks that encourage these multiple means of communicating with one another? In what ways might I design assessment tasks during which participants engage with and through multiple mediums? Here, it would not be the mode or use of medium themselves that are evaluated as part of the assessment; rather, it is the assessment that would facilitate the interaction and communication through these modes and mediums. In this way, the assessment practice honours a multiplicity of modes and mediums of interaction.

This theme, multiplicity in assessment practice (**Figure 14**), attends to contextual, socio-cultural, modal, and existential multiplicities regarding the knowing and doing of mathematics by honouring the pluralistic nature of how assessment and mathematics intersect; that is, the intersection of what it means to do and create mathematics and what it means to assess student learning. In this way, I would pursue multiple answers to the questions "how might I assess the students?" (assessment philosophy, assessment strategy, assessment mode), and "what will I assess?" (assessment content, mathematical content, mathematical perspectives). This would require attention to including multiple contexts in which mathematics may dwell, broadening the scope of assessment philosophies I engage with, providing variation in modes of representation and expression, and finally, engaging with a wider range of definitions of mathematics.

Figure 14

A Fractal Representation of Multiplicity in Assessment Practice



5.3.4 Sharing Responsibility Within the Assessment Practice

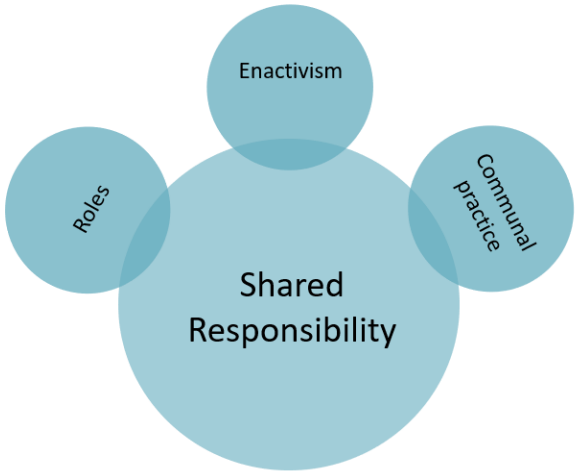
In thinking and talking about the first two themes with colleagues, family and friends, and even as I reflected on them myself, I noticed some common threads of concern. The biggest concern had to do with teacher workload. Teachers may feel they need to know all of the perspectives from which one could look at mathematics, be familiar with the cultures of every student in the room, know all the students' preferences for communication mode and medium, and know all of their interests. In this way, they might enable students to see meaning in or develop a sense of awe in any given task. This idea of being able to know each student so deeply as to be capable of planning multiple versions of assessment tasks for multiple students, and that enriched them spiritually, elicited positive emotion or gave them a sense of accomplishment and engage them with multiple media and modes is simply not feasible. This major concern is what brought me to realise that a third theme must be added if the first two themes are going to be conceivable in any way shape or form: I must share responsibility with certain aspects of any

given assessment task. That is to say, act, not as an all-knowing expert and assessment designer, but as a collaborator and guide working with the students to design and execute assessment tasks.

One might argue that sharing responsibility already occurs within the testing paradigm; after all, both the teacher and the student each have their role to play in the process of testing. However, when I think about the notion of shared responsibility, I am referring to extending the students' roles in a way that gives them more flexibility and choice. This final theme of pursuing an assessment practice that involves sharing responsibility has two major components to it. The first, involves disrupting the idea of teacher-as-expert in terms of giving information and evaluating the proof of learning; the audience of students' math creations, in this case, becomes the students and teacher *together*. How might the process of planning for an assessment task change when assessment is seen as a communal act or practice? In what ways and at which points in the assessment process might students' wisdom be honoured? The second major component is the notion of surrendering to unpredictability which involves following emergent mathematical trajectories and learning paths on a case-by-case basis using the expertise that I have while at the same time being mindful of and open to situations in which my knowledge and assumptions may be challenged. How might an assessment practice that honours those unexpected tangential explorations look in practice? Where is the balance between targeted investigation of student learning and student-led demonstration of student learning? The above two ideas—communal assessment practice and engaging with emergent ideas—shape my ideas around sharing responsibility of my assessment practice (**Figure 15**).

Figure 15

Beginning to Conceptualise Shared Responsibility



Testing has often been characterised as policing students or teaching compliance (TODOS, 2020; von Foerster, 2003). In effect, these are both characteristic of an environment where one entity—in this case, the teacher—exerts control over another—in this case, the students. Singh (2018) describes this idea of exerting control as mastery. She notes that, in environments such as this, there will always be a master and a mastered. While Singh's work takes an anthropological approach describing colonial efforts, this can be applied to assessment in mathematics. In fact, as I read through her work, I find many opportunities to draw parallels. Take for example the following quotation. "English language and literature education was a "humanistic" method of civilizing natives by teaching them how to approximate their colonial masters" (Singh, 2018, p. 68). Here, the teaching of the English language, as the language of the intellectual, and the forcing of colonised populations to learn and speak English together set a premise of dominance; those whose mother tongue is English are implicitly in a position of intellectual (and otherwise) control over those whose mother tongue is (an)other language. The simple act of imposing this language on a people sets the president for a hierarchical power structure. What if we were to rewrite this quotation as "current mathematics assessment and

mathematics education is a “humanistic” method of civilizing students by teaching them how to approximate their colonial masters”? Given what I discussed in the second theme of multiplicity, I feel this is a compelling statement, and as such, it further solidifies my resolve to share the responsibility with students over the content of the assessment and the method of assessment. In other words, I dissolve any notions of teacher as master, and as a result make space for alternative potentially unexpected modes, mediums and content within the assessment practice—the modes, mediums and content brought forth by the students. What opportunities have I missed to know what students know because I was pursuing particular mathematical content, a particular end-point or a particular method of measurement of learning? In what ways might I pursue an assessment practice that prevents me from being limited by my own resolves and, instead, creates space for students’ resolves in their own evaluations of their learning?

For this theme of sharing responsibility, I am also inspired by literature in enactivist approaches in mathematics education (Glanfield et al., 2020; Simmt & Kieren, 2015). The theory of enactivism suggests that “an individual brings forth meaning through the interaction of a physical world and the individual” (Glanfield et al., 2020, p.71). In particular, Simmt and Kieren (2015) suggest that enactivist research in mathematics education consists of three elements: (1) an observer as an open inquirer and participant within an interactive space under observation; (2) the knowing mathematics as collectively “bringing forth a world of SIGNificance” (p.310) through the process of doing mathematics; and (3) an ethical imperative to approach emergent interactions with the awareness of one’s subjectivities and one’s influence within the interactive space. While their commentary characterises themes within enactivist methodologies of research where the researcher is the observer, there are parallels with assessment (Simmt & Kieren, 2015). Suppose we look at the element of assessment as being a means of gathering data on

student learning—just as a researcher gathers data on their participants. In this instance, the pillars of enactivist research methodologies apply. If I look at myself as a researcher of students' capabilities in mathematics, how might I ethically proceed with an assessment practice aligned with that perspective? The process of gathering data could been seen as participatory, collaborative and meaningful in a sense of bringing forth significance of mathematical knowing and doing as part of a communal assessment practice.

An enactivist assessment practice, as I conceptualise it, involves surrendering to emergent mathematical knowing by abandoning prescribed ideas of what constitutes evidence of learning (Simmt & Kieren, 2015), surrendering to unanticipated mathematical productions, which may diverge from preconceived definitions of mathematics, and approaching assessment as the process of collectively bringing into awareness the meaning through doing mathematics. What are the consequences of diverging from the plan for an assessment task and do the negative consequences outweigh the benefit, or is it the other way around? In what ways might the pursuit of emergent mathematical demonstrations benefit students' and teachers' understandings of student mathematical knowing and doing? In what ways might the pursuit of emergent mathematical demonstrations engender student flourishing? Implied within this framing of enactivist assessment practice is the presumption that the student's expression of mathematical knowing is validated and observed regardless of the extent to which it diverges from the teacher's expectations.

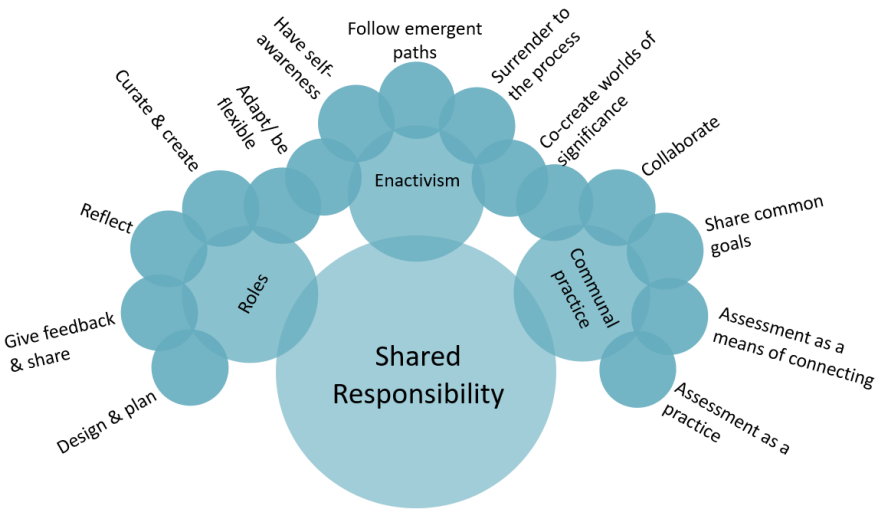
This theme of sharing responsibility (**Figure 16**), is centred around ideas of unpredictability and uncertainty, surrender to the process, and honouring multiple wisdoms. I am no longer the sole authority in the assessment practice—be it planning for, executing or evaluating—instead, I share this responsibility and practice with the students in co-creating

assessment tasks. Students bring forth their expertise in this collaborative effort, which brings a second element to this theme of shared responsibility. The elements of unpredictability and uncertainty take into account the unanticipated learning trajectories and mathematical creations that emerge throughout the process of any given single assessment task. To embrace the unpredictability and uncertainty, one must surrender to the process and be mindful of preconceived ideas regarding indicators of learning, learning trajectories, and foci of the assessment. That is to say, one cannot hold on too tightly to the alignment between the intended goal of the assessment and the outcome; rather, the teacher becomes a mindful observer[28] embracing the complexities of student learning and expression of learning, which at times may require a renegotiation of one's assumptions around what assessment tasks ought to look like.

[28] I use the term mindful observer to describe a third person, separate from the process who sits as a less involved witness. This idea is inspired from some guided meditations I have been doing from the Headspace app (Headspace Inc., 2021).

Figure 16

A Fractal Representation of Shared Responsibility



5.4 Putting the Assessment Practice Framework Together

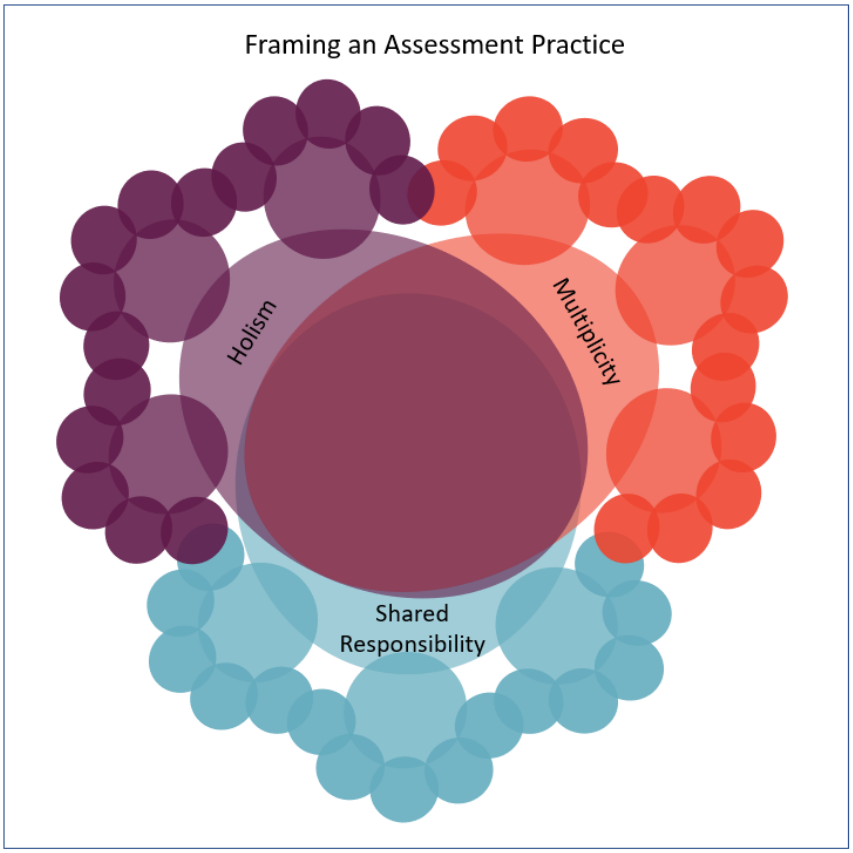
5.4.1 Modelling the Assessment Practice

The themes above are presented as distinct within the speculative fiction, but they are deeply interconnected. In order to take a holistic approach, I must share in the responsibilities because I am not privy to the deep inner workings of a student's notions of self as learner, and the multiple versions of their selves as a singular person and in relation to the learner community. The assessment practice welcomes the student, as they are in their entirety, as a dynamic person, into a space of sharing for the purpose of assessment, and my responsibility is to open myself up to knowing the contexts from which students derive their creations. Similarly, shared responsibility involves surrendering to the multiple ways of knowing and doing mathematics as they emerge within any given assessment context. These multiplicities, however, stem from and are interdependent with the human experience, which further supports taking a holistic approach to assessment. As an interconnected set, the assessment practice can be

conceptualised as a system of all of these intermingling elements that, no single assessment task would cover, but that an assessment practice as a whole can be framed within (**Figure 17**). In this way, the assessment practice is a fractal image of the three themes that emerged and their sub-parts.

Figure 17

Fractal Representation of Assessment Practice in Mathematics

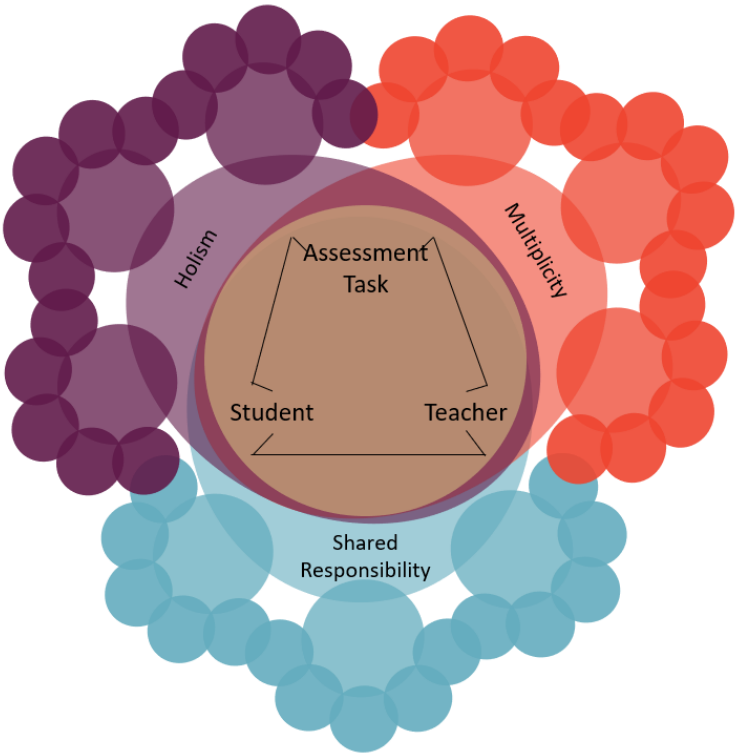


If the assessment practice is the whole fractal image, then any given assessment task aligned with this assessment practice could be conceived of at the centre intersection of the three themes (**Figure 18**). I suggest, instead, that the 'end' that we plan for when we are 'planning with the end in mind', is not a specific collection of content, but rather specific ways of being mathematical in and through assessment which I characterise with the three-dimension assessment practice. In fact, it is in this space of intersection that the teacher, student and

assessment task interaction would be embedded. I imagine this interactive assessment space in terms of Aoki's (2011c) man/world relationships which "permits probing of the deeper meaning of what it is for persons (teachers and students) to be human, to become more human, and to act humanly in educational situations" (p. 95); namely, in assessment situations. In his framing, there are three subjects: student, teacher and displayed object meant to be acted upon, in this case, an assessment task. In this environment, the teacher and student each act as autonomous beings and as a collective, and their actions are influenced by interactions with each other and within the embedded contexts by way of feedback. At the same time, this inter-responsiveness can be seen between student and assessment task, and teacher and assessment task.

Figure 18

Assessment Interactions as Embedded Within the Assessment Practice



To end this section, I would like to briefly return to the proposed definition of assessment that I presented in Chapter 1 assessment is a continuous and dynamic process and practice of

teacher and learner sitting beside one-another and *co-creating* evidence of teaching/learning mathematics in a way that contributes positively to the strength, wellness, value and worth *of the student*, the students learning, and the discipline of mathematics. This philosophy of assessment is showcased in the above model, which deliberately lacks hierarchical relationships and is situated within environments of wellness and flourishing, plurality of perspectives and means of interacting with one another and the assessment task, and communal being. This approach to an assessment practice more properly imagines the development, observing and communicating of mathematical competence, where competence is a "critical venturing together…with its interests in liberating [participants] from hidden assumptions and techniques, promotes a theory of [person] and society that is grounded in the moral attitude of liberation" (Aoki, 2011a, p. 132).

5.4.2 Reflecting on the Assessment Practice

I am a lover of checklists; I use them to hold myself accountable to what I want to get done. In line with this character trait, and as a result of this research, I began to think about how I might hold myself accountable to this future assessment practice. How might I evaluate myself in engaging with these dimensions of assessment? How might I ensure that I am, not only aligning my assessment tasks in terms of holism, multiplicity and shared responsibility, but doing so in a critical way that ensures continuous reassessment of my own assessment practice. As such, I present a checklist in **Appendix B** that I would use to assessment my assessment practice and that carries potential for use by other practitioners as a professional development activity.

5.3 Second Speculative Fiction: Showcasing an Assessment Task

5.2.1 Prelude

The main purpose of the following text is to provide a speculative fiction about planning for and executing a singular assessment task. In order to do this, I use a particular mathematical context with which I am familiar. This singular example is meant to provide a fictional task illustration from which one might glean insight into student learning for the purpose of assessment. The following speculation provides a concrete starting point from which an alternative assessment practice may be conceived. With this in mind, I present the text as a chronological story of sorts, starting with the beginning point of planning an assessment task, followed by the execution and reflection of it.

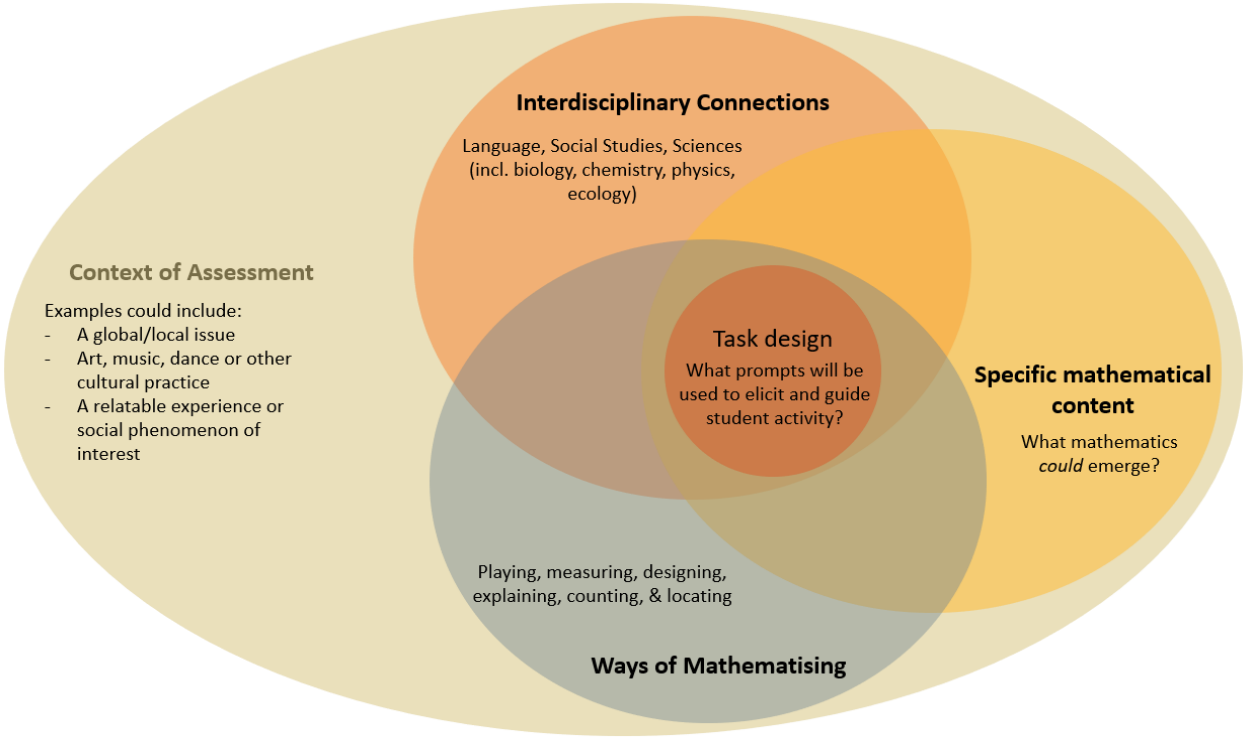
5.2.2 An Alternative Approach to Planning an Assessment Task

I imagine the assessment planning process (**Figure 19)** as follows: first, draw on an historical or contemporary, social or cultural context. Next, outline the social, cultural and historical relevance of this context to ensure opportunities for a multiplicity of mathematical connections to emerge in context. Then, identify potentially relevant specific mathematical content, opportunities for mathematizing (Bishop, 1988), and interdisciplinary connections. As with any planning phase, this is only a draft—a curriculum as planned (Aoki, 2011b). The mathematical content and the mathematising afforded by the context is determined subjectively in the planning phase, and students are encouraged to find mathematical connection that deviate from the teachers' draft. In fact, this is an opportunity to discover the breadth of student knowing. This is the advantage of situating an assessment task within a context; it provides an open relatable space from which students can showcase the breadth and depth of their mathematical knowledge and skill.

As in the diagram (**Figure 19**), I begin within the outer most circle and move towards the centre of the three-part Venn diagram—the intersection of interdisciplinary content, specific mathematical content and mathematisation. The centre circle at this intersection represents the context space in which the assessment task is planned and executed; it is in this space that the specific prompts to elicit and guide student responses as well as how the assessment task will be set-up in terms of modes and mediums used and nature of student interactions is drafted. The context continues to remain part of the mathematics assessment and vice versa; all interconnected and relevant. However, the elements of the context that are relevant are determined as such by the student, and in doing so, implicitly and explicitly communicates what they know and can do as they progress through the assessment task. This suggests that there must be an openness to the possibility that students may demonstrate mathematical competence in terms of interdisciplinary connections. Throughout the process, I use the term drafted, because I must maintain a level of flexibility keeping in mind that the mathematics knowing and doing that emerge may not align with my draft, but are nonetheless still valid and provide opportunities to gain insight on student learning for assessment purposes.

Figure 19

Conceptualisation of the Planning for Assessment



Note. The sweet spot in which I want to dwell with my assessment is within the Task Design circle: the overlap of Interdisciplinary Connections, Mathematising, and Mathematical Processes.

Vignette 1: A Model for Assessment Tasks. I choose a context I know well which may also be relatable for my imagined student audience: riding the bus. There is a special kind of contemplative meditation that happens on a bus when you've ridden a route so many times that you subconsciously know how long it will take. You surrender to the moment letting your thoughts and noticings come and go as you casually observe the space around you. I think back to my many experiences riding the bus to and from school, shifting my awareness to the nuances of what riding the bus can teach me about what it means to be a mathematical being; in effect wondering within and about this particular context to see what mathematical phenomena could potentially emerge. I replay these moments to tease out the mathematical knowing.

Figure 20

Teacher Planning and Reflection on Task Set-Up

Step 1: Reflecting on the context

Noticings

- Passengers tend to fluctuate in a pattern based on time of day. Some stops consistently yield more passengers than others.
- Many of the same people come onto the morning bus from day to day—some staying on the bus longer than others.
- Certain stops seem to be a crossing point for buses of the same route but going separate directions.
- The driver tends to stop letting people on the bus when it reaches a certain point
- Some bus routes are quite direct between two end-points while others seem to take the scenic route
- Major transfer points can come in the form of a public transit hub, which is often a mall, or in the form of a bus stop at a major intersection between two more direct bus roots
- When I plan a trip, I consider my priorities: number of transfers, wait time at transfer locations, total time in transit, amount of walking required. I imagine different people would prioritise different things

Wonderings (these could be task prompts)

- What is the relationship between particular landmarks and the busy stops?
- At what point on the bus route is the bus the fullest, and how is this related to time of day?
- What is the average number of stops that a person stays on the bus?
- What mathematical models can we use to represent passenger fluctuations? How might we set up an experiment to gather data on passenger fluctuation?
- Is capacity based on volume or weight? Would the bus reach space capacity before it would meet weight capacity?
- How do they plan bus routes (particularly the scenic ones)? What do they take into consideration? Who is involved in bus route planning and city infrastructure?
- Why are some bus routes more popular than others? What is the relationship between neighbourhood population and extent to which the bus route is used?
- What is the relationship between popularity of the bus route versus the frequency at which any given bus comes by, and how this might be influenced by the percent of maximum capacity?

- How does Google Maps trip planning work? What variables might one consider?
- Why do the neighbourhoods on the outskirts of the city have poor bus service? Why is public transit the last thing to be developed in the newer neighbourhoods?

Mathematical concepts afforded by the context

- Central tendencies
- Scale factors
- Capacity (load: sum of weight ratio)

Mathematical processes afforded by the context

- Modeling data with different types of diagrams
- Data collection and population sampling
- Mapping and using scaled diagrams
- Graphing (number of passengers vs time, keeping bus stop or bus rout constant)

Mathematising

- Measuring explaining, locating, designing

Interdisciplinary connections

- City infrastructure planning
- Social studies: neighbourhood demographic vs number of bus routes, number of people on the bus, or location in the city
- Fuel consumption and environmental sustainability
- Mechanics (air brakes would be noticeable, driver's chair bounces, tire set-up)
- Chemistry (fuel, windshield wiper fluid)

Reflections:

- Anticipated themes of relevance: passenger fluctuations, infrastructure, mechanics of the bus, public transit user demographic

Step 2: Reflecting on task set-up

- I want the task to be collaborative and start with a space for sharing experiences
- I want the task to yield some sort of concrete artifact that I can use to gain further insight into their learning
- Task will likely take several classes
- I want the task to be open but I need to be prepared to guide students via use of probing questions in order to help them narrow in on the mathematics.
- Evidence of student learning will be gathered from observation and discussion and the artifact that is created. I will use a notebook to log observations during the task, and reflections after the task.

5.2.3 Imagining the Assessment Task

Vignette 2: Drafting the Task Sequence. I plan by making notes for the lesson. I would use shorthand but for the purpose of readability, and have included extra details.

Figure 21

Drafting the Task Sequence

Step 3:	**Determining Purpose and Drafting Guiding Questions**
	General goal of task sequence: - Begin broad; narrow in on mathematical competence (knowledge and skills)
	Sub-task 1
	Purpose of task: preface the mathematical exploration and structure the environment around sharing and acknowledging the multi-layered, multi-disciplined relationships that the context welcomes. Need broad prompts. Notes for first sub-task: - Elicit collaborative discussion centred around riding the bus, - Offering an opening for the teacher and students to become familiar with prior knowledge of this context, setting stage for narrowing in on mathematical knowledge and skills. - Teacher and students are learning about and connecting with each other—human environment - Teacher and students are gaining an understanding of the extent to which the context is familiar for each person. In sharing stories, students are implicitly giving and receiving information about this level of understanding
	Sub-task 2
	Purpose: begin narrowing the discussion towards mathematics, while still maintaining the interdisciplinary relevance and an ambiguous enough space to enable the emergence of potentially new or unexpected mathematical conceptions. Notes: - Students share their noticings and wonderings as authors of their own Mathematical storylines. - Students demonstrate their conceptualisations of what it means to be a mathematical being. The teacher would bear witness to the specific ways in which students are demonstrating mathematical knowledge and skills. - I am at once a learner, participant and guide using observations to suggest a direction for the third sub-task while at the same time noting students' unique ways of mathematising. - This is where each group would begin to diverge based on elements of the context that become relevant to them.

- Different prompts are necessary depending on the trajectory they take with mathematical content and the mathematising they demonstrated.

Sub-task 3

Purpose of sub-task: to provide opportunities for the teacher and students to give and receive feedback about particular mathematical knowing and doing

Notes on sub-task:

- Keep eyes open for showcasing of domain specific knowledge (Thanheiser, 2017), mathematical habits of mind (Cuoco et al., 2010; Pyper, 2018) and more technical mathematical language.
- Communications and interactions are done through oral discussion, however, there are opportunities for students to interact with different modes (e.g., written: drawing or listing).
- The interactions that occur during this third sub-task provide a basis for the fourth sub-task, which could, again, take unique forms with each group.
- Prompts dependent on group progression

Sub-task 4

Purpose: to provide opportunities for the teacher and students to give and receive feedback about how the mathematical content in sub-task three might be represented or modelled in other ways.

Notes:

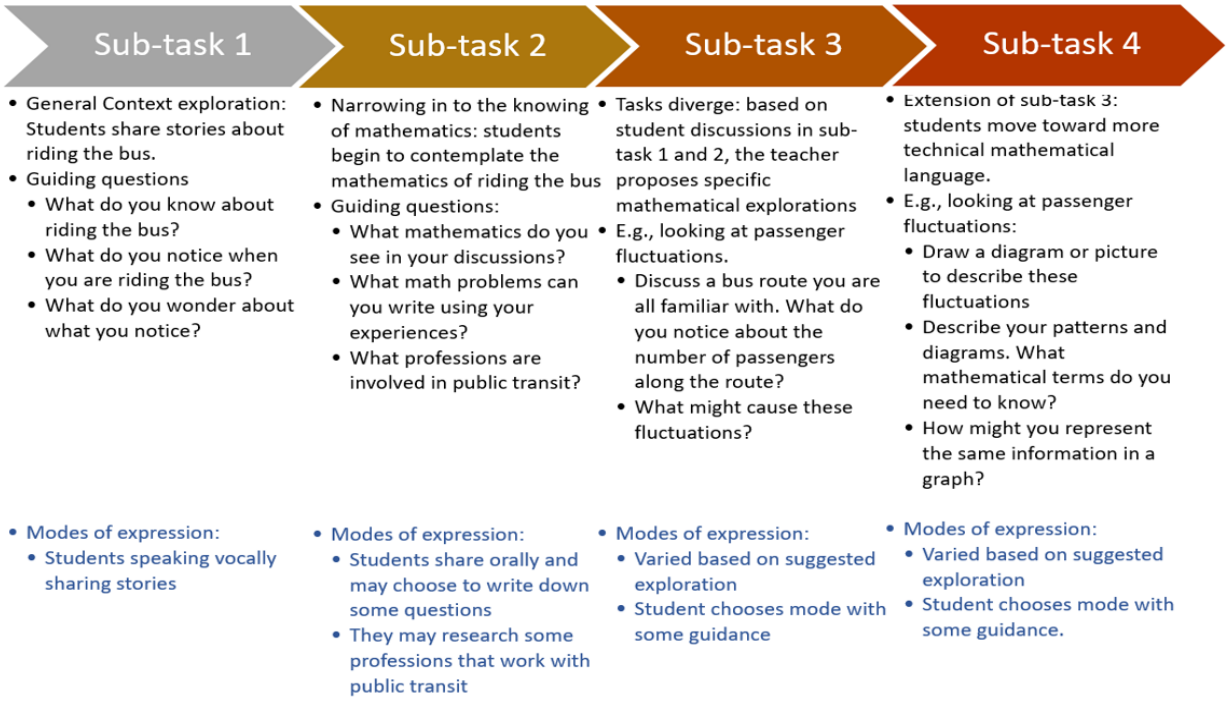
- Give opportunities for students to draw connections between different mathematical representations and potentially between different mathematical content.
- Provide opportunities for students to create mathematical artifacts (e.g., map →graphic model).

Step 4: Bringing it all together

I need to bring these planning points together into a cohesive task or task sequence knowing that students may need some guidance and scaffolding—especially since they are in middle school. I want to anticipate their actions and productions so that I am properly prepared to respond but at the same time, I keep in mind that I may need to improvise as I cannot anticipate all possible projections in student activity throughout the task sequence. This is by design.

Figure 22

Task Sequence Guide



Vignette 3: Imagining Student and Teacher Dialogue. The following includes a dialogue and teacher reflection. In the dialogue, I have included both what would be the main dialogue between teacher and student, as well as the inner monologue of myself as teacher. The main dialogue is aligned left, while the inner monologue is marked by right-aligned italic text in square brackets. The teacher reflection at the end of each of the two dialogues is marked with the bolded title: Teacher Reflections.

Figure 23

Student-Teacher Dialogue

Teacher walks up to group

Kessa: Hey madame! I heard you ride the bus in the morning on the early bus. Vic told me.

Teacher: Yeah, I do take the bus every morning

Kessa: Yeah, that's what we were talking about, haha!

Vic: Well, that's what we started with, anyway.

Teacher: Oh yeah? Where are you at now?

Neelan: Well, after Vic said he saw you, we were all wondering if you take the same bus everyday and then we kinda got to talking about how the regular bus has the same people.

[*sharing experiences. Noticing trend*]

Teacher: Interesting. I notice the same thing for the early bus.

Neelan: Well, of course it will be the same people for the regular bus because mostly we are all going to school and school starts at the same time for all of us.

[*some logics. How to interrogate*]

Nur: But there's that other dude too. Some construction worker. He stays on the bus when we get off.

[*noticing trend extends beyond school kids*]

Neelan: Oohhh right! That guy! And that other one, the older lady. She's always on when I get on but she gets off at the mall.

[*second confirmation – gathering more evidence*]

Kessa: Uggghhh. In the afternoon, so many people get on the bus at the intersection right after the mall. It's like, ugh!

[*noticing patterns in fluctuations*
Elicit more information on this train of thought]

Teacher: Hmm. That's an interesting observation. I wonder what other parts of the route might be busiest…

Neelan: Oh, that's easy. I don't even have to ride the bus to know that it would be busiest by the mall and at the transit station.

[*I wonder about the reasoning, here*]

Nur: Not the transit station! Maybe the mall, though.

[*disagreement; evidence?*]

Teacher: Ah! I see an opportunity for debate, here! How about you all discuss where you think it might be busiest and see if you can map it out on a piece of paper.

Teacher Reflections

As they continue to discuss their multiple experiences, they may begin to identify the effects of major transit centres, time of day, the average number of stops a person stays on the bus for, or whether there are shopping malls or other neighbourhood amenities around.

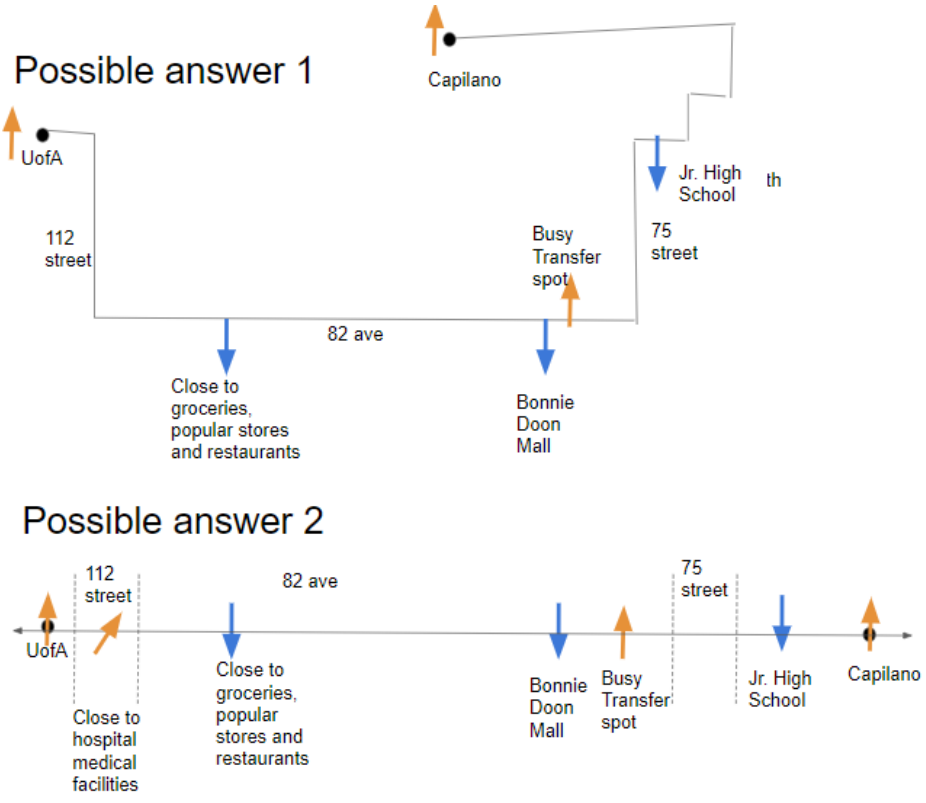
More information is needed from this group. Seems they are making some observations, but need to develop their thinking a bit more. Making some conjectures. Plan to guide students towards particular mathematical content.

I wonder what they will come up with for the "hot spots" where there are larger fluctuations and what their reasoning will be. I would like to see them make some conjectures and support with an analysis of some sort.

Vic did not speak. Kessa spoke very little. – check in with these two; make sure they are okay.

Teacher leaves temporarily to attend to other groups with the intention to return to group

Teacher returns to group and views productions



[*nice figures! Opportunity to connect to continuous graphs*]

Teacher: Okay! You have a map here. Tell me about that! Either Kessa or Vic

Vic: Um…I dunno *looks at ground and kicks foot*

[*What's going on, here? Is he okay? Ask later*

Kessa didn't say much earlier. Move to her.]

Teacher: Kessa?

Kessa: We drew the route and we traced from google maps.

[*intuitive use of technology as tool*]

Teacher: Oh! I wouldn't have thought to trace it from google maps!

Vic: *grins*

[*Okay, a grin; keep observing*]

Teacher: Vic, was that your idea?

Vic: Yeah, I do a lot of tracing and painting on my iPad at home.

[*I want to know more; I want to connect – don't be pushy*
take note of interest; context for future math?]

Teacher: Oh! Nice! You will have to show me some of your stuff sometime…if you want.

Vic: Yeah, okay *tiniest evidence of a grin forming; looks to ground*
Yeah, we traced it and then when we were running out of paper space, we thought it might be better to put it on a line.

[*problem solving, adapting to suit goal;*
pragmatic solution – I wonder if there are other benefits]

Nur: Yeah, but I thought it would be good to keep the landmarks.

[*Yes. Why?*]

Teacher: How come?

Nur: Well, because there are like, sections where the bus passengers change.

[*thinking in spatial intervals;*
noticed the need for landmarks as interval headers;
opportunity for vocab development]

Teacher: Yeah, so the landmarks help track passenger fluctuations within the sections of the route.

Nur: Yeah

[*Neelan hasn't said much in this part of the task*]

Teacher: Okay, Neelan, you want to explain the diagram?

Neelan: Not really.

[*Hmm. What changed?*
Maybe there's trouble with the visualisation?
Probe, but set the tone – messiness is okay]

Teacher: Don't want to give it a shot? It's okay if it's a messy explanation.

Neelan: Well, the up arrows are increase and the down arrows are decrease.

[*Start of connecting arrows to passenger fluctuations*
Some evidence of understanding rules that are forming a basis for visualisation
No mention of diagonal arrow – need more info]

Teacher: Okay! What is the diagonal arrow about?

Kessa: That is increase but it's not the same as the vertical one

Nur: Yeah, the vertical ones are where there are the most people getting on.

[*distinguishment and defining symbols*
Interesting way to code it
I wonder about placement of arrows]

Teacher: Oh, yeah. Now that you mention it, I see the vertical arrows are on specific spots and the diagonal one is over a distance.

Vic: Steady increase.

[*concise word choice; effective communication*]

Teacher: That's a good term to use.
Alright, so, what I want you to think about now is how you might make this a continuous graph. Right now, you have it on a number line, and that is useful. The next thing I want you to do is see if you can put it on a graph. What would your x- and y- axes be in that situation?

Neelan: Time? And passenger number?

Nur: No, not time. Place on the route….but I don't know how you would do that.

Teacher: I will let you think about it and come back.

Teacher Reflections

At this point, students are beginning to manage information about a particular topic and visually map out the multiple phenomena connected to this topic (passengers, locations and landmarks, using a specific bus route as an example).

Changing from a 2D representation to a linear representation was a good idea. Seems like they knew which information could be distorted (direction) and which information needed to remain clear (landmarks, passenger fluctuations). This is good information management. My next steps are to get them to translate the linear diagram into a graph.

I would like to see more discussion about reasoning behind these landmarks and some discussion about their hypotheses: why are there large sudden fluctuations as specific points? Tomorrow, when we get going again, I will ask them to, first, come up with some reasons behind their landmark choices and come up with some reasoning for why there are heavy fluctuations there; then, as them to translate their linear diagram to a graph. They will need some scaffolding on this. Perhaps give an example that could be used as an analogy.

Worried about Vic and Neelan. Check in tomorrow.

6 Discussion: Understanding Assessment Practice in Terms of My Identity

In this chapter, I include two key discussions. The first discussion surrounds the alignment between the task sequence and the proposed framework for assessment practice. This discussion is organised by the themes of the first speculative fiction. The second discussion that follows surrounds the influence of the work on my identity and the continued contemplations around assessment practice. This discussion is organised by the four pillars of the theoretical framework (DSMRI): self-definitions and self-perceptions, ontological and epistemological beliefs, purpose, and perceived action possibilities.

6.1 Reflecting on the Speculative Task Sequence

In this section, I discuss the connections between the first and second speculative fictions above by discussing where elements of the guide for assessment practice (first speculative fiction) are showcased in the assessment task example (second speculative fiction). Evaluating the task sequence for alignment with the first speculative fiction is not about assessing the behaviour of students. This section is meant to discuss an evaluation of the task, not the students, in regards to its integrity using the first speculative fiction as a reflective guide.

6.1.1 Analysing Evidence of Holism in First Speculative Fiction

Recall that holism involves the development of virtues, the elements necessary for flourishing and a welcoming of the multiple selves. With this in mind, I ask myself: what virtues are developed or demonstrated as a result of the task? What elements of well-being are present? And, which of the multiple selves are welcomed by the task? This is a difficult dimension to assess as I can only perceive what is present from my perspective. As a teacher, I observe utterances, behaviours and actions, and can only speculate as to what those performances mean (accounting for).

Horn (2012) discusses the importance of setting expectations around respectful interactions as well as developing norms of behaviour within the class culture. The work that goes into developing these classroom norms must preface the assessment task because a singular task would not elicit the particular virtues if the development of these virtues was not part of the norms of behaviour to begin with. Even so, I feel it important to consider the alignment between a task and the development of virtues; that is to say, assessment tasks must be designed in a way that honours the virtues I want to encourage in my students, and if this is done consistently, assessment tasks might present further opportunities to support and develop these virtues. As such, I would suggest that the focus of this task sequence is not the development of virtues. The atmosphere in which the task is situated is one that engenders honesty and loving kindness but the task in and of itself would not guarantee that these virtues would emerge; rather, it would be dependent on the development of classroom norms around working on collaborative tasks..

I suggest that students sharing their stories and experiences within a relatable, to many but not all, context, promotes belonging and positive relationships and opens up opportunities for creating and experiencing meaning. During the task, as students engage, I look for indicators that students are perhaps losing track of time—an indicator Seligman (2011) notes of engagement. Students may show a continuous persisting through challenging contemplations as part of a think tank of sorts, and as they progress towards creating a map, there are opportunities for feeling a sense of accomplishment (Seligman, 2011). Finally, through these interactions, students come to feel a sense of belonging and accomplishment as their contributions to the mathematical discussions take form and develop throughout the task—the mathematics aspect of the task becomes a human endeavour as students flourish.

Each student comes with a different experience, some familiar with riding the bus and some not. There is space for students to play the role of peer, student, friend, acquaintance or other social role; there are opportunities to develop the self in relation to others through sharing stories and finding common or uncommon experiences; students work together, rather than in isolation, with freedom to explore elements of riding the bus that are mathematically meaningful to them. I would critique that there is room for improvement when it comes to cultivating the rational self as the teacher prompts and task structure could be refined to encourage more challenge and mathematical sophistication. As well, there could be improvement in the task so as to make connections to a bigger picture, although, if students were aware of their character strengths beforehand, there may be opportunities to utilise those character strengths (University of Pennsylvania, n.d.; VIA Institute on Character, n.d.) or point out when they are being used during the task sequence, which would certainly increase a sense of value in the student. This task sequence welcomes the student as they are and creates the environment for them to grow.

6.1.2 Multiplicity

As I notice and wonder about these things, I begin to form an idea about the specific tasks and prompts I want to present to my students. I know that these tasks would be multilayered because of the multiple access points for extracting the mathematics from the context and acting mathematically within the context. In this assessment task, there are multiple means of doing mathematics (e.g., through oral communication or creation of artifacts), and there are multiple opportunities to access a variety of mathematical connections and definitions. This is enabled through the design of the task and through situating the assessment task within a human context. Situating the assessment task in the context of riding the bus provides a human experience with many cultural, historical, sociological and scientific connections thus opening up opportunities

for various points of entry into the task. As well, the assessment task remains situated in context so that the mathematics is expressed, not as a separate abstract phenomenon, but as an alternative mode of thinking about a particular context. There are more opportunities for students to express and represent completely valid mathematical ideas that may diverge from the teacher's anticipated student activity, and may diverge from the current standards of written mathematical solutions; each student has the opportunity for their mathematical ideas to be validated and developed. This highlights the relationship between human experience, multiple disciplines, and multiple mathematical phenomena. These relationships are based on the fact that they are connected to the context.

Note that throughout the entire task sequence, if the context is removed, the sub-tasks and mathematical explorations lose meaning. This indicates that the mathematical content has remained deeply rooted within the context, even when more abstract mathematics is explored[29]. As the teacher, I might use this as a way to ensure the mathematics is not decontextualized. If I notice that the mathematics that emerges at the end of the assessment task sequence is isolated from the original context, I might deduce that the assessment task was not properly centred around context. Another explanation could be that there was an emergent focus on—or probing on—ability to generalise information. In the latter, a refocusing on the context and how it connects to the task or task sequence should happen.

---

[29] This is something I came to know as part of the course on Indigenous perspectives in mathematics and science

6.1.3 Shared Responsibility

The design of the task puts letting go of preconceived ideas of mathematical content at the forefront of student and teacher activity. The teacher, as an observer free of scripted ideas of "what to look for" when assessing, now has more opportunities to understand students' mathematical thinking more deeply and accurately. The awareness as it shifts throughout the assessment task enables me "to notice what is really taking place at every moment without interpretation or judgment of the mind" (Nakagawa, 2019, p. 47). Through this surrender, my awareness is brought to elements of learning that deviate from curricula, that may be unfamiliar to me, but that are. nonetheless, significant and must be honoured; "emerging from surrender, we are left with fragments of what we learned from being in touch with what happened" (Darroch-Lozowski, 2019, p. 21). In other words, it is through the role of being witness that I enable a space of mathematical doing which provides opportunities for me to be enlightened to students' mathematical knowledge without the filter of prescribed mathematical indicators to blur the truth of their knowing. With that said, part of being witness is also maintaining an awareness of any preferences I have for the direction students are taking, and ensuring that those preferences and expectations do not limit these opportunities for seeing mathematical competence. It is not that having preferences or expectations are necessarily wrong or unhelpful—on the contrary, they form a scaffolding for how to proceed; rather, it is that the awareness enables a critical reflection on the influence of those preferences on students' opportunity to show their learning.

Note that throughout the task sequence, I log any personal observations I make in a notebook, noting actions or utterances of significance, and use these to reflect on both the accounting for and accounting of learning (Mason, 2002). I then use these reflections to plan for future instruction and assessment, as well as use the information gleaned from these reflections

to give further feedback to students and/or parents. It is the assessment environment and the opportunities it opens up to gleaning insight into students' mathematical knowledge and skill that is the focus of this speculative fiction, Important to note is that, throughout the assessment task, students would have received immediate feedback on their thinking, not just from me but from their peers. So, students come to know what they understand both during and after the assessment task.

6.2 Discussion: Reflecting on My Speculative Assessment Practice

6.2.1 Self-definitions and Self-perceptions

As I reflect on the times in my life when I felt well with mathematics and well with the assessment of mathematics, I realise that my relationship with mathematics has generally become more positive over time; it began to truly flourish in university and has continued to be cultivated since. On the other hand, my relationship with assessment in mathematics has followed a not-so-linear path. I remember dreading tests in my later K to 12 years as a student, but felt more or less at peace with the assessment in my university mathematics courses—even the test-like assessments. Later, as I transitioned between student and teacher, I found my relationship with assessment deteriorating once again as I defaulted to the assessment resources I was given. I find the distinctions interesting. If my previous assertion is true—that assessment is what drives motivation—then why did my relationship with mathematics and my relationship with assessment take such different paths? To delve into this, I draw from Kaplan and Garner's (2017) work on self-perceptions and self-definitions as being a pillar component of role identity.

Recall that role identities are fluid and that one can shift roles throughout the day based on context (micro transitions) or shift roles via promotions or change in positions (macro transitions) (Ashforth, 2001). How I define my role influences the relationship I have with

assessment. Note that there does not seem to be a correlation between self-definition as student and relationship with assessment practice because I remained a student in university, yet my relationship with assessment improved; even more interestingly, upon a macro role transition of student to teacher, my relationship reverted back to what it was as a young student. To me this suggests that the relationship with mathematics lies in the physiological self-definitions including cognitive development but that my relationship with assessment in mathematics seems to be more influenced by my self-defined roles within sociological contexts. Even so, I can only speculate about these accounts for because, as Kaplan and Garner (2017) noted, these self-definitions are not distinct from one another. Kaplan and Garner also discuss how emotion is closely tied to self-definitions and self-perceptions, as they act interdependently. I may have been soured by the use of testing in my younger student career, when I transitioned into a role where I was responsible for students the same age as I once was, I was (and am) soured by the idea that I might impose on them what I despised so much. In a way, I might say that I perceive myself as protector—though I find this troublingly hubris.

Why had my assessment practice remained rooted in testing if my perceived role was to protect my students from the harshness of it? I alluded to this in my introduction and in the theoretical framework. As a new teacher, I defined myself as newbie—one with little knowledge and naïve perspectives. I had little confidence in my opinions and beliefs about teaching. My perception of self-as-newbie (or pre-professional) was in conflict with my perceived self-as-protector. Even as I contemplated attempting to explore new assessment methods, the self-perceived naïveté often won in the tug-of-war between self-as-knower and self-as-dreamer. Thus began my journey to gaining more expertise via professional development and furthering my education. One thing that this research has afforded me is a shift in self-perception and a

dissolution of the tension from this tug-of-war. Exploring my beliefs about assessment within a speculative fictional space posed no immediate threat to my students, was uninterrupted by my perceived narrative that I would be rocking the boat, and in which my naïveté was a strength, not a weakness.

Looking at the assessment practice that emerged as a result of the research, reading and re-reading this writing, and seeing the wealth of literature that was savoured, I see a person with valuable ideas—perhaps rather ideological, but that suggest interesting contemplations—and that person is me. More interestingly, my self-definition as being naïve has not changed but my perception around being naïve has. I see this characteristic as one that will help me contemplate fresh ideas, and knowing that I do have this characteristic will hold me accountable to thinking critically about ideas that emerge. Finally, and tangentially, I find my perceived self-as-protector is rather narcissistic. Who am I to presume I am masterful enough to protect students from an assessment practice? I have come to see that every assessment practice has benefits and risks, and rather than seeing myself as a protector, perhaps I am more of an explorer, but an explorer within a community of explorers (my students) with the common goal of coming to know what we know.

6.2.2 Ontological and Epistemological Beliefs

I organise this section around some questions that drive my thinking around assessment—think of them as prompts in an assessment of my assessment practice. The questions are as follows: What can I reasonably define as mathematical knowledge and processes? How do students come to show what they know of mathematics? What can I reasonably expect to learn from any given assessment task? How has my thinking around assessment developed over the course of the research? As I mentioned in the theoretical

framework, much of what shapes ontological and epistemological beliefs are our histories and training, so it is in discussing these experiences that I come to respond to the above questions.

What can I reasonably define as mathematical knowledge and processes? In order to unpack why my relationship with mathematics and mathematics assessment really flourished in university, I feel it is important to explore the specific characteristics of the assessment practice at that post-secondary level. The nature of the assessments in post-secondary mathematics courses are unique in that they were centred around mathematical argumentation rather than calculation. The assessment practice included weekly assignments and midterm and final exams. The assignments could be completed with or without peers and with or without the use of the internet, textbook, calculator or other resources, and had no more than five questions each. I have fond memories of the mathematical discussions I got to have with my father about the mathematics I was learning and the solutions I was considering. The exams, on the other hand, were designed to be completed independently, without calculators, and some courses let students have a cheat sheet while others, like the calculus courses, did not. There were no more than ten questions on these exams, each of which had ample space below for a solution, with elegant numbers[30] and were accurately designed to be completed in three hours. For both the weekly assignments and the exams, the problems were focused on mathematical argumentation rather

[30] Here, I use the term elegant numbers to describe what one may call "nice" or "friendly" numbers; these types of numbers are easily manipulated and operated on using only mental math. For example, integers of three digits or fewer are elegant numbers, even if they find themselves as the numerator or denominator of a fraction. With that said, whether or not a number is considered elegant or not is a matter of opinion.

than calculation. At times, they required a memorised rule, such as the chain rule in calculus, while at other times, like in my geometry course, they gave opportunity for creative logical reasoning. The solutions were always a proof of sorts that the student discovered and created for themselves. These experiences in university enabled me to rediscover what mathematics, as a discipline, really was.

The problems presented in the lectures used the same basic principles or rules as the problems in the assignments and exams, but they were never quite the same, in the sense that they were not the same problems but with different numbers. I love this aspect because the feeling of accomplishment when one has successfully created a proof is that much more intense when you have not encountered a similar problem before. I really felt that I had discovered the mathematics rather than repeated or regurgitated it. Even more, many of the problems I encountered in calculus, linear algebra and geometry provided a space for discovering the proofs behind formulas that I had had to memorise in my pre-university career; all of the sudden, they made sense because I discovered their origin using basic mathematical properties or principles (e.g., derivation). I felt alive and the mathematical content seemed to come alive through the slow, thorough and deep contemplations involved in solving the problems, many of which required drawing.

Through an exploration of the literature around philosophies of mathematics, I came to know, once again, how narrow my definition of mathematics was. Through this research, I continue to interrogate these definitions I hold of mathematics, which then shapes my thinking around what ought to be assessed. If I am assessing student knowing of mathematics, I ought to remain open to questioning what mathematics entails and the contexts in which it may emerge. One concern that surfaced through this research is the idea of merging the disciplines of

mathematics and sciences, and merging the humanities with the sciences. There are deep connections between these two realms of knowing. One that comes to mind is that both engage in the element of intuition and beauty. Beauty is a subjective thing, one situated in the spiritual and experiential realms of being (Ehrenfeld & Hoffman, 2013; Hart, 2019). We know something is beautiful when we experience it as such or when we feel a sense of meaning in it—it is intuitive. I am reminded of the following quote:

> Modernity split science from the arts. But the differences between them were turned into artificial division, absolutized as if they had nothing to do with one another and no way to relate. Resonance and reason, feeling and fact, were "officially" divorced from one another and our schooling, and we, ourselves, fragmented (Hart, 2019, p. 26).

If the difference between sciences and arts is artificial, and if there is deep value in cultivating the relationship between resonance and reason or feeling and fact, then in order to prevent this fragmentation, we must merge the disciplines, or at the very least, provides spaces for them to coexist. In the latter suggestion, it would mean that each school subject is situated within a holistic context of merged arts and sciences, but that the awareness, in the case of math class for example, is brought to mathematics *within* that context.

How do students come to show what they know of mathematics? I am a firm believer that the environment of any assessment task, including the psychic atmosphere, plays an important role in facilitating the expression of learning. That is to say, the environment can enable or disable a student's ability to express their learning accurately. It is for this reason that much of the assessment practice suggested above revolves, not so much around the content of the assessment tasks, but the environment in which the assessment tasks are set.

As I reflect on my university experiences with assessment, I find that all of the elements of flourishing were present: positive relationships (with peers, with professors, with the mathematical content and the world around me that it described), engagement (the deep contemplations that transcended time), positive emotions (resulting from the process and satisfaction of solving a problem), a sense of meaning (feeling alive and feeling that the content was, too), and sense of accomplishment. The virtues it cultivated in me, which continue to manifest in my daily life, included prudence and persistence, appreciation for beauty, gratitude for opportunities for growth, and an enthusiasm for contemplating and understanding problems. To me, this indicates a spiritual experience as it is to re-experience the joy, appreciation, wonder and reverence of mathematics and demonstrates a connectedness with and love of the content which encourages the seeking out of beauty for myself (e.g., Hart, 2019). There is a sense of oneness with the content (Nakagawa, 2019). I find these virtues are poorly cultivated with the prescriptive nature of my testing methods—not to mention the sheer volume of questions presented in those tests. While I may have not done well on all of these assessments, I remained confident that what I submitted was an accurate depiction of what I knew. In other words, the person evaluating my work would be able to see what I knew.

What can I reasonably expect to learn from any given assessment task? More recently, as part of the MEd program, I designed an activity with one of my thesis colleagues around playing with puzzles. I made assumptions about the emotional impact of playing with puzzles, presuming that the normal reaction would be joy and productive struggle (Boaler, 2016). In fact, I discovered that for some of the participants, the activity had brought up many negative emotions and a sense of overwhelmingness. My fond memories of doing puzzles with my father as a mode of play had yielded holes in my thinking about an ‘ideal’ task. This is not to say that

there is no value in experiencing negative emotions—it is, after all, part of the human experience—but having not anticipated that type of response, I was poorly equipped to act as moderator between the participant and the assessment task effectively missing the opportunity for enabling that participant to flourish and seeing what that participant knew of mathematics within that context. While I will not always be able to anticipate students' responses to assessment tasks, this example acts as a reminder for me to be cognisant of my own relationship to mathematics and how the defining characteristics of that relationship will continue to produce holes in my thinking about assessment.

Since beginning the writing of this chapter, I was gifted the opportunity to hear about different contemplations in regards to mathematics research during a group gathering. One of the contemplations mentioned by Dr. Florence Glanfield was around the idea of interpretation and honouring voices of participants. How do we ensure we honour participants' stories in the gathering, interpretation and dissemination of research? This got me thinking deeply about assessment. If I look at assessment as a process of gathering students' stories, then how might I honour their representations of mathematics knowing which are gathered, interpreted, evaluated, and later disseminated to them and their parents? There is such room for subjectivity in this process. Many nuanced influences are present including the influence of the mode of communication, the translation of that mode of communication into text or another means of dissemination and my own interpretations of the information based on what I identify in that moment as being relevant for the assessment.

I have not yet worked out the tensions in that dilemma, however, a starting point for me would be to return to Mason's (2002) work on subjectivity; specifically, the distinction between accounting of and accounting for, which I modeled in Chapter 1. Another way I might work

towards honouring the voices of my students lies in the collaborative efforts with them and with their parents. Developing deeper relationships with them, and keeping an open collaboration aimed at coming to know what the student knows could be a form of member checking; did I interpret this correctly? Does the student and parent agree with my assessment? These are two of my starting points in addressing the issue of subjectivity.

How has my thinking around assessment developed over the course of the research?

As I propose taking a holistic and pluralistic approach to assessment, I caution myself into presuming that this approach will address all of the problems that my past assessment practice, rooted in testing, presented. It is especially dangerous to assume that this new approach to my assessment practice would not present ethical issues of its own. If I do this, I am effectively claiming mastery over my assessment practice which, as I have noted before with notions of mastery, produces many unintended consequences (Ehrenfeld & Hoffman, 2013; Singh, 2018). With this cautionary note in mind, I come to the conclusion that I must not only relinquish control in a sense of surrendering to students' mathematical perspectives and trajectories, but also surrender my ego as assessor. That is, to accept and become witness to what I perceive to be in the best interest of the students; rather than getting involved in or committing to my ontological and epistemological beliefs, simply noting them. This idea is inspired by the guided meditations I do every night led by Andy Puddicombe (Headspace Inc., 2021) where I practice noting thoughts and feelings, rather than getting involved in them. The idea being that, becoming an observer to thoughts and feelings, prevents me from becoming emotionally attached to particular truths so as to negotiate any potential tensions between my own perception of truth and their absolute truth, all the while acknowledging that, for me, there are some absolute truths.

Through the study of various literature in education scholarship I have come better understand and articulate my beliefs around assessment. The format of the typical unit test reflects particular ideas around normalcy of body and mind. This, in turn, produces certain ideas about an alternative assessment practice, which requires a recursive critique. That is, what assumptions am I making about the dispositions and variations of students' multiple selves in the framing of assessment practice as described above? And which behaviours, as a result, become (de)valued? The above speculation suggests a new normal for assessment, and this new normal, as it is implicitly value-laden, so I caution myself in presuming any sort of authority on defining this new normal as ideal.

Aikenhead (2017) states that "educators need to be vigilantly aware of not inadvertently recolonizing the people they intend to serve" (p. 75). Literature on Indigenous education typically focuses on addressing the colonial powers head-on and making transparent its misplaced power, and also function to heal communities (Lunney Borden et al., 2020). It is this exposure to Indigenous literature in (and outside of) mathematics education that formed the largest inspiration for involving multiplicities of mathematical engagement. Given my history with mathematics and mathematics assessment, I find it difficult to imagine and uncomfortable to validate different forms and settings of mathematics. However, this challenge is one that epistemologically and ontologically, I believe is necessary. Coming to understand and include Indigenous perspectives in mathematics education, for me, begins (but, importantly, does not end) with finding elements of relatability.

I situate my future assessment practice as a process rather than a fixed set of principles. Perhaps the most important element of this assessment practice is the sharing of responsibility because it opens up continuous and unprescribed opportunities for re-imagining the content that

lies within the realms of mathematics as a discipline through multiple interactions over time. The positive direct relationship between wisdom and age is disrupted so that my students' wisdom is honoured and respected within the assessment practice opening up opportunities for me to, over time, indigenize my definitions of mathematics and my assessment practice. In this way, my ontological and epistemological beliefs are open to be called into question by the very people those beliefs may harm.

Leaning into Discomfort: (Un)conscious Tensions. There are particular implications of situating my assessment practice within the three dimensions proposed above that I continue to find discomforting. I understand this discomfort in three ways: (1) discomfort arises as a result of an unwelcome threat to my current ontological and epistemological beliefs which drive a resistance to changing my assessment practice; (2) discomfort arises as a result of a welcome threat to my current ontological and epistemological beliefs which drive a change in my assessment practice; and (3) discomfort arises as a result of tension between a wanted change in my assessment practice and what I imagine as reasonably possible within my current circumstances and knowing my current capacity (perceived action possibilities). In either of these situations, there are aspects of resistance due to the value structures I become involved with (Cho, 2009).

My first discomfort has to do with the authority I assume throughout different parts of the assessment practice; to what extent does my training, knowledge base and experience entitle me to presuming what is *better* for the students? This idea of presuming students are better off with a particular assessment practice is precarious territory. The fail-safe within this framework is the notion of shared responsibility. When it is a communal practice, there are opportunities for negotiation and enlightenment. Even so, there are perspectives of mathematics and the doing of

mathematics with which I am unfamiliar, so begs the question: how will I know what is or what is not mathematics as it emerges, in order to assess it? My unfamiliarity with the multiplicity of perspectives in mathematics poses a risk to the student in that it makes the assessment environment a vulnerable space, and even as I become familiar over time with more and more mathematical phenomena, I will always be learning it in comparison to Eurocentric mathematics. Just as when one learns a language through their mother tongue, one learns the language by translating back and forth, and "every translation is a betrayal, an interpretation which breaks open the being of the object and makes it vulnerable to the otherwise ear and tongue and imagination" (Jardine, 2008, p. 16). What needs to be negotiated in this instance is not whether or not I have authority to make decisions, but rather, the extent to which students weigh in on those decisions, and the awareness and reflexivity I bring to that negotiable space.

My second discomfort, which follows from the first, has to do with efficiency. In my mind, shared responsibility threatens the efficiency in assessment; it suggests a certain level of messiness and complexity because the anticipated student engagement with the assessment task may not be aligned with the actual student engagement with the assessment task—there is a muddling of expectations. Even more, this deviation will likely be different for each student. On the one hand, I cling to the security of predictability, while on the other (as a result of my contemplations in this program), I wonder if there is room to either caution or critique the notion that we ought to be able to predict student activity. Can we assess in what feels like chaos? I suspect much of the discomfort I feel towards leaning into this felt chaos is rooted in a certain level of unconscious appreciation for accountability and consistency. I wonder to myself whether I am on the right track in suggesting a less controlled assessment environment. I guess I will

dwell in the discomfort of not knowing, and take solace in having an awareness of what is unknown[31].

My final discomfort, which follows from concerns of efficiency, has to do with consistency, mainly in terms of content assessed across grades and across locations. For example, if I am to relinquish control and surrender to emerging mathematical trajectories that I then assess, there is little to no guarantee—in fact, it may even be perfectly unreasonable to assume—those students in the same grade across different schools would learn and be assessed on the same content. At the same time, I ask myself: is this a remnant of the mythologies around accountability and consistency that I was told, and that I continue to tell? Even if this is so, my role as teacher and as assessor is to seek to develop students' abilities to

> move beyond the self, to understand the limits of their subjectivities, to challenge the normalizing practices, and the history that they are a part of, and to thus, transform their subjectivities so that they may be someone other than who they were when they first attended school (Carlson, 2006, p. 41).

In that regard, perhaps the way forward is to model those very virtues so that my role identity as assessor is changed from when I initially entered the MEd program, and so that I may heal my relationship with my assessment practice.

---

[31] I struggle with uncertainty in all dimensions of my life including the personal and professional. It is something I have worked on extensively through cognitive behavioural approaches. Letting go of the urgency 'to know' has produced this phrase as a mantra of sorts, and it seemed applicable to my assessment practice because of that lingering question of "am I doing the right thing?" I guess I will never know.

6.2.3 Purpose

The main purpose I have as an educator, now, is to enact an assessment practice aligned with my philosophical beliefs. Specifically, it is to provide an assessment practice worthy of the students I teach; one that is equitable and welcoming. With my Albertan context, much of this involves a focus on decolonial practices and reconciling the relationship between Western and Indigenous ways of knowing and doing mathematics. I have come to understand some major threads in Indigenous perspectives in mathematics education, as being (1) importance placed on relationships and relationality, which suggests (2) learning within interconnected webs of context with particular importance placed on land and place. A question that coalesced as I contemplate my role and my understanding reconciliatory practice is as follows: What does where I am, temporally and spatially, and how I am, statically and dynamically, teach me about being a mathematical being? This question is very much a human centred question, which I will critique later on, but it is a starting place for me in my journey towards reconciliation of mathematics assessment practice. What I mean by where I am spatially and temporally is my physical environment at any given time; whereas, when I say statically and dynamically, I am referring to both the more fixed elements of being (e.g., self-definitions) and the daily fluctuating ways of being (e.g., experiences in the world). This question has helped me discover mathematics within familiar contexts rather than projecting the mathematics I am familiar with onto various contexts. The latter can only strengthen the power of the mathematics I currently know (abstract western mathematics), whereas the former affords opportunities for me to redefine mathematics from and within the contexts I know. Here, there is still a risk of me only being able to tease out familiar mathematics, which is where human relations become important.

In the previous section, I noted the characteristics of the assessment environment, and only touched briefly on the nature of the content. The content of those assessments was strictly abstract mathematics, which I mention in the theoretical framework as being the type of mathematics to which I related to most. Whether this is because I was enculturated into the abstract mathematics world throughout my schooling, or whether there is a sort of hereditary love of it from my European ancestry, I cannot say. However, as I mentioned in the theoretical framework, there is a move for reconciliation in education in Alberta, which means I need to deconstruct and re-imagine the content I include in the living discipline of mathematics (Friesen & Jardine, 2009; Jardine, 1992). I have come to know the importance of reconciling the harm done through colonial curricular programming and pedagogies. In particular, and in terms of the focus of my thesis, this means reconciling the harm done through assessment practices I have used that unintentionally continue the act of colonisation both in terms of assessment format and mathematical content. I feel urgency in addressing the settled[32] practices that pervade in assessment—which I became aware of through graduate work.

6.2.4 Perceived Action Possibilities

In this section, I discuss some cautionary notes to myself about the proposed assessment practice above. Through reflection, I hope to at least identify some unintended consequences of the assessment practice itself, as well as the philosophies that guide my thinking on it. Ehrenfeld and Hoffman (2013) in their discussion about finding solutions to the climate crisis, mentioned

---

[32] I use this term as did Dr. Marc Higgins in a talk he gave as a guest speaker in one of my courses, where he noted that the term indicates colonially situated phenomena as well as the notion of a firmly rooted ideal; in other words, something that has been settled on.

that current approaches to environmental stability are situated within the same social paradigm that caused them, and "as long as we operate according to its structure, we will continue to produce unintended consequences that threaten and overwhelm our desired outcomes" (p. 15). I discuss some of the ways in which this is also true for my own assessment practice in that, I have come to speculate about an alternative more ethically situated assessment practice, but there continues to be a risk that these solutions are grounded in the philosophical and social paradigms I am familiar with, and as such, I know that there will be unintended consequences that need to be contemplated.

Resisting the Urge to Suggest This Is a Solution. "It is tempting to search for simple solutions to complex problems and to offer simple responses to complex situations; that is what Western thought teaches us to do" (Doolittle, 2006, p.19)—including mathematics. Donald (Donald, 2020) notes that we live in a complex time where it is hard to know what is the right thing to do. He suggests that there needs to be a shift away from polarized perspectives and towards complex solutions to complex problems (rather than simple solutions). With this in mind, and knowing that I may be unconsciously seeking a simple solution, I ask myself: in what ways does the above speculative fiction suggest a simple solution?

The framework that I propose is presented as parts of a whole with the reflective questions being approached almost as a checklist. This, to me, indicates that I have not yet moved past western compulsions to categorise. The speculative fiction is meant to showcase the parts of a whole—a collection of contemplations around assessment that, when put together, create something that is more than the sum of its parts. I admit, I have not yet come to fully grasp such a holistic approach. I think there is value in organising my thinking around simple categories, but I must caution myself not to suppose my proposed assessment practice is

unwaveringly ‘good’ making my past assessment practice entirely ‘evil’. One of the ways in which I attempted to dwell in the complexity is to refrain from defining a set list of content outcomes and characteristics of assessment that must be measurably present. I wanted to embrace a certain level of ambiguity adding a third dimension, shared responsibility, almost as a failsafe to preventing me from falling back into my more comfortable habit of following a fragmented checklist. I remind myself, and suggest to the reader, that this is not a solution by any means, but instead a suggestion and thought experiment.

Remainders of Mastery. Relating to the idea of critical and decolonial mathematics and expectations of student success, suggested in the multiplicity dimension of this speculative fiction, is the notion of mastery. Here, I pause and draw from Singh’s (2018) work in decolonial thinking; one of the points Singh makes is that, in any pursuit to empower one group, there are always “*remainders* of mastery” (p. 30)—groups or peoples that become collateral damage of decolonial movements. She goes on to explain that, simply the act of empowering one group, further perpetuates the notion of hierarchical structures as an important organisational scheme. Singh is discussing decolonial efforts in terms of freeing human beings from oppressive practices—which may in fact be an apt analogy for the sorting mechanism that current mathematics assessment (and accountability measures) provide. In this case, I would caution myself to view this shift in assessment practice as a mode to empower those whose perspectives of what is mathematical and what it means to do mathematics are being denied. In other words, being aware of the remainders of moving towards valuing alternative mathematics and assessment as much as colonial mathematics and assessment because this approach will always yield some ‘other’ of mathematics and assessment that remains undervalued, silenced and/or oppressed.

My thought process is this: first, mathematics is a human endeavour (Aikenhead, 2017; Fowler, 2004; Lunney Borden et al., 2020); second, any human endeavour is rooted in the culture in which it is born, making it implicitly a culturally situated practice; thus, both mathematics and assessment are culturally situated practices. If these pluralities of mathematics and of assessment are organised into hierarchies of value, then we will continue to privilege particular mathematical content (including through assessment) and particular modes and mediums of interaction. At the same time, I must caution against destabilising the privileged practices, rather than attempting to bring more value to the underprivileged practices as a solution because this too suggests a sort of value hierarchy. Again, as in my discussion about resisting the urge to find a simple solution, I suggest that the shared responsibility is a key aspect in mitigating—but not preventing—this risk.

7 Concluding Thoughts and Further Research

Within this thesis I explored, within a speculative space, what I imagine for my future assessment practice, giving both a framework to guide practice and an example of an assessment task aligned with it. This research was a subjective exploration of ideological nature within a speculative space. Through the use of autoethnographic methods and DSMRI as a theoretical framework, I was able to delve, not only into what I perceive to be ideal, but into the influence of my own identities (personal and professional) on my idealism. Through discussion, I reflect and make cautionary notes, making sure not to presume this research suggests a simple solution to reconciling my relationship with mathematics assessment. The initial inquiry, framed within the context of dreaming first and negotiating later, was to respond to the question: If assessment is to be a continuous and dynamic process and practice of sitting beside one-another and *co-creating* evidence of learning mathematics in a way that contributes positively to the strength, wellness, value and worth *of the student*, the students learning, and the discipline of mathematics, then *what might I come to know about my future assessment practice?* I leave it as a rather ambiguous response, as it merely suggests a future assessment practice, and not how I might negotiate current barriers so as to implement it. Indeed, "we must first dream and think differently ideologically, even if it seems abstract or against the grain, before we can act upon our ideas and seek to implement alternative visions for the future" (Eizadirad, 2019, p. 203).

7.1 Review of Methodology

In this thesis, I used a combination of speculative fiction and autoethnography as a woven methodology. These two methodologies overlap in many ways; both aim to critically interrogate current normative practices, both set the research within an intimate space of subjectivity and ambiguity, and both scaffold the inquiry around the researcher’s perception of reality. As such,

this research was aimed at challenging my current realities—as they were when I began the research—and enabled me to linger in a recursive process of suggestion-reflection. I first explored texts I had written in the past as part of graduate studies and, through reflection, produced a new suggestive narrative, which I then, again, reflectively explored and contemplated. This recursive process leaves the research only temporarily concluded, as I could very well continue the cycle in the future and produce, from this text, a new speculative future.

There are also distinctive differences in the two methodologies. Where speculative fiction situates the narrative in the future by suggesting slight alterations to current practice, autoethnography affords a reflective narrative. Using the two together, I was able to critically reflect on what I suggested as an alternative future for my assessment practice. Where speculative fiction enables an almost limitless exploration of the future, autoethnography situates the exploration within the limits of my current role identity. In this sense, by integrating both methodologies together, I was able to explore the promise of a future assessment practice not limited by current barriers I faced, while structuring the inquiry within a space of reasonable possibility.

The use of the two methodologies engendered the unique opportunity for two styles of writing: reflective writing and suggestive narrative. I began with a reflective discussion about the past context that brought me to the research, from which I contemplated the near past of my beliefs about assessment as well as my present understanding of the research around the topic of assessment. As a result, a narrative situated in the extended future emerged, which led to a discussion around near future action. This temporal variation in the writing showcased a full-spectrum of thinking as my contemplations, as a practitioner and researcher, exist both in reflection, present contemplation and future imagination.

7.2 Review of Theoretical Framework

How I perceive my past experiences, and how I imagine my future experiences to be are implicitly part of my identity as an educator. Even more, they are deeply influenced and interwoven with my ever-fluctuating role identities as educator, practitioner, researcher, family member, guardian and the like. As such, it seemed appropriate that this self-study around assessment be analysed through the lens of role identity—namely, the Dynamic Systems Model for Role Identity (Kaplan & Garner, 2017). Recall that this model for understanding the complex system that defines role identity was organised in terms of four pillars: self-perceptions and self-definitions, ontological and epistemological beliefs, purpose, and perceived action possibilities. Characterising the nature of these four pillars in terms of my own role identities enables both a situating of the research in the multiple presents that occurred throughout the research, as well as a deeper understanding and analysis of what emerged as a result of this research.

The theoretical framework not only enabled a deep exploration of my assessment practice (past, present and future), but situated the inquiry of what I imagine for my future assessment practice in mathematics. There were elements of my ontological and epistemological beliefs about assessment that were in conflict with my self-perception and self-definitions. This, in turn, dampened my sense of purpose and impeded my action possibilities in my assessment practice. For example, my confidence in my own beliefs stopped me from taking my own ideas seriously, and trying alternative modes of assessment. Similarly, a sensed obligation to political factors including the program of studies and accountability measures, eclipsed my longing to change my assessment practice, and thus, altered what I perceived to be possible in my future action possibilities. What the speculative fiction afforded, is a renegotiation of these threats to my

action possibilities, and an opportunity to lessen the tensions between what I perceived ought to be, and what I perceived as possible.

Finally, this research enabled a healing of the self-as-educator. I was stuck in a mindset of novice teacher with dampened confidence. Through a processing of what was my current context (chapter 1), an exploration of current literature (chapter 2), an exploration of what assessment practice I imagined to be ideal (chapter 5), and a critical discussion of it through the lens of my role identity (chapter 6), I was able to develop a stronger sense of self-as-expert. I developed the perception that my ontological and epistemological beliefs were of value on the micro scale (my students and my school), and the macro scale (contributions to the discussion around assessment in mathematics). This further supported the use of DSMRI as a theoretical framework and its connection to the woven methodology discussed above.

7.3 Review of the Results of the Research

In this research project, I explored some suggestions for my future assessment practice, first, starting with a speculation about characteristics of assessment practice, and second, giving an example of an assessment task aligned with this characterised assessment practice. Through the research, I found that three major themes reoccurred in my thinking about assessment throughout the graduate program which I used to characterise what I might attend to in my assessment practice. These three themes were: holism, multiplicity and shared responsibility. A holistic assessment practice was conceptualised as one that attends to the multiple dimensions of self—beyond the cognitive that I tended to focus on in the past. This dimension was about situating assessment within a context of flourishing, being well with ourselves, others and our environment, and developing particular virtues. The second theme, multiplicity, characterised an assessment practice that valued a plurality of ways of doing and knowing mathematics including

the inclusion of multiple modes and mediums through which to engage in mathematics and mathematics assessment. Finally, the third them of shared responsibility, emerged as a result of the first two themes, and described an assessment practice where the roles of students, teacher and parents are more balanced, and where unexpected or emergent demonstrations of mathematics are welcomed, pursued and seen as opportunities to gain an understanding of student learning.

As a result of the three themes, I found myself re-thinking how I might plan for assessment tasks. I found that by planning from a lived context, rather than a mathematical concept, I might better be able to situate my assessment tasks within a holistic, pluralistic and shared environment for communication and interaction. With this in mind, I provided the example of riding a bus—an experience I am deeply familiar with—and created a fictional narrative and dialogue around how I might plan for such an assessment task, and how it might play out in a classroom setting. This example suggests that it is more a shift in focus of an assessment task, rather than a recreation of assessment tasks, is necessary. That is to say that teachers' current assessment tasks might only need to be tweaked in order to align with the assessment practice proposed in this research.

7.4 Contribution of the Research

I discussed the contribution of the research to my personal development in the previous sub-section. Now, I would like to discuss the contribution of this research to the field of mathematics education. Research in critical (mathematics) education involves re-envisioning the roles of teachers and students in a way where both are learners and teachers (Nicol, 2018). Critical pedagogies attend to students' lived experiences and enable students to draw meaningful connections between mathematics and their lives (Nicol, 2018). Asking what is and what ought

to be in a way that enables students and teachers to use mathematics as a way of reading and transforming the world (Nicol, 2018) is an important area of exploration; thus, this research contributes to these discussions as an example of my own contemplations as a practitioner around what ought to be in mathematics assessment. This thesis served as professional development for myself aligned with this critical education lens, and provides an exemplar of how other practitioners might approach their own professional development.

This research contributes to the field beyond providing an exemplar, as well. The checklist and planning guide for assessment produced as part of the speculative fictions provides a starting place for other practitioners to evaluate and plan for their own assessment practice. It may act as a starting place for professional development that I may facilitate, or as an independently guided professional development for other teachers. Finally, this research may act as a starting place for researchers who investigate the experiences of classroom teachers in a sense that it showcases evidence of conflict between current practice and longed-for practice. Conflict within the elements of teacher identity, and its effect on teachers' practice, is well documented (Day et al., 2006; Hong et al., 2018; Pelini, 2017; Zembylas, 2004), thus there is opportunity for research into how one might facilitate professional development that enables an exploration of longed for practice through the healing of these conflicting elements of identity.

7.5 Suggestions for Future Research

This research was a personal reflection guided by principles of dreaming first and negotiating later. This is a method of reflection that I have used as an approach to professional development for most of my career, and it interests me deeply to find out what other teachers in my field are dreaming about when it comes to assessment. I suggest that future research be taken to explore the experiences of other teachers in secondary mathematics education to see how they

characterise an ideal assessment practice. Perhaps that by hearing more stories about ideal assessment practices and the barriers that threaten these action possibilities, we might come to a suggestion for later professional development and future directions in mathematics assessment.

A second area of future research that is needed is targeted on the planning phase of assessment. There exists research in terms of mathematics instruction situated in student-chosen contexts. One example is the Show Me Your Math project (SMYM; Lunny Borden et al., 2020). Through this work students get to investigate something meaningful to them that places them in a position of expert, and which values other worldviews. Even more, students are finding their own mathematical truths using their own experiences, the knowledge they learn from the community, thus creating new emergent mathematical ideas. As well, there is a shift to valuing the connection and relationship between communities' mathematics and school mathematics, and the mathematics that emerges is valued as a central role rather than as an add-on to school math curriculum (Lunney Borden, et al., 2020). This is a wonderful example of making relationships a central role. Nonetheless, I do wonder what assessment might look like in this context. Would it address skills and competencies? Or perhaps it would focus on the mathematical content connections? Part of me even wonders whether it would be ethical to assess this sort of activity at all. On the other hand, the way in which I have framed assessment lends well to this type of work. The ethical dilemma would arise if I were to have a conversation about grading.

References

Ahern, N. R., Kiehl, E. M., Sole, M. L., & Byers, J. (2006). A review of instruments measuring resilience. *Issues in Comprehensive Pediatric Nursing, 29*(2), 103-125. doi: 10.1080/01460860600677643

Aikenhead, G. S. (2017). Enhancing school mathematics culturally: A path of reconciliation. *Canadian Journal of Science, Mathematics and Technology Education, 17*(2), 73-140. doi: 10.1080/14926156.2017.1308043

Aitken, N., Webber, C. F., Lupart, J., Scott, S., & Runté, R. (2011). Assessment in Alberta: Six areas of concern. *The Educational Forum, 75*(3), 192-209. doi: 10.1080/00131725.2011.576803

Alberta Assessment Consortium [AAC]. (2017). Key principles of assessment practice from the AAC perspective. https://aac.ab.ca/

Alberta Education. (2008a). Mathematics grades 10-12. https://education.alberta.ca/

Alberta Education. (2008b). Mathématiques 10e - 12e année. https://education.alberta.ca/

Alberta Education. (2016). *Mathematics Kindergarten to grade 9* (Program of Studies 2007). https://education.alberta.ca/

Alberta Education. (2017). Competencies and current programs of study: Mathematics. https://education.alberta.ca/

Alberta Education. (2018). Teaching quality standard. https://open.alberta.ca/dataset/4596e0e5-bcad-4e93-a1fb-dad8e2b800d6/resource/75e96af5-8fad-4807-b99a-f12e26d15d9f/download/edc-alberta-education-teaching-quality-standard-2018-01-17.pdf

Alberta Teachers' Association [ATA]. (2019). Problems in education series number 7: Teachers' rights and responsibilities and legal liabilities [Revised edition]. www.teachers.ab.ca

Andersson, C., & Palm, T. (2017). Characteristics of improved formative assessment practice. *Education Inquiry, 8*(2), 104-122. doi: 10.1080/20004508.2016.1275185

Aoki, T. A. (2011a). Competence in teaching as instrumental and practical action: A critical analysis (1984). In W. F. Pinar & R. L. Irwin (Eds.), *Curriculum in a new key* (pp. 125-135). Routledge. (Reprinted from *Competence: Inquiries into its meaning and acquisition in educational settings,* pp.71-79, by E. Short, Ed., 1984, University Press of America, Inc)

Aoki, T. A. (2011b). Curriculum implementation as instrumental action and as situational praxis (1983). In W. F. Pinar & R. L. Irwin (Eds.), *Curriculum in a new key* (pp. 111-123). Routledge. (Reprinted from *Understanding situational meanings of curriculum in-service acts: Implementing, consulting, inservicing. Curriculum praxis monograph series. Monograph 9*, pp. 3-17, by T. T. Aoki, T. R. Carson, & B. J. Favaro, Eds., 1983, Department of Secondary Education, Faculty of Education)

Aoki, T. A. (2011c). Toward curriculum in a new key (1978/1980). In W. F. Pinar & R. L. Irwin (Eds.), *Curriculum in a new key* (pp. 89-110). Routledge. (Reprinted from *Curriculum praxis occasional paper No.2*, by T. T. Aoki, 1980, Department of Secondary Education, Faculty of Education)

Ashforth, B. E. (2001). *Role transitions in organizational life: An identity-based perspective*. Routledge.

Beesley, A. D., Clark, T. F., Dempsey, K., & Tweed, A. (2018). Enhancing formative assessment practice and encouraging middle school mathematics engagement and persistence. *School Science and Mathematics, 118*(1-2), 4-16. doi: 10.1111/ssm.12255

Beijaard, D. (2019). Teacher learning as identity learning: Models, practices, and topics. *Teachers and Teaching, 25*(1), 1-6. https://doi.org/10.1080/13540602.2019.1542871

Beijaard, D., Meijer, P. C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. *Teaching and Teacher Education, 20*(2), 107-128. doi:10.1016/j.tate.2003.07.001

Bekerman Z., & Zembylas M. (2018). Identity. In *Psychologized language in education: Denaturalizing a regime of truth* (pp.57-66). Palgrave Macmillan. https://doi.org/10.1057/978-1-137-54937-2_7

Belmondo, J. [Jean Belmondo]. (2017, June 23). *Spoonful Of Sugar – Julie Andrews in Mary Poppins 1964* [Video]. YouTube. https://www.youtube.com/watch?v=_L4qauTiCY4

Ben-Hur, M. (2006). Assessment. In *Concept-rich mathematics instruction: Building strong foundations for reasoning and problem solving* (pp. 109-128). Association for Supervision and Curriculum Development.

Bennett, R. E., & Gitomer, D. H. (2009). Transforming K-12 assessment: Integrating accountability testing, formative assessment, and professional support. In C. Wyatt-Smith, & J. J. Cumming (Eds.), *Educational assessment in the 21st century*: *Connecting theory and practice* (pp. 43-61). Springer Publishing. https://doi.org/10.1007/978-1-4020-9964-9

Berry, J., & Nyman, M. A. (2002). Small-group assessment methods in mathematics. *International Journal of Mathematical Education in Science and Technology, 33*(5), 641-649. doi: 10.1080/00207390210144034

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M. M-R., & Rumble, M. (2012). Defining twenty-first century skills. In P. Griffin, E. Care, & B. McGraw (Eds.),

Assessment and teaching of 21st century skills (pp.16-66). Springer Dordrecht Heidelberg. https://doi.org/10.1007/978-94-007-2324-5

Birenbaum M. (1996). Assessment 2000: Towards a pluralistic approach to assessment. In M. Birenbaum, & F. J. R. C. Dochy (Eds.), *Alternatives in assessment of achievements, learning processes and prior knowledge* (Vol 42, pp. 3-29). Springer Science+Business Media, LLC. https://doi.org/10.1007/978-94-011-0657-3

Bishop, A. J. (1988). The interactions of mathematics education with culture. *Cultural Dynamics, 1*(2), 145–157. https://doi.org/10.1177/092137408800100202

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability, 21*(1), 5–31. https://doi.org/10.1007/s11092-008-9068-5

Boaler, J. (2016). Assessment for a growth mindset. In K. Bradford (Ed.), *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching* (pp.141-169). Jossey-Bass A Wiley Brand.

Boylan, M., & Woolsey, I. (2015). Teacher education for social justice: Mapping identity spaces. *Teaching and Teacher Education, 46*, 62-71. https://doi.org/10.1016/j.tate.2014.10.007

Brooker, M. K., & Thomas, A-M. (2009). Science fiction in western culture. In *The science fiction handbook* (pp. 3-12). John Wiley & Sons, Incorporated. https://ebookcentral.proquest.com

Brown, M., Brown, P., & Bibby, T. (2008). "I would rather die": Reasons given by 16-year-olds for not continuing their study of mathematics. *Research in Mathematics Education, 10*(1), 3-18. https://doi.org/10.1080/14794800801915814

Buchanan, R. (2015). Teacher identity and agency in an era of accountability. *Teachers and Teaching, 21*(6), 700-719. https://doi.org/10.1080/13540602.2015.1044329

Burkhardt, H., & Schoenfeld, A. (2018). Assessment in the service of learning: Challenges and opportunities or Plus ça change, plus c'est la même chose. *ZDM*, *50*(4), 571-585. https://doi.org/10.1007/s11858-018-0937-1

Cambridge University Press. (n.d.a). Methodical. In *Cambridge English Dictionary.* Cambridge University Press. Retreived August 11, 2021, from https://dictionary.cambridge.org/dictionary/english/methodical

Cambridge University Press. (n.d.b). Rigour. In *Cambridge English Dictionary.* Cambridge University Press. Retreived August 11, 2021, from https://dictionary.cambridge.org/dictionary/english/rigour

Cambridge University Press. (n.d.c). Tradition. In *Cambridge English Dictionary.* Cambridge University Press. Retreived August 11, 2021, from https://dictionary.cambridge.org/dictionary/english/tradition

Carlson, D. (2006). Proposing a care of the self in secondary English studies: A critical ontology of ourselves. In J. Milam, S. Springgay, K. Sloan, & B. S. Carpenter II (Eds.), *Curriculum for a progressive, provocative, poetic + public pedagogy.* Educator's International Press, Inc.

Cho, K. D. (2009). On the ego and other strategies of resistance. In *Psychopedagogy: Freud, Lacan, and the psychoanalytic theory of education* (pp. 27-44). Palgrave Macmillan. https://doi.org/10.1057/9780230622210

Chronaki, A., & Kollosche, D. (2019). Refusing mathematics: A discourse theory approach on the politics of identity work. *ZDM, 51*(3), 457-468. https://doi.org/10.1007/s11858-019-01028-w

Clarke, M. (2009). The ethico-politics of teacher identity. *Educational Philosophy and Theory, 41*(2), 185-200. https://doi.org/10.1111/j.1469-5812.2008.00420.x

Collins. (n.d.a). Rigour. In *Collins English Dictionary [online reference].* Collins. Retrieved August 11, 2021, from https://www.collinsdictionary.com/dictionary/english/rigour

Collins. (n.d.b). Rigorous. In *Collins English Dictionary [online reference].* Collins. Retrieved August 11, 2021, from https://www.collinsdictionary.com/dictionary/english/rigorous

Connolly, M., Hadfield, M., Barnes, Y., & Snook, J. (2018). The accommodation of contested identities: The impact of participation in a practice-based masters programme on beginning teachers' professional identity and sense of agency. *Teaching and Teacher Education, 71*, 241-250. https://doi.org/10.1016/j.tate.2018.01.010

Cornett, J. D. (1982). A review of the options: Alternatives to paper-and-pencil testing. *National Association of Secondary School Principals Bulletin*, *66*(467), 44-46. https://journals.sagepub.com/toc/buld/66/457

Corrêa, P. D. (2018). Observing for mathematical proficiency in secondary mathematics education. In A. K. Kajander, J. Holm, & E. J. Chernoff (Eds.), *Teaching and learning secondary school mathematics: Canadian perspectives in an international context* (pp. 453-464). Springer International Publishing. https://doi.org/10.1007/978-3-319-92390-1

Creswell, J. W. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th ed.). Boston, MA: Pearson Education Inc.

Cross Francis D., Hong J., Liu J., & Eker A. (2018). "I'm not just a math teacher": Understanding the development of elementary teachers' mathematics teacher identity. In P. Schutz, J. Hong, & D. Cross Francis (Eds.), *Research on Teacher Identity* (pp.133-143). Springer International Publishing, AG. https://doi.org/10.1007/978-3-319-93836-3_12

Cumming J. J., & Wyatt-Smith, C. (2009). Framing assessment today for the future: Issues and challenges. In C. Wyatt-Smith, & J. J. Cumming (Eds.), *Educational assessment in the 21st century*: *Connecting theory and practice* (pp. 1-15). Springer Publishing. Retrieved from https://doi.org/10.1007/978-1-4020-9964-9

Cuoco, A., Goldenberg, E. P., & Mark, J. (1996). Habits of mind: An organizing principle for mathematics curricula. *Journal of Mathematical Behavior, 15*(4), 375–402. https://doi.org/10.1016/S0732-3123(96)90023-1

Curtis, B., & Curtis, C. (2017). Autoethnographic research - Writing and reading the self. In *Social research: A practical introduction* (pp. 263-284). SAGE Publications Inc. https://doi.org/10.4135/9781526435415

Darragh, L. (2016). Identity research in mathematics education. *Educational Studies in Mathematics, 93*(1), 19-33. https://doi-org/10.1007/s10649-016-9696-5

Darroch-Lozowski, V. (2019). Experiencing nets of holism through the threshold body. In J. P. Miller, K. Nigh, M. J. Binder, B. Novak, & S. Crowell (Eds.), *International handbook of holistic education* (pp. 17-24). Routledge. https://doi.org/10.4324/9781315112398

Day, C., Kington, A., Stobart, G., & Sammons, P. (2006). The personal and professional selves of teachers: Stable and unstable identities. *British Educational Research Journal, 32*(4), 601-616. https://doi.org/10.1080/01411920600775316

de Freitas, E. (2008). Mathematics and its other: (Dis)locating the feminine. *Gender and Education, 20*(3), 281-290. https://doi.org/10.1080/09540250801964189

de Freitas, E., & Paton, J. (2009). (De)facing the self: Poststructural disruptions of the autoethnographic text. *Qualitative Inquiry, 15*(3), 483-498. https://doi.org/10.1177/1077800408318419

Donald, D. (2020, January 28). *Dwayne Donald - Homo economus and forgetful curriculum: Remembering other ways to be a human being* [Recorded Presentation]. https://www.youtube.com/watch?v=VM1J3evcEyQ&feature=youtu.be

Doolittle, E. (2006). Mathematics as medicine. In P. Liljedahl (Ed.), *Proceedings of the Canadian Mathematics Education Study Group* (pp. 17-25). y CMESG/GCEDM. http://www.cmesg.org/past-proceedings/

Duncan, C. R., & Noonan, B. (2007). Factors affecting teachers' grading and assessment practices. *The Alberta Journal of Educational Research, 53*(1), 1-21. https://journalhosting.ucalgary.ca/index.php/ajer/article/view/55195

Edmonton Catholic Schools. (2000). Administrative procedure 360: Assessment [pdf document]. Retrieved from https://www.ecsd.net/ParentsStudents/ParentResources/ProfessionalLearning/Pages/Assessment.aspx

Edmonton Catholic Schools. (2019, September). District plan for continuous growth 2019-2022. https://sbecsdstor.blob.core.windows.net/docs/3395545a-5cf8-4239-a007-78aaa190fd3f_District%20Plan%20for%20Continuous%20Growth%202019-2022.pdf

Edmonton Public Schools. (2014, August 18). Administrative Regulation: Standards for evaluation. https://epsb.ca/ourdistrict/policy/g/gkb-ar/

Edmonton Public Schools. (2018a). District Strategic Plan 2018-2022. https://epsb.ca/media/epsb/ourdistrict/visionmissionvalues/district-strategic-plan-2018-2022.pdf

Edmonton Public Schools. (2018b, November 30th). Three year education plan (3YEP) 2018-2021. https://epsb.ca/media/epsb/ourdistrict/results/annualeducationresults/AERR-3YEP-2017-18.pdf

Edwards, F. C. E., & Edwards, R. J. (2017). A story of culture and teaching: The complexity of teacher identity formation. *The Curriculum Journal, 28*(2), 190-121. http://dx.doi.org/10.1080/09585176.2016.1232200

Ehrenfeld, J. R., & Hoffman, A. J. (2013). Introduction. In *Flourishing: A frank conversation about sustainability* (pp. 1-11). University Press.

Eizadirad, A. (2019). Decolonizing educational assessment models. In *Decolonizing educational assessment: Ontario elementary students and the EQAO* (pp. 203-228). Palgrave Macmillan. https://doi.org/10.1007/978-3-030-27462-7

Elharrar, Y. (2006). Teacher assessment practices and perceptions: The use of alternative assessments within the Quebec education reform [Doctoral Dissertation, Université du Québec à Montréal]. UQÀM Dépot Institutionel. https://archipel.uqam.ca/9490/

Ellis, C. S. (2012). Autoethnography. In L. M. Given (Ed.), *The SAGE encyclopedia of qualitative research methods (Vols. 1-0)*. SAGE Publications. https://doi.org/10.4135/9781412963909

Féraud, J-F. (1994). Évaluation. In *Dictionaire critique de la langue française : (1787)*. De Gruyter

Fowler, K. K. (2004). Mathematics culture. In *Using the mathematics literature* (pp. 1-16). CRC Press.

Frey, B. (2014). Formative assessment. In *Modern classroom assessment* (pp. 59-90). SAGE Publications, Ltd. https://doi.org/10.4135/9781506374536.n4

Friesen, S., & Jardine, D. (2009, October). 21st century learning and learners. Commissioned Report prepared for Western and Northern Canadian Curriculum Protocol by Galileo Educational Network, Calgary, AB. https://www.academia.edu/7925594/21st_Century_Learners_and_Learning_A_report_prepared_for_the_Western_and_Northern_Canadian_Curriculum_Protocol_for_Collaboration_in_Education

Garner, J. K., & Kaplan, A. (2019) A complex dynamic systems perspective on teacher learning and identity formation: An instrumental case. *Teachers and Teaching, 25*(1), 7-33. https://doi.org/10.1080/13540602.2018.1533811

Gerofsky, S. (2011). Ancestral genres of mathematical graphs. *For the Learning of Mathematics, 31*(1), 14-19. https://www-jstor-org.login.ezproxy.library.ualberta.ca/stable/41319546

Gipps, C., & Stobart, G. (2009). Fairness in assessment. In C. Wyatt-Smith, & J.J. Cumming (Eds.), *Educational assessment in the 21st century* (pp. 105-118). Springer Science+Business Media. https://doi.org/10.1007/978-1-4020-9964-9 11

Glanfield, F., Sterenberg, G., & Donald, D. (2020). Understanding the landscape of culturally responsive education within a community-driven mathematics education research project. In C. Nicol, J. Archibald, F. Glanfield & A.J. Dawson (Eds.), *Living culturally responsive mathematics education with/in Indigenous communities* (pp. 71-90). Brill Sense

Graue, M. E., & Smith, S. Z. (1996). Parents and mathematics education reform: Voicing the authority of assessment. *Urban Education, 30*(4), 395-421. https://doi.org/10.1177/0042085996030004003

Griffin, P., & Care, E. (2015). *Assessment and teaching of 21st century skills: Methods and approach.* Science+Business Media. *https://*doi.org/10.1007/978-94-017-9395-7

Griffin, P., Care, E., & McGaw, B. (2012). The changing role of education and schools. In P. Griffin, B. McGraw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 16-66). Dordrecht, Netherlands: Springer Science+Business Media. https://doi.org/10.1007/978-94-007-2324-5

Grootenboer, P. (2013). The praxis of mathematics teaching: Developing mathematical identities. *Pedagogy, Culture & Society, 21*(2), 321-342. https://doi.org/10.1080/14681366.2012.759131

Haraway, D. (2016). *Staying with the trouble*. Duke University Press. https://doi.org/10.1215/9780822373780

Hargreaves, A., & Earl, L. (2002). Perspectives on alternative assessment reform. *American Educational Research Journal, 39*(1), 69-95. https://doi.org/10.3102/00028312039001069

Harper, D. (n.d.a). Assess. In *Online Etymology Dictionary*. https://www.etymonline.com/

Harper, D. (n.d.b). Rigor. In *Online Etymology Dictionary*. https://www.etymonline.com/

Hart. T. (2019). Beauty and learning. In J. P. Miller, K. Nigh, M. J. Binder, B. Novak, & S. Crowell (Eds.), *International handbook of holistic education* (pp. 25-32). Routledge. https://doi.org/10.4324/9781315112398

Headspace Inc.. (2021). Headspace (Version 3.176.0) [Mobile app]. Google Play Store. https://headspace.app.link/bylphAMin7

Heffernan, K., Kaplan, A., Peterson, S., & Newton, J. N. (2017). Integrating identity formation and subject matter learning: Math concepts as tools and identity exploration. In E. Lyle (Ed.), *At the intersection of selves and subject* (pp. 53-61). Sense Publishers.

Heritage, M. (2010). Assessment with and for students. In *Formative assessment: Making it happen in the classroom* (pp. 7-20). Corwin Press. https://doi.org/10.4135/9781452219493.n2

Hesse, F., Care, E., Buder, J., Sassenberg, K., & Griffin, P. (2015). A framework for teachable collaborative problem solving skills. In P. Griffin, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp.37-56). https://doi.org/10.1007/978-94-017-9395-7

Hoad, T. F. (Ed.). (2003). Assess. In *The Concise Oxford Dictionary of Etymology.* Oxford University Press. https://www.oxfordreference.com/view/10.1093/acref/9780192830982.001.0001/acref-9780192830982-e-895

Holm, J. (2018). Planning a unit by starting with the end in mind: Unit and lesson planning. In A. K. Kajander, J. Holm, & E. J. Chernoff (Eds.), *Teaching and learning secondary school mathematics: Canadian perspectives in an international context* (pp. 441-452). Springer International Publishing. https://doi.org/10.1007/978-3-319-92390-1

Hong J., Cross Francis D., & Schutz P. A. (2018). Research on teacher identity: Common themes, implications, and future directions. In P. Schutz, J. Hong, & D. Cross Francis (Eds.), *Research on teacher identity* (pp. 243-251). Springer Nature. https://doi.org/10.1007/978-3-319-93836-3_21

Horn (2012). *Strength in numbers: Collaborative learning in secondary mathematics*. National Council of Teacher of Mathematics.

Huang, J., Wang, Y., & Teng, F. (2019). Understanding changes in teacher beliefs and identity formation: A case study of three novice teachers in Hong Kong. *Teaching Education, 32*(2), 193-207. https//doi.org/10.1080/10476210.2019.1693535

Hughes, S. A., & Pennington, J. L. (2018a). Autoethnography: Introduction and overview. In *Autoethnography: Process, product, and possibility for critical social research* (pp. 4-33). Sage Publications, Inc. https://dx.doi.org/10.4135/9781483398594

Hughes, S. A., & Pennington, J. L. (2018b). Second guiding process: Legitimizing autoethnography with three approaches. In *Autoethnography: Process, product, and possibility for critical social research* (pp. 88-109). SAGE Publications, Inc. https://dx.doi.org/10.4135/9781483398594

Hunter, R., Hunter, J., & Bills, T. (2020). Enacting culturally responsive or socially response-able mathematics education. In C. Nicol, J. Archibald, F. Glanfield, & A.J. Dawson (Eds.), *Living culturally responsive mathematics education with/in Indigenous communities* (pp. 137-154). Brill Sense.

Jardine, D. W. (1992). The fecundity of the individual case: Considerations of the pedagogic heart of interpretive work. *Journal of Philosophy of Education*, *26*(1), 51-61. https://doi.org/10.1111/j.1467-9752.1992.tb00264.x

Jardine, D. (1996). "Under the tough old stars": Meditations on pedagogical hyperactivity and the mood of environmental education. *Canadian Journal of Environmental Education 1*(1), 47-55. https://cjee.lakeheadu.ca/article/view/492

Jardine, D. W. (2008). Translating water. *Journal of Curriculum Theorizing, 24*(1), 11-19. https://journal.jctonline.org/index.php/jct/article/view/JARTRA

Jardine, D. (2012). "Figures in hell". In *Pedagogy left in peace* (pp. 133-144). Information Age Publishing. https://doi.org/10.5040/9781472541239

Jorgensen, D. (2009). Postmodernism. In M. Bould, A. M. Butler, A. Roberts, & S. Vint (Eds.), *The Routledge companion to science fiction* (pp. 256-266). Routledge. https://doi.org/10.4324/9780203871317

Joseph, G. G. (2011). The crest of the peacock: Non-European roots of mathematics (3rd Edition). Princeton University Press.

Kaplan, A., & Garner, J. K. (2017). A complex dynamic systems perspective on identity and its development: The dynamic systems model of role identity. *Developmental Psychology, 53*(11), 2036-2051. https://doi.org/10.1037/dev0000339

Kaplan, A., & Garner, J. K. (2018). Teacher identity and motivation: The dynamic systems model of role identity. In P. Schutz, D. Cross Francis, & J. Hong (Eds.), *Research in teacher identity: Mapping challenges and innovations* (pp. 71–82). Springer International Publishing. https://doi.org/10.1007/978-3-319-93836-3

Khan, S. K., & Armstrong, A. (2019). Mathematics a place of loving kindness and (Editorial). *Journal of the Canadian Association of Curriculum Studies, 17*(1), 1-12. https://jcacs.journals.yorku.ca/index.php/jcacs/article/view/40441/36419

Khan, S., & La France, S. (April 5-9, 2019). *Curating Math I/identities* [Poster presentation]. American Educational Research Association (AERA) Annual Conference, Toronto, ON. https://tinyurl.com/yxwrlg54

Khan, S., La France, S., May, A. (2019, October 3). *Curating intersectional I/identities after gender: Towards more human(e) genres in mathematics teacher education, research, and practice* [Conference presentation]. Conference of Research at the Intersections of Gender (RIG) 1st Annual Conference, Edmonton, AB.

KIASualberta. (2014, June 27). *Donna Haraway - SF: String figures, multispecies muddles, staying with the trouble* [Video]. YouTube. https://www.youtube.com/watch?v=Z1uTVnhIHS8

Kilpatrick, J., Swafford, J., & Findell, B. (2001). The strands of mathematical proficiency. In J. Kilpatrick, J. Swafford, & B. Findell (Eds.), *Adding it up: Helping children learn mathematics* (pp. 115–155). National Academy Press. https://doi.org/10.17226/9822.

Klein, E. (Ed.). (1971). Assess. In *A Comprehensive Etymological Dictionary of the English Language : Dealing with the Origin of Words and Their Sense Development Thus Illustrating the History of Civilization and Culture*. Elsevier Pub. Co.

Kollosche, D. (2018). Social functions of mathematics education: A framework for socio-political studies. *Educational Studies in Mathematics, 98*(3), 287-303. https://doi.org/10.1007/s10649-018-9818-3

Kooken, J., Welsh, M. E., McCoach, D. B., Johnston-Wilder, S., & Lee, C. (2016). Development and validation of the mathematical resilience scale. *Measurement and Evaluation in Counseling and Development*, *49*(3), 217-242. https://doi.org/10.1177/0748175615596782

Kress, G. (2009). Assessment in the perspective of a social semiotic theory of multimodal teaching and learning. In C. Wyatt-Smith, & J. J. Cumming (Eds.), *Educational*

assessment in the 21st century: *Connecting theory and practice* (pp. 19-41). Springer Publishing. https://doi.org/10.1007/978-1-4020-9964-9

Langer-Osuna, J. M., & Esmonde, I. (2017). Identity in research on mathematics education. In C. Jinfa (Ed.), *Compendium for research in mathematics education* (pp. 637-648). The National Council of Teachers of Mathematics, Inc.

Larousse. (n.d.). Évaluer. *Larousse Dictionaire de Français.* Larousse. Retrieved August 11, 2021, from https://www.larousse.fr/dictionnaires/francais

Learn Alberta (2008, October 1). Mathematics: Assessment in Mathematics. http://www.learnalberta.ca/

Le Roux, C. S. (2017). Exploring rigour in autoethnographic research. *International Journal of Social Research Methodology, 20*(2), 195-207. https:/doi.org/10.1080/13645579.2016.1140965

Lewis, A. E., & Diamond, J. B. (2015). *Despite the best intentions: How racial inequality thrives in good schools.* Oxford University Press.

Liljedahl, P. (2016). Building thinking classrooms: Conditions for problem solving. In P. Felmer, J. Kilpatrick, & E. Pekhonen (Eds.), *Posing and solving mathematical problems: Advances and new perspectives* (pp. 23-36). Springer International Publishing. https://doi.org/10.1007/978-3-319-28023-3

Little Bear, L. (2000). Jagged worldviews colliding. In M. Battiste (Ed.), *Reclaiming Indigenous voice and vision* (pp. 77-85). UBC Press. https://www.deslibris.ca/ID/404356

Lunney Borden, L., Wagner, D., & Johnston, N. (2020). Show me your math. In C. Nicol, J. Archibald, F. Glanfield, & A.J. Dawson (Eds.), *Living culturally responsive mathematics education with/in Indigenous communities* (pp. 91-112). Brill Sense.

Lutovac, S., & Kaasila, R. (2018). Future directions in research on mathematics-related teacher identity. *International Journal of Science and Mathematics Education, 16*(4), 759-776. https://doi.org/10.1007/s10763-017-9796-4

Maclellan, E. (2004). How convincing is alternative assessment for use in higher education?. *Assessment & Evaluation in Higher Education, 29*(3), 311-321. https://doi.org/10.1080/0260293042000188267

Mason, J. (2002). *Researching your own practice: The discipline of noticing*. RoutledgeFalmer. https://doi.org/10.4324/9780203471876

Matters, G. (2009). A problematic leap in the use of test data: From performance to inference. In C. Wyatt-Smith, & J. J. Cumming (Eds.), *Educational assessment in the 21st century: Connecting theory and practice* (pp. 209-225). Springer Science+Business Media. https://doi.org/10.1007/978-1-4020-9964-9

McMillan, J. H. (2003). Understanding and improving teachers' classroom assessment decision making: Implications for theory and practice. *Educational Measurement: Issues and Practice, 22*(4), 34-43. https://doi.org/10.1111/j.1745-3992.2003.tb00142.x

Mentis, M., Holley-Boen, W., Butler, P., Kearney, A., Budd, J., Riley, T., MacArthur, J., Dharan, V., & Bevan-Brown, J. (2016). Mawhai: Webbing a professional identity through networked interprofessional communities of practice. *Teaching and Teacher Education, 60*, 66-75. https://doi.org/10.1016/j.tate.2016.08.008

Moon, J. A. (2004). Assessment issues. In *A handbook of reflective and experiential learning: Theory and practice* (pp. 149-157). RoutledgeFalmer. https://doi.org/10.4324/9780203416150

Morgan, C. (1999). Assessment in mathematics education: A critical social research perspective. In J. Portela (Ed.), Actas do IX Seminário de Investigação em Educação Matemática (pp. 5-23). Associação de Professores de Matemática. https://www.academia.edu/443152/Assessment_in_mathematics_education_A_critical_social_research_perspective

Nakagawa, Y. (2019). Eastern philosophy and holistic education. In J. P. Miller, K. Nigh, M. J. Binder, B. Novak, & S. Crowell (Eds.), *International handbook of holistic education* (pp. 42-50). Routledge. https://doi.org/10.4324/9781315112398

National Academies of Sciences, Engineering, and Medicine [NASEM]. (2018). *How people learn II: Learners, contexts, and cultures.* The National Academies Press. https://doi.org/10.17226/24783

Nicol, C. (2018). Connecting mathematics, community, culture and place: Promise, possibilities and problems. In G. Kaiser, H. Forgasz, M. Graven, A. Kuzniak, E. Simmt, & B. Xu (Eds.), *Invited lectures from the 13th international congress on mathematical education* (423-440). Springer International Publishing Inc. https://doi.org/10.1007/978-3-319-72170-5

Oxford University Press. (n.d.a). Evaluation. In *The Oxford English Dictionary [Online reference]*. Retreived August 11, 2021, from www.oed.com/view/Entry/65182

Oxford University Press. (n.d.b). Rigour. In *The Oxford English Dictionary [Online reference]*. Retreived August 11, 2021, from www.oed.com/view/Entry/165946

Oxford University Press. (n.d.c). Rigorous. In *The Oxford English Dictionary [Online reference]*. Retreived August 11, 2021, from www.oed.com/view/Entry/165942

Oxford University Press. (n.d.d). Traditional. In *The Oxford English Dictionary [Online reference]*. Retreived August 11, 2021, from www.oed.com/view/Entry/204304

Oziewicz, M. (2017). Speculative fiction. In *The Oxford research encyclopedia.* Oxford University Press. https://doi.org/10.1093/acrefore/9780190201098.013.78

Pai, J. (2018). Observations and conversations as assessment in secondary mathematics. In D. R. Thompson, M. Burton, A. Cusi, & D. Wright (Eds.), *Classroom assessment in mathematics: Perspectives from around the globe* (pp. 25-42). Springer International Publishing. https://doi.org/10.1007/978-3-319-73748-5

Passell, A. (2013). SF Novels and sociological experimentation: Examining real world dynamics through imaginative displacement. In P. L. Thomas (Ed.), *Science fiction and speculative fiction: Challenging genres* (pp. 59-72). SensePublishers. https://doi.org/10.1007/978-94-6209-380-5

Patell, C. R. K. (2015). Speculative fiction. In *Cosmopolitanism and the literary imagination* (pp. 87-110). NY, New York: Palgrave Macmillan. https://doi.org/10.1057/9781137107770

Paterson, J., & Sneddon, J. (2011). Conversations about curriculum change: Mathematical thinking and team-based learning in a discrete mathematics course. *International Journal of Mathematical Education in Science and Technology*, *42*(7), 879-889. https://doi.org/10.1080/0020739X.2011.613487

Pelini, E. S. (2017). Analysing the socio-psychological construction of identity among pre-service teachers. *Journal of Education for Teaching, 43*(1), 61-71. https://doi.org/10.1080/02607476.2017.1251095

Pinxten, R. (2016). Education in a post-industrial world. In: *Multymathemacy: Anthropology and mathematics education* (*pp.21-28)*. https://doi.org/10.1007/978-3-319-26255-0_3

Pyper, J. S. (2018). Mathematical mindsets for teaching and learning of mathematics. In A. Kajander, J. Holm, & E. J. Chernoff (Eds.), *Teaching and learning secondary school mathematics: Canadian perspectives in an international context* (pp. 165 - 177). Springer International Publishing Inc. Retrieved from https://doi.org/10.1007/978-3-319-92390-1

Rapke, T., Hall, J., & Marynowski, R. (2018). Re-framing testing to better fit within problem-solving classrooms: Ways to create and review tests. In A. K. Kajander, J. Holm, & E. J. Chernoff (Eds.), *Teaching and learning secondary school mathematics: Canadian perspectives in an international context* (pp. 465-471). Springer International Publishing. https://doi.org/10.1007/978-3-319-92390-1

Reeves, J. (2018). Teacher identity work in neoliberal schooling spaces. *Teaching and Teacher Education, 72,* 98-106. https://doi.org/10.1016/j.tate.2018.03.002

Reid, M. (2009). Postcolonialism. In M. Bould, A. M. Butler, A. Roberts, & S. Vint (Eds.), *The Routledge companion to science fiction* (pp. 256-266). Routledge. https://doi.org/10.4324/9780203871317

Richards, M. (2015). Turning back to the story of my life: An autoethnographic exploration of a researcher's identity during the PhD process. *Reflective Practice, 16*(6), 821-835. https://doi.org/10.1080/14623943.2015.1095731

Richardson, L. (2000). Evaluating ethnography: Assessing alternative modes of qualitative and ethnographic research: How do we judge? Who judges?. *Qualitative Inquiry*, *6*(2), 253–255. http://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=1567289

Roicki, J. (2016, December 24). Digging deeper into student thinking [Blog post]. *Math musings.* https://mathmusingsblog.wordpress.com/

Ruohotie-Lyhty, M., & Moate, J. (2016). Who and how? Preservice teachers as active agents developing professional identities. *Teaching and Teacher Education, 55*, 318-327. https://doi.org/10.1016/j.tate.2016.01.022

Ruthven, K. (1994). Better judgment: Rethinking assessment in mathematics education. *Educational Studies in Mathematics, 27*(4), 433-450. https://doi.org/10.1007/BF01273382

Schaefer, L., & Clandinin, D. J. (2019). Sustaining teachers' stories to live by: Implications for teacher education. *Teachers and Teaching, 25*(1), 54-68. https://doi.org/10.1080/13540602.2018.1532407

Schraw, G. J., & Olafson, L. J. (2008). Assessing teachers' epistemological and ontological worldviews. In M. S. Khine (Ed.), *Knowing, knowledge and beliefs: Epistemological studies across diverse cultures* (pp. 25-44). Springer. https://doi.org/10.1007/978-1-4020-6596-5

Schur, M. (Writer), & Schur, M. (Director). (January 19, 2017). Michael's gambit (1, 13) [Tv series episode]. In M. Schur, D. Miner, M. Sackett, & Goddard, D. (Executive Producers), *The good place*. Fremulon, 3 Arts Entertainment, Universal Television.

Seligman. M. P. (2011). *Flourish: A visionary new understanding of happiness and well-being*. Simon & Schuster.

Simmt, E., & Kieren, T. (2015). Three "moves" in enactivist research: A reflection. *ZDM, 47*(2), 307-317. https://doi.org/10.1007/s11858-015-0680-09

Sinclair, N., & de Freitas, E. (2019). Body studies in mathematics education: Diverse scales of mattering. *ZDM Mathematics Education, 51*(2), pp. 227-237. https://doi.org/10.1007/s11858-019-01052-w

Singh, J. (2018). Unthinking mastery: Dehumanism and decolonial entanglements. Duke University Press. http://library.oapen.org/handle/20.500.12657/30252

Skovsmose, O. (2008). Mathematics education in a knowledge market: Developing functional and critical competencies. In L. deFreitas, & K. Nolan (Eds.), *Opening the Research Text: Critical insights and in(ter)ventions into mathematics education* (pp. 159-174). Springer Science+Business Media. https://doi.org/10.1007/978-0-387-75464-2

Star, J. R., & Rittle-Johnson, B. (2008). Flexibility in problem solving: The case of equation solving. *Learning and Instruction, 18*(6), 565–579. https://doi.org/10.1016/j.learninstruc.2007.09.018

St. Albert Public Schools (2017, November). Combined three-year education plan and report to our community. https://www.spschools.org/cms/One.aspx?portalId=969799&pageId=17015415

St. Albert Public Schools (2018, November). Combined three-year education plan and report to our community. https://www.spschools.org/cms/One.aspx?portalId=969799&pageId=17015415

St. Albert Public Schools. (2019, April 10th). Administration Regulations: Student assessment. https://www.spschools.org/UserFiles/Servers/Server_969709/File/Board-Governance/Policy%20Manual/F-100.pdf

Stenmark, J. K. (Ed.). (1991). *Mathematics assessment: Myths, models, good questions, and practical suggestions.* National Council of Teachers of Mathematics.

Stevenson, R. (Director). (1964). *Mary Poppins* [Film]. Walt Disney Productions.

Su, F. (2020). *Mathematics for Human Flourishing*. Yale University Press.

Suurtamm, C. (2018). Enhancing mathematics teaching and learning through sound assessment practices. In A. K. Kajander, J. Holm, & E. J. Chernoff (Eds.), *Teaching and learning secondary school mathematics: Canadian perspectives in an international context* (pp. 472-482). Springer International Publishing. https://doi.org/10.1007/978-3-319-92390-1

Suurtamm, C., Thompson, D. R., Kim, R. Y., Moreno, L. D., Sayac, N., Schukajlow, S., Silver, E., Ufer, S., & Vos, P. (2016). State of the art. In *Assessment in mathematics education: Large-scale assessment and classroom assessment* (pp. 2-29). Springer International Publishing. https://doi.org/10.1007/978-3-319-32394-7

Swan, M., & Burkhardt, H. (2012). A designer speaks: Designing assessment of performance in mathematics. *Journal of the International Society for Design and Development in Education, 2*(5), 1–41. http://www.educationaldesigner.org/

Swan, M., & Foster, C. (2018). Formative assessment lessons. In D. R. Thompson, M. Burton, A. Cusi, & D. Wright (Eds.), *Classroom assessment in mathematics: Perspectives from around the globe* (pp. 11-24). Springer International Publishing. https://doi.org/10.1007/978-3-319-73748-5

Thomas, P. L. (2013). A case for SF and speculative fiction: An introductory consideration. In P. L. Thomas (Ed*.), Science fiction and speculative fiction: Challenging genres* (pp. 15-33). Sense Publishers. https://doi.org/10.1007/978-94-6209-380-5

Thompson, D. R., Burton, M., Cusi, A., & Wright, D. (2018). Formative assessment: A critical component in the teaching-learning process. In D. R. Thompson, M. Burton, A. Cusi, & D. Wright (Eds.), *Classroom assessment in mathematics: Perspectives from around the globe*. Springer International Publishing. https://doi.org/10.1007/978-3-319-73748-5

TODOS (Producer). (2020, May 17). *Episode 10: Rethinking assessment with Amanda Ruiz and Vanson Nguyen* [Audio podcast]. https://todosmath.podomatic.com/

Tran, T. T. H., Khan, S., & La France, S. (2020). Mathematics for multispecies' flourishing: Make kin with Vietnamese Bánh Chưng. Philosophy of Mathematics Education Journal, 36. http://socialsciences.exeter.ac.uk/education/research/centres/stem/publications/pmej/pome36/index.html

Tveit, S. (2009). Educational assessment in Norway—A time of change. In C. Wyatt-Smith, & J.J. Cumming (Eds.) *Educational assessment in the 21st century: Connecting theory and practice* (pp. 227-243). Springer Science+Business Media B.V.. https://doi.org/10.1007/978-1-4020-9964-9

Van Galen, J. A. (2017). Agency, shame, and identity: Digital stories of teaching. *Teaching and Teacher Education, 61*, 84-93. https://doi.org/10.1016/j.tate.2016.09.009

von Foerster, H. (2003). Perception of the future and the future of perception. In *Understanding understanding: Essays on cybernetics and cognition* (pp. 199-210). New York, NY: Springer-Verlag New York, Inc. https://doi.org/10.1007/b97451

Worthen, B. (1993). Critical issues that will determine the future of alternative assessment. *The Phi Delta Kappan, 74*(6), 444-454. http://jstor.org/stable/20404908

Wyatt-Smith, C., & Gunn, C. (2009). Towards theorising assessment as critical inquiry. In C. Wyatt-Smith, & J. Cumming (Eds*.), Educational assessment in the 21st century: Connecting theory and practice* (pp. 83-102). London, NY: Springer Publishing. https://doi-org/10.1007/978-1-4020-9964-9

Zembylas, M. (2004). The emotional characteristics of teaching: An ethnographic study of one teacher. *Teaching and Teacher Education, 20*, 185-201. https://doi.org/10.1016/j.tate.2003.09.008

Zembylas, M. (2018). Rethinking the demands for 'preferred' teacher professional identities: Ethical and political implications. *Teaching and Teacher Education, 76,* 78-85. https://doi.org/10.1016/j.tate.2018.08.011

Appendix A: Sample Test

As I teach in a French Immersion program—that is, a program in which core subjects, with the exception of English Language Arts, are taught in French—the following sample test is in French. I have included the English translations in red below each test item.

Mathématiques 8 : Examen de module 1

Les racines carrées et le théorème de Pythagore

Pour toutes les questions qui suivent, montre tous les calculs.

For all of the questions below, show all of your work.

1. Donne la différence entre la racine carrée et le carré d'un nombre. Comment sont-ils reliés? Donne un exemple.
   (Explain the difference between a square root and a square of a number. How are they related? Give an example.)

2. Une image carrée a une aire de 121 cm^2.
   (The area of a square is 121cm^2)
   a) Détermine la longueur d'un côté de l'image.
      (Determine the length of one side)
   b) Détermine le périmètre de l'image.
      (Determine the perimeter)

3. Calcule *le carré* de chaque nombre.
   (Calculate the square of each number)
   a) 5
   b) 15

4. Une table carrée mesure 165 cm à chaque côté. Détermine l'aire de la table.
   (The length of each side of a square table is 165cm. What is the area of the table?)

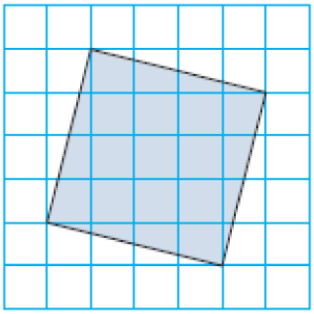
5. Détermine *la racine carrée* de chaque nombre.
   (Determine the square root of each number.)
   a) 625

b) 81

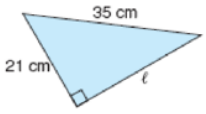
6. Un tapis volant à une aire de 62 500 cm^2. Détermine la longueur de chaque côté du tapis.
(A flying carpet has an area of 62 500cm^2. Determine the length of each side of the carpet.)

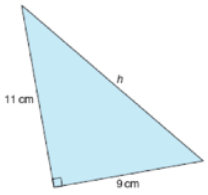
7. Situe chacune des racines carrées sur la droite pour montrer leur valeur approximative.
(Place each of the following square roots on the number line to show its approximate value)
   a) 19
   b) 22
   c) 39
   d) 60

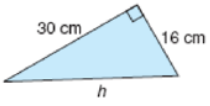
8. Détermine la longueur de chaque côté du carré ombré. Montre la solution complète et explique le processus.
(Determine the length of each side of the shaded square. Show a full solution and explain your process.)

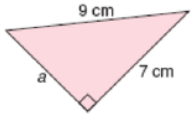


9. Détermine la longueur de chaque côté inconnu en montrant une solution complète.
(Determine the length of the missing sides, giving a full solution.)

a)


b)


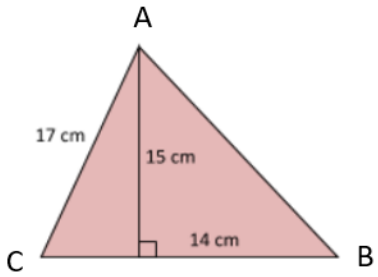
c)


d)


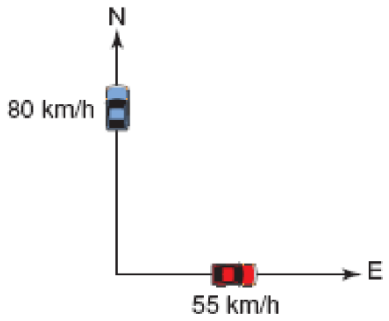
10. Est-ce possible que les trois côtés d'un triangle rectangle mesurent 21, 25 et 32 unités? Comment le sais-tu?
(Is it possible for a right triangle to have sides measuring 21, 25, and 32 units? How do you know?)

11. Les nombres suivants représentent-ils des triplets de Pythagore? Montre ton travail.
(Are the following sets of numbers Pythagorean triples? Show your work)
    a) 24, 32, 40
    b) 5, 8, 9
    c) 25, 60, 65

12. Détermine le périmètre du triangle ABC. Montre une solution complète.
(Determine the perimeter of the triangle ABC. Show a full solution.)



13. Deux voitures se rencontrent à une intersection. L'une se dirige vers le nord à une vitesse moyenne de 80 km/h. L'autre se dirige vers l'est à une vitesse moyenne de 55 km/h. Quelle distance séparera les deux voitures *dans trois heures*?
(Two cars meet at an intersection. One continues north at an average speed of 80km/h. The other heads east at an average speed of 55 km/h. What distance will separate the two cars three hours after they had met at the intersection?)



Appendix B: Reflection Checklist for Assessment Practice

Below, is a table that I would use to evaluate my own assessment practice. Questions appear on the left that finish the sentence "To what extent…" On the righthand side, I would use shorthand symbols to represent to a great extent (↑), to some extent (~), to a lesser extent (↓), and not at all (*X*). This worksheet-like table would be a means to reflect on the assessment practice as a whole rather than on a singular assessment. As I mentioned earlier, no singular assessment would attend to all of the elements in the framework in Chapter 5.

Evaluative guide for an assessment practice

Holism	
Development of virtues	↑ / ~ / ↓ / *X*
Appreciation and gratitude	
…did the assessment practice provide opportunities to feel a sense of appreciation for someone or something?	
…did the assessment practice make space for acknowledging that which we are grateful for?	
Persistence and patience	
…did the assessment practice provide opportunities to practice or demonstrate persistence?	
…did the assessment practice elicit the need for patience?	
Love and loving kindness	
…was the assessment practice (and the tasks therein) situated in an atmosphere of loving kindness towards oneself and others?	
…was the environment of the assessment practice designed to engender a love of mathematics?	
Honesty and integrity	
…did the assessment tasks engender honesty and integrity?	
…did the atmosphere of the assessment practice operate within a space welcoming of honesty and integrity?	
Curiosity and awe	
…did the assessment practice promote or provide opportunities for feeling curious or feeling a longing to know more?	
…did the assessment tasks elicit a sense of awe? (e.g., awe at the beauty of the mathematics, awe at the depth of the mathematics, awe when a sense of achievement was felt)	

Flourishing and well-being: PERMA framework	↑ / ~ / ↓ / *X*
Positive emotion	
…were there indications that students found pleasure in the assessment tasks?	
…did the assessment practice engender a sense of satisfaction?	
…were tasks designed in a way that, upon completion of the task, no matter what the performance, students felt worthy and proud?	
Engagement	
…were there indications that time stopped for students as they completed tasks?	
…were there opportunities for students to become completely absorbed by the tasks?	
…was the assessment practice designed to encourage deep thinking over extended periods of time?	
Positive relationships	
…was the assessment practice situated in an atmosphere of trust?	
…did the assessment practice foster team-building and collaboration?	
…did the assessment demote competition[33]?	
Meaning	
…did the assessment practice point to or inspire students to engage with a 'bigger picture' or feel a sense of purpose?	
…did the assessment practice engender the development and utilisation of a multitude of signature strengths[34]?	
… did the assessment practice engender reflection and awareness of multiple wisdoms, including conceptual, emotional, and spiritual/existential, with and through mathematics?	
Accomplishment	
…did the assessment practice provide opportunities to achieve? (this does not need to exclusively be achievement in terms of academic achievement)	
…was the assessment practice situated in an atmosphere of improvement (in contrast to the attainment of a set standard)?	
Multiple versions of self: Dimensions of self	↑ / ~ / ↓ / *X*
Spiritual	

[33] Here, I use the term demote, rather than inhibit, because there are student who are inspired or motivated by competition; however, it is important to inhibit mean-spirited competition or competition for the purpose of creating a hierarchy of competence that becomes conflated with value.

[34] Signature strengths are a set of twenty-four character strengths; each person has these signature strengths to a varying degrees, and they can be determined using a signature strengths test (https://www.authentichappiness.sas.upenn.edu/testcenter)

…did the assessment practice provide opportunities to work with mathematics from spiritual contexts? (e.g., inclusion of the mathematics of Islamic art embedded in the histories and related cultural context)

…was the assessment practice set in a space of welcome for multiple spiritual worldviews and moral codes?

…was the assessment situated within a space of seeking truth, self-knowledge, right action and sense of purpose?

…did the assessment practice provide a space for demonstrating or developing self-awareness, sense of agency, self-regulation, self-motivation, and social awareness?

Psychological

…was the assessment practice framed in a way to maintain the dignity and wellbeing of students?

…did the assessment practice honour multiple psychological and neurological abilities?

Rational

…did the assessment practice provide opportunities to develop or demonstrate procedural fluency, adaptive reasoning and productive dispositions?

…did the assessment practice provide opportunities to develop or demonstrate content knowledge?

…did the assessment practice provide opportunities to develop or demonstrate mathematical habits of mind?

Physical

…did the assessment tasks engage with mathematical tasks with and using the body?

…did the assessment practice honour multiple corporeal abilities?

Self in relation to others

…were students given the opportunity to collaborate and demonstrate competence as a team?

…were students given opportunities to develop a respect for themselves, others and the mathematics?

…did the assessment practice involve engaging in respectful ways of communicating and collaborating?

Multiplicity

Being mathematical: Ways of doing mathematics ↑ / ~ / ↓ / *X*

Mathematical dispositions

…did the assessment practice engage students in conjecturing, though experimenting

Mathematising	
…did the assessment practice engage with and provide opportunities to demonstrate multiple ways of measuring, playing, designing, explaining, counting and locating?	
Definitions of mathematics	
…did the assessment practice provide opportunities to demonstrate mathematical competence abstractly and contextually?	
…was the assessment practice situated in various cultural, disciplinary and lived contexts in which one might demonstrate mathematical knowledges and processes?	
Mathematical fluencies	
…were there opportunities for students to demonstrate automation of various mathematical skills?	
… did the assessment practice engage with and provide opportunities to demonstrate multiple ways of visualising, estimating, communicating, reasoning, and using technology?	
Mathematical competencies	
…did the assessment practice engage with and provide opportunities to demonstrate multiple ways of thinking critically, making conjectures, writing proofs, and modelling (pictorially, concretely and symbolically)?	
Modality and medium	↑ / ~ / ↓ / *X*
Modality	
…did the assessment practice engage with and provide opportunities to demonstrate learning in written, spoken and dramatic forms? (e.g., hands-on activities)	
…did the assessment practice engage with written, spoken and dramatic displays as prompts?	
Medium	
…did the assessment practice engage with and provide opportunities to demonstrate learning using concrete artifacts, technologies and the use of the body? (e.g., move the body during the task or use the body to measure/model)	
Contexts for mathematics: Ways of knowing mathematics	↑ / ~ / ↓ / *X*
Cultural multiplicities	
…were there opportunities to engage with cultural contexts to inspire mathematical thinking?	
…was the assessment practice welcoming of a plurality of cultural identities?	
Nature and ecologies	

…were there opportunities to engage with or demonstrate learning within natural or ecological contexts? (e.g., using mathematics in issues of sustainability)

Histories and mythologies

…did the assessment practice engage with or situate mathematical tasks within diverse mathematical histories?

…was the assessment practice situated within multiple mythological contexts from which to study mathematics or demonstrate mathematical knowing?

Lived experiences

… was the assessment practice situated within multiple lived contexts from which to study mathematics or demonstrate mathematical knowing?

Interdisciplinary

…was the assessment practice representative of the interdisciplinary interrelations that provide frameworks for understanding the world?

…did the assessment provide multiple interdisciplinary contexts from which to engage with mathematics?

Sharing Responsibility

Roles ↑/~/↓/*X*

…did the teacher, student and parent share responsibility in designing and planning, giving feedback and sharing, reflecting, curating and creating, adapting and being flexible?

Enactivism ↑/~/↓/*X*

…did actors (teacher/student) need to adapt and be flexible?

…was there a focus on self-awareness?

…did the assessment practice provide opportunities for following emergent paths?

…did the assessment practice engage in surrendering to the process?

…did the assessment practice engender a co-creating worlds of significance?

Communal practice ↑/~/↓/*X*

…was the assessment practice situated within a space of collaboration?

…was the assessment practice aimed at sharing common goals?

…was the atmosphere of the assessment practice facilitative of human connection?

…was the assessment practice representative of a practice?