Mathematical Mindsets and Grade 9 Mathematics Learners:

A Case Study of Teachers' Experiences

by

Laura Masterson

A Thesis submitted to the Faculty of Graduate Studies of
the University of Manitoba
in partial fulfilment of the requirements of the degree of

MASTER OF EDUCATION

Department of Curriculum, Teaching and Learning
University of Manitoba
Winnipeg, Manitoba

Copyright © 2020 by Laura Masterson

ABSTRACT

This research explores the implementation of growth mindset with high school mathematics students. I conducted a secondary analysis of case study data gathered for the Ontario Association for Mathematics Education (OAME) Grade 9 Applied Collaborative Inquiry Project. I questioned how these mathematics educators understood mindset, the strategies they used to foster growth mindsets, and their perceptions of the value of, and obstacles associated with, using a mindset approach particularly within a streamed mathematics course context. The observations describe these teachers' efforts to embed mindset into their mathematics classrooms as well as their sense of how ingrained fixed mindsets, views of mathematics as a right or wrong subject, marks-based assessment practices, and the streamed nature of the Applied mathematics course, may discourage growth mindset. These observations highlight the importance of ensuring that approaches to fostering growth mindset permeate every aspect of classroom practice, effectively calling for change in many secondary mathematics norms.

ACKNOWLEDGEMENTS

I was not on this journey alone, and its completion is due to a number of highly generous individuals. Foremost, I am incredibly grateful for the support of my advisor, Dr. Martha Koch, who somehow knew before I did how much I would love the research process and gifted me incredible opportunities to grow as a scholar. She was always ten steps ahead of me, encouraging me to dig deeper, and understood the challenge of writing a thesis with a little one on your lap.

My gratefulness extends to the other two members of my committee, Dr. Christine Suurtamm and Dr. Thomas Falkenberg, for their insights and sincere interest in this topic, and for encouraging me to take what I've learned and continue on. Thank you to the researchers and participants of the OAME Grade 9 Applied Collaborative Inquiry Project for allowing me to use a piece of your study to explore math education in this way.

Thanks to the friends and family in my life who gave their time to care for my children so that my time could be used for this purpose; to my husband, Scott, who is by far my number one fan and knows better than anyone else how hard this process was. Thanks for sacrificing with me to make this happen.

TABLE OF CONTENTS

List of Tables and Figures …… 5

Chapter 1: Focus, Context, and Theoretical Basis of the Study ……... 6
Background for the Study ……... 6
Focus of the Study ……... 9
Context of the OAME Project …… 10
Rationale for Secondary Analysis of the Data ……11
Theoretical and Conceptual Framework of the Study ……11

Chapter 2: Review of the Literature ……19
Studies of the Influence *of* Mindset ……20
Studies of the Influence *on* Mindset …….. 22
Mindset intervention studies …… 22
Nonintervention studies of mindset influences …… 25
Enhancing Teaching and Learning in Ontario's Grade 9 Applied Mathematics Course ….. 31
Gaps in the Literature …… 34

Chapter 3: Research Design and Methods ……... 35
Rationale for the Methodology …….. 35
Selection and Description of the Case from the OAME Project ……37
Methods ……..43
Trustworthiness ……... 46

Chapter 4: Observations ……... 48
Question 1: Understandings of Mindset ……48
Question 2: Mindset Strategies and Approaches ……64
Question 3: Mindset Value and Obstacles …… 89
Summary of Observations and Insights about the Research Questions ……115

Chapter 5: Discussion, Limitations, and Final Thoughts ……118
Insights for Mathematics Teachers and Secondary Mathematics Departments ……... 118
Perceptions of Applied Mathematics: Connections to Research ……... 119
Feasibility of Growth Mindset for Enhancing Grade 9 Students' Achievement ……..122
Limitations of Secondary Analysis and Generalizations from Case Study Research …….. 139
Final Thoughts ……... 141

References ……...143

Appendix A: Concept Map Example ……...152
Appendix B: Student Mindset Questionnaire ……153
Appendix C: Growth Mindset Bulletin Board ……154

LIST OF TABLES AND FIGURES

Tables

Table 1: Overview of Participants ……40
Table 2: Overview of Data ……... 42
Table 3: Mindset Look-fors ……. 62

Figures

Figure 1: Pathway model representing the connection between mindset and achievement …… 16
Figure 2: Supplemented pathway model illustrating the structure of the literature review ……. 19
Figure 3: Growth mindset analogy illustration ……... 136

Chapter 1: Focus, Context, and Theoretical Basis of the Study

In the past few years, a *mindset* mantra has revolutionized mathematics pedagogy by communicating that switching from a belief in the static nature of intelligence, or a *fixed mindset*, to a belief in the malleability of intelligence, referred to as a *growth mindset*, will increase student achievement (Boaler, 2016; Dweck, 2006). Initially, research on interventions using growth mindset lessons suggested high gains for low cost initiatives (for example, Blackwell, Trzensniewski, & Dweck, 2007; Yeager et al., 2016). More recently, some of these studies and Dweck's theory of mindset have come under question. For instance, a meta-analysis refutes the claims of significance in many mindset studies (k=43) (Sisk, Burgoyne, Sun, Butler, & Macnamara, 2018). Despite this debate, those who have doubts about the connection between mindset and achievement and those who advocate the approach tend to agree that the students who are more likely to benefit from a growth mindset are those who are academically at-risk (Denworth, 2019). In this this qualitative study, I explored a community of educators' strategies with and perceptions of using growth mindset in Grade 9 mathematics classrooms.

Background for the Study

Four years ago, after teaching Grade 9 mathematics and science for a decade, I shifted out of a classroom teacher role into a newly created numeracy support position at a large high school in my rural school division. I was entrusted with the task of increasing achievement (more specifically, the passing rate) by working with the mathematics teachers and their students who were at-risk of failing Grade 9 mathematics. It was at this time that I began my graduate studies, with the intention of pursuing research into effective interventions for students entering Grade 9 without adequate mathematics skills and understanding. Evenings were spent fervently looking for strategies to diagnose the gaps in knowledge, fill conceptual understanding voids, and

connect seemingly abstract ideas to students' experiences. I changed my instructional approach to incorporate research-based practices such as rich, open-ended mathematical tasks (Foster, 2018), number talks (Parrish, 2010), and vertical non-permanent surfaces (Liljedahl, 2016). While I saw some positive shifts in student engagement with these changes, I found that many students still lacked persistence and held on to the notion that they could not do math, in spite of their success with various tasks. It seemed to me that students' negative beliefs about their mathematics ability persisted and interfered with their perceptions of themselves as mathematics learners.

I was introduced to mindset theory when the principals at my school presented each teacher with a copy of Dweck's *Mindset: The New Psychology of Success* (2006). I then discovered Boaler, an internationally known mathematics education researcher who is applying ideas from Dweck's theory to transform mathematics education, and signs emails with "viva la révolution!" (Ward, 2015). Boaler currently facilitates two massive open online courses (MOOCs) through Stanford University on how to increase growth mindset in mathematics classrooms (see scpd.stanford.edu). The first course has had over 65,000 participants and counting. Her website (youcubed.org) includes a growing set of resources for teachers to implement growth mindset approaches. In addition, online mathematics education enterprises like Khan Academy and the Project for Educational Research that Scales (PERTS) also produce mindset materials for mathematics (see www.learnstorm2017.org or www.mindsetkit.org) and Dweck, until recently, was the director for a web-based company that provides award-winning educational programming based on her growth mindset research (see mindsetworks.com). I believe the extensive visibility and availability of training and instructional materials is fueling this mathematical mindset phenomenon, and I find teachers like myself are eager to employ

mindset resources under the assumption that a growth mindset is what many underachieving mathematics students lack.

Throughout this thesis, I use the term "underachieving" to describe students who have been less successful in the educational system at maintaining grade-level mathematics outcomes. Mathematics is a subject that many students find challenging, and gaps in understanding can seem like insurmountable barriers to learning as students move to higher grades (Blackwell et al., 2007). Often, students who are underachieving as they enter high school are at risk for higher levels of disengagement and academic failure (Boaler, 2008). I see the term "underachieving" as a way of identifying those students who have been underserved academically and who are capable of exhibiting higher achievement if their circumstances shift. In using this term, I am seeking to convey my belief that these underachieving students can learn mathematics if they have support to do so.

Over the past few years in my role as a numeracy support teacher, I engaged this notion that underachieving students simply require a dose of growth mindset to change the course of their mathematics education. I immersed myself in the available materials and enrolled in Boaler's second online course, Mathematical Mindsets, having read her bestselling book with the same title (Boaler, 2016). I also began exploring research involving mindset and mathematics, and was intrigued by one study that took place in Chile. In that study, the researchers looked at the data collected through a national mathematics achievement test for over 168,000 Grade 10 students. In addition to mathematical scores, the data also included students' socioeconomic information and the results of a mindset survey (Claro, Paunesku, & Dweck, 2016). The authors reported that students from low-income backgrounds were half as likely to have a growth mindset and had lower achievement than students from wealthier backgrounds. However, the

small proportion of low-income students with a growth mindset achieved the same scores as fixed mindset students from wealthier backgrounds. The researchers concluded that having a growth mindset effectively reduces the typical low achievement found in students experiencing poverty. Although the study did not focus on influencing mindset, it prompted me to wonder whether changing students' mindsets could significantly impact their achievement, especially for those from disadvantaged backgrounds like many of the students I work alongside.

Since other research also suggests that students who underachieve in mathematics are more likely to have a fixed mindset (Grant & Dweck, 2003; Hardre & Sullivan, 2008), and teachers of mathematics more likely have a fixed mindset than teachers of other disciplines (St. Amant, 2017), the task of imparting growth mindset messages to students and teachers could be significant to student learning. But how are these messages imparted to underachieving students and do they really have the impact desired?

Focus of the Study

As I explored the research on mindset and mathematics, the evidence for teaching toward a growth mindset emerged with ease, but a clear gap in the literature also presented itself. Specifically, I found a lack of research into what educators were actually doing and thinking when using a mindset approach with underachieving students in Grade 9 mathematics classrooms. To begin to address this gap, I set out to conduct some research on three related topics. I wondered how educators understand mindset as it relates to mathematics teaching and learning, what strategies or approaches they use to foster growth mindset in a Grade 9 mathematics classroom, and what they feel are the benefits and obstacles associated with using growth mindset approaches specifically with underachieving mathematics learners.

To explore these ideas, I conducted a secondary analysis of case study data gathered in a two-year study in Ontario. The study was called the Ontario Association for Mathematics Education (OAME) Grade 9 Applied Collaborative Inquiry Project (Suurtamm et al., 2017), which I will refer to as the OAME Project. In the next sections, I describe the context where the data was gathered and provide a rationale for choosing to use this data in my thesis.

Context of the OAME Project

In Ontario, Grade 9 students must select a mathematics course in one of three pathways, namely Academic, Applied, and a Locally Developed Course, sometimes called Essentials. The pathways are intended to reflect their plans for post-secondary education (Ontario Ministry of Education [OME], 2005), though some researchers contend that they more often reflect students' achievement in Grade 8 (Hamlin & Cameron, 2015). The Applied mathematics pathway offers the mathematics knowledge students require for the workplace or for post-secondary programs that don't require a mathematics focus (OME, 2005). The Grade 9 Applied mathematics course has been associated with low passing rates and higher numbers of lower achieving students when compared with the Grade 9 Academic course (Hamlin & Cameron, 2015; Parekh & Gaztambide-Fernandez, 2017). In response to concerns about achievement in the Grade 9 Applied mathematics course, a group of researchers from the University of Ottawa collaborated with the OME and the OAME to facilitate ten professional learning communities (PLCs) who met from 2014-2016 (Suurtamm et al., 2017). The researchers documented each PLC's monthly day-long meetings, which centered on discussing challenges, developing goals, and reflecting on the progress of effective teaching strategies for the Applied mathematics course. Each PLC chose the focus of their inquiry. After reviewing the OAME Project report, I learned that several teams chose to focus, at least in part, on growth mindset (Suurtamm et al., 2017).

Rationale for Secondary Analysis of the Data

As an educator and graduate student in Manitoba, I decided to use the data from Ontario to gain insights into my research topics rather than conduct a study in Manitoba. One reason for my decision is that the OAME Project provides me with a collection of data gathered from a group of educators over two years as they engaged with growth mindset. Replicating this approach within the time and budgetary constraints for a master's thesis would be difficult. Secondly, the inquiry-based collaborative nature of the PLCs in the OAME Project allows me to explore diverse perspectives from teachers, support teachers, and administrators as they discuss mindset. Their conversations during meetings were less structured than interviews often are, giving me insights into many aspects of mindset and the connections these educators were making over the two years. Additionally, Grade 9 mathematics in Manitoba is a single, compulsory course, meaning low achieving students are mixed with higher achieving students. Ontario students are given a choice of mathematics courses with lower performing students usually opting to take the Applied course in Grade 9 (Hamlin & Cameron, 2015; Macaulay, 2015). As I am interested in understanding the perspectives of teachers who use mindset approaches to support underachieving students, and the OAME Project context was a mathematics course often taken by students who seem to be less successful in mathematics, I felt it was valuable to explore my research topic using this data.

Theoretical and Conceptual Framework of the Study

When I began looking at the research supporting Boaler's growth mindset approach in mathematics, I quickly realized I needed to return to Dweck's foundational theory of mindset, which stems from over four decades of research on efficacy and behaviour. In her work, Dweck frequently cites Bandura's studies on motivation (see Dweck & Leggett, 1988, for example).

Accordingly, to position my study, I begin with describing Bandura's theory of motivation and then present a conceptual structure that links mindset to achievement, discussing how these ideas influenced the exploration of my research topic and help to frame my analysis of the data.

Theoretical framework. Mindset theory arises from a social cognitive approach to motivation (Bandura, 1999), which suggests that an individual's life path is constructed from the interactions between personal attributes, behaviours, and environmental factors. In this theory, people are motivated to action or inaction by their *self-efficacy*, the inward beliefs about their ability to perform a task and outward beliefs about the potential outcomes of success or failure (Urdan & Schoenfelder, 2006). Bandura (2006) posits that people regulate their behaviour through ongoing reflection, self-evaluation, and goal setting, and therefore "are not simply onlookers [but] contributors to their life circumstances" (p. 164). In an earlier study, he claims that "an ability is only as good as its execution" (Wood & Bandura, 1989, p. 414). In other words, to fully understand human motivation, it is important to understand the threefold relationship between how people think about self-abilities, how they act based on those thoughts, and the responses they receive from the environmental context. Social cognitive theory places self-efficacy at the foundation of human action; ultimately efficacy beliefs decide which opportunities are worth pursuing and to what extent they will be pursued (Bandura, 2006). This theoretical lens implies efficacy and action are intertwined within an environmental context. In the next sections I describe two theoretical approaches related to Bandura's ideas on motivation: mindset theory (efficacy beliefs) and goal theory (human action), and then provide a description of what it might look like when growth mindset is implemented within a mathematics classroom (the environmental context).

Mindset theory. Mindset theory, originally called "implicit theories of intelligence" (p. 302) claims *efficacy*, the individual belief about inherent ability, manifests in two approaches to understanding intelligence (Yeager & Dweck, 2012). In the *entity* interpretation intelligence is static and uncontrollable while in an *incremental* interpretation intelligence is dynamic and malleable (Dweck & Leggett, 1988; Wood & Bandura, 1989). Dweck (2006) re-introduced the entity view as *fixed mindset*, and the incremental view as *growth mindset*. In my thesis, I use the terms fixed mindset and growth mindset to describe beliefs about inherent ability, and use the term efficacy when I refer to studies that explored these beliefs prior to this shift in terminology.

Fixed and growth mindsets are not mutually exclusive; they exist on a spectrum and are also task specific (Gross-Loh, 2016). This means that someone could have a growth mindset toward one area of their life, such as musical ability, but a fixed mindset toward another, such as mathematics. According to Dweck (2006), a person's mindset determines their perspective of success, failure, and effort required for a task. People with a fixed mindset operate out of a need to prove their intelligence, viewing failure as an exposure of weakness and success as a verification of giftedness. From this perspective, effort is only necessary for those who lack innate ability, as those who are "smart" in an area do not need to try. When faced with difficulties, Dweck observes that fixed mindset individuals tend to admit defeat, surrendering to a lack of talent. People with a growth mindset, on the other hand, view effort as the means to success, and will persevere in a challenge. Trying and failing at a task is seen as an opportunity to learn. Once a belief about ability is established, Bandura (2006) maintains that people are stimulated to create goals toward action that reflect their beliefs.

Goal theory. In the 1980s, Dweck collaborated on a series of projects which led to the emergence of two distinct classes of goals that link to mindset beliefs (see Dweck & Leggett,

1988, for a review). *Mastery* goals are associated with incremental (or growth mindset) beliefs and *performance* goals are associated with entity (or fixed mindset) beliefs (Dweck & Leggett, 1988). Individuals who pursue mastery goals use failure to signal a necessity to increase effort or change strategies. Those with performance-oriented goals focus not on the task, but on the validation of their ability, often in comparison with others. Liem, Lau, & Nie (2008) suggest a person with a mastery goal asks "what am I doing to *develop* competency?" while a person with a performance goal asks "what am I doing to *demonstrate* my competency?" I believe it is worthwhile to understand the association between mastery goals and growth mindset as well as between performance goals and fixed mindset when examining student motivation and actions in a learning environment. That is, since I am working from a social cognitive theoretical base, it will not be enough to look only at students' perceptions of their ability (i.e. mindset); I will also need to consider how these perceptions relate to students' learning behaviours (including their goal orientation), which I feel can be more visible to teacher observation.

A traditional versus mathematical mindset approach. A mathematics classroom that emphasizes growth mindset will look vastly different from the mathematics classrooms most educators were exposed to as students (Boaler, 2016). If I think back to my own experience as a secondary student, and even how I structured my mathematics classes in the first years of my teaching career, a typical class would follow the same format day after day: review the previous day's homework, copy step-by-step examples from the board, start new homework. Zager (2017) describes it well:

> Our days were filled with pages of calculations, timed tests, procedures that worked according to incomprehensible codes…and, above all else, a singular right method to follow…We watched our teachers demonstrate and explain procedures – some well,

> some not so well – and tried to replicate those procedures through repetitive exercises. We heard correct answers praised and mistakes criticized…Day after day of worked examples, night after night of computing problems 1 to 31 odd for homework, we learned what mathematics was. (p. 4)

The National Council of Teachers of Mathematics (NCTM, 2014) advocates moving away from these traditional approaches and reconsidering what it means to learn and teach mathematics. Moving from what NCTM calls unproductive to productive beliefs, students should be seen as active, creative problem solvers as opposed to passive receptacles that regurgitate the rules teachers impart (p. 11). To foster the development of these productive beliefs and a growth mindset, Boaler (2016, p. 277) encourages teachers to communicate seven mathematical mindset "norms" to their students, paraphrased as follows:

- there is no such thing as a 'math person'; everyone can learn math to the highest levels
- struggling and making mistakes are valuable as they grow your brain
- questions are really important, particularly 'why' questions
- math is about creativity, seeing patterns and creating solution paths
- math is about connections and communicating using different visual representations
- depth is much more important than speed
- math class is about learning, not performing, and therefore takes effort and time

Boaler indicates that these ideas must be entrenched in each task students undertake, each assessment, and each conversation. Challenging, open-ended, visual mathematics problems are at the forefront of her instructional approach, aiming to demonstrate to students that they are capable of understanding complex mathematics (see Boaler, 2016 and youcubed.org for examples of these problems). Teaching students and teachers about neuroplasticity, the brain

science that says the brain is like a muscle that can grow when it encounters struggle, is also explicit to Boaler's approach. She has developed lesson plans to start each school year that include mathematics tasks embedded with brain-based growth mindset video clips to use in the classroom (see youcubed.org/week-inspirational-math). These norms, strategies, and lessons are intended to create an environmental context to support the development of growth mindset and mastery goal orientations in students.

Conceptual framework. As I became more familiar with Bandura's work, the social cognitive approach to motivation stood out as a viable footing for connecting mindset theory, goal theory and student achievement. I found that research on human motivation suggests a relationship between mindset beliefs, goals that motivate behaviour, and achievement, with several studies proposing similar models (Blackwell et al., 2007; Dweck & Leggett, 1988; Greene, Miller, Crowson, Duke, & Akey, 2004; Liem et al., 2008; Wood & Bandura, 1989). The models, although varying in focus, correlational strengths, and the inclusion of additional variables such as past performance and teacher support, portray a similar sequence. I discuss these studies in more detail in my literature review, but for now, I have simplified the models in the studies to highlight the relationship between the four most common variables that underpin these studies (see Figure 1).

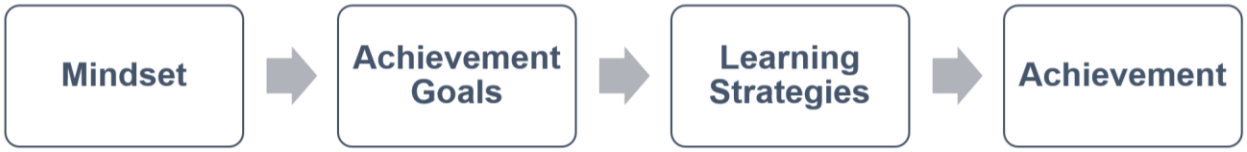


Figure 1. Pathway model representing the connection between mindset and achievement.

In this pathway model, the basis for achievement in mathematics is the student's mindset. Ideally, students who start with a growth mindset are able to set goals to master the content and then use effective learning strategies to engage in the content and be successful. Alternatively, students who begin the pathway with a fixed mindset set performance goals to prove their ability or to avoid revealing their lack of ability, and their resulting learning strategies are too shallow or they are too disengaged to be successful.

I found myself repeatedly returning to this sequence when exploring the connection between mindset interventions and success in mathematics learning, and decided to use this conceptual framework in this study. According to the model, if teachers desire to increase the achievement of their students, they would need to start with the students' perceptions of their ability. Initially, my view was that the entire mindset phenomenon revolved around altering the beginning of the pathway – instilling growth mindset views in students, and then assuming the students' goals and learning strategies would turn toward a mastery approach. Some studies that explore this idea are summarized in Chapter 2.

However, I also recognized that altering students' mindsets may be more difficult due to the environmental context of many mathematics classrooms. For example, mathematics is believed to be a discipline that emphasizes talent and giftedness more than any other school subject (Allexsaht-Snider & Hart, 2001; Leslie, Cimpian, Meyer, & Freeland, 2015). It is also said to be the most over-tested, performance-based subject, whose traditional practices provoke fear and anxiety in many students (Boaler, 2008). If this is the common view of mathematics education then shifting students' mindsets could in fact require a significant change in pedagogy. As I explored my research questions, I used this conceptual framework to analyze the approaches educators use to teach growth mindset, their perspectives on what it is, and how valuable it is to

their practice. In the end, I determined that while this pathway allowed me to gain a deeper understanding of why classroom practices associated with growth mindset influenced student achievement, it was insufficient to describe the experiences of this PLC. I suggest an alternate way of looking at the observations in Chapter 5.

Chapter Two: Review of the Literature

To continue to position my study within the literature on mindset, this review focuses on empirical studies that support the use of mindset approaches in education. I began by exploring studies cited in Dweck (2006) and Boaler (2016) in their well-known books. I found additional articles that discussed mindset or efficacy approaches through educational databases, and in turn uncovered relevant studies in the reference sections of those articles. When I noticed several articles citing some of the same studies, I made sure to be familiar with those as well. Although I attempted to seek out Canadian studies, the literature on mindset seems to be dominated by studies situated in the United States.

The research I collected appears to me to fall into two categories, each attempting to analyze the influences of ability beliefs on student achievement. One category examines *how* student mindsets affect achievement, while the other category seeks to explore *if* mindsets can be influenced in order to change the course of student achievement. To help visualize these categories, and the structure of this literature review, I refer back to the conceptual pathway connecting mindset beliefs to achievement, showing the categories of research as arrows along the pathway (see Figure 2).

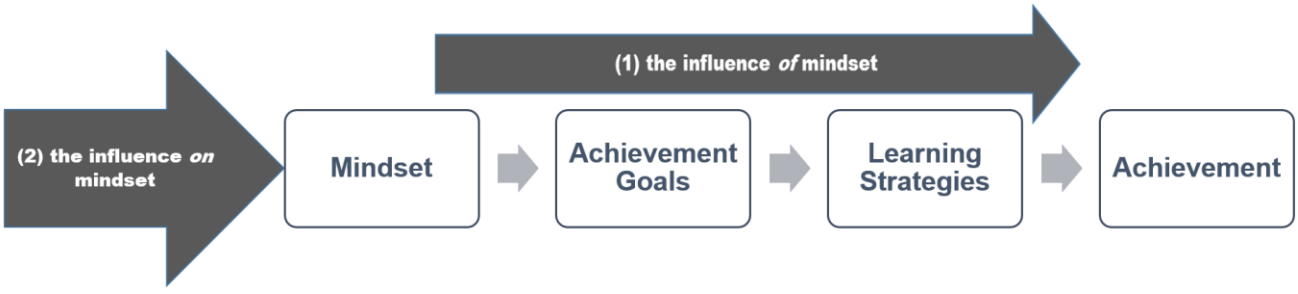


Figure 2. Supplemented pathway model illustrating the structure of the literature review.

I begin this literature review with a summary of the studies which support the theory that student mindsets influence achievement through student goals and learning strategies (Arrow 1). I then

focus on articles that highlight influences on mindset (Arrow 2), discussing them in two groups which I have termed intervention studies and nonintervention studies. Where I was able to locate relevant literature, I highlight the impact on students in secondary mathematics contexts and/or with low-achieving students, as these dimensions pertain to my research focus. I end this chapter with a discussion of research related to the Grade 9 Applied mathematics course in Ontario.

Studies of the Influence *of* Mindset

Initial research on efficacy beliefs focused on establishing a firm link from mindset to student achievement, often identifying mediating factors between the variables, two of which I have included in the conceptual pathway (achievement goals and learning strategies). In an early study on student engagement in mathematics, 269 students from a southern US high school participated in surveys using likert-scaled items to determine factors that influenced their semester grades (Miller, Greene, Montalvo, Ravindran, & Nichols, 1996). The researchers discovered that student perceptions of ability were positively related to student persistence and achievement, but only in the cases when students adopted mastery goals. The same study also reported other mediator variables between perceived ability and achievement, such as the use of deep or shallow learning strategies and the students' perceptions of the future consequences of doing well in the course. More recently, empirical studies have sought to clarify the mindset-achievement link by separating the variables to test for correlational strengths. For instance, two studies established a significant relationship between student efficacy and the learning goals (either mastery or performance) that students adopt in English courses at a Midwest US high school (Greene et al., 2004) and with a national sample (n=1475) of Year-9 students in Singapore (Liem et al., 2008). Other studies have suggested that the learning goals students adopt relate to their learning strategies and ultimately, their achievement. For example, in a

difficult General Chemistry course at Columbia University, 128 students were surveyed at four different points over the semester and those with ability-linked (performance) goals were more prone to withdraw effort and use shallow processing strategies, achieving lower grades in the course (Grant & Dweck, 2003).

A few mathematics-related studies attempt to directly relate mindset to achievement and do so by including student learning goals and strategies in their analyses. Most use mindset scales, initially called theories of intelligence scales, to measure students' perceptions of ability rated on a scale from 1-6. They ask students to agree or disagree with statements such as "you have a certain amount of intelligence, and you can't really change it" and "you can always greatly change how intelligent you are" (Blackwell et al., 2007). Two studies took place with middle school students in the US (n=373; n=115) that employed these scaled-efficacy measurements and related the results to mathematics achievement as well as student strategy use, such as the helpless versus mastery responses to challenge (Blackwell et al., 2007; Romero, Master, Paunesku, Dweck, & Gross, 2014). In both studies, the researchers examined student efficacy over the duration of the students' time in middle school, and determined that high efficacy (beliefs associated with a growth mindset) was related to greater levels of intrinsic motivation, goal-setting, willingness to try new strategies, and performance. In each study, term grades in mathematics were used as an indicator of performance. Blackwell et al., (2007) claimed that students' "theories of intelligence [mindset] became a significant predictor of their mathematics achievement" (p. 251) at the end of the first as well as the second year of middle school, although they cited a global motivational variable mediating the relationship. This motivational variable however also included student goals and learning strategies.

While reading these studies, I began to wonder if the numerous mediating factors (goal setting, learning strategies, persistence, and perceived future use) that exist on the pathway between mindset and achievement might also impact achievement, not just students' mindsets. To change the trajectory of student achievement, I began to wonder if instructing students in mastery goal setting or effective learning strategies might inspire the same success as teaching a growth mindset. However, I also noted that the positive results on achievement from relatively brief mindset interventions found in several studies tended to favour the idea of teaching growth mindset. These studies are discussed in the following section.

Studies of the Influence *on* Mindset

As some researchers were supporting the link between mindset and achievement through mediating variables, other researchers were gathering compelling evidence to support the notion that mindsets can be manipulated, either through researcher-led interventions or school-based influences.

Mindset intervention studies. One of the first well-known mindset interventions, although not math-specific, took place with African American college students (n=79) in the US, who have been found to perform below average academically regardless of socioeconomic status (Aronson et al., 2001). The students were exposed to three one-hour sessions detailing the nature of intelligence as either expanding or fixed. Those who were exposed to the expanding-intelligence message significantly increased their grade point averages and engagement in school. Years later these results were echoed by a group of researchers who led a math-specific mindset intervention with four groups of students entering Grade 7 and moving to Grade 8 in one US junior high school (Blackwell et al., 2007).

The positive correlation that was observed between a growth mindset and higher achievement prompted several groups of researchers to examine the effects of interventions at a neurological level. In one study, undergraduate students who read a growth mindset message prior to engaging in a challenging recall task showed an increase in the brain's activity in response to error and feedback (Mangels, Butterfield, Lamb, Good, & Dweck, 2006). Subsequent studies used a similar approach and achieved comparable results, finding that the brain's heightened attention to error with the growth mindset intervention led to higher achievement gains on a subsequent task (Moser, Schroder, Heeter, Moran, & Lee, 2011; Schroder, Moran, Donnellan, & Moser, 2014). Boaler often cites these studies to explain the value of making mistakes in mathematics as they "spark and grow your brain" (2016, p. 12).

Two quantitative studies set out to increase the generalizability of past research by using wide-scale interventions with high school students, although neither focused specifically on mathematics. Paunesku et al., (2015) analyzed the positive effect of two 45-minute online growth mindset sessions on the next semester's grade point average with over 1500 high school students from locations throughout the United States. Yeager et al., (2016) then redesigned the online mindset intervention to include more specific scientific information about brain growth, to emphasize strategies over effort, and to explicitly state the benefits of having a growth mindset. This wide-scale intervention took place with all Grade 9 students in 10 US schools (n=3676). Both studies claimed statistically significant increases in grade point average and course passing rates for students who had low past mathematics grades, and who were considered at-risk for failing or dropping out of high school.

More recently, 1,090 middle school students across 10 school districts in California were a part of a study that analyzed the impact of an open, online mathematical mindset course offered

through Boaler's website (Boaler, Dieckmann, Pérez-Núñez, Sun, & Williams, 2018). The researchers found that students who participated in the six 20-minute modules (n=439) showed higher levels of engagement, more growth mindset toward mathematics, and were more likely to have higher achievement on a national mathematics test than the students in the control group.

Empirical research on mindset is experiencing increasing scrutiny, particularly for assertions about its positive effect on student achievement. One study conducted two meta-analyses of mindset related studies (Sisk et al., 2018). The author's first meta-analysis included 273 studies that associated mindset with student achievement. The second meta-analysis focused on 43 studies that showed mindset interventions increased student achievement. The researchers reported a very weak average correlation for both meta-analyses, although they noted that certain subgroups, particularly students with low SES or students at-risk academically, did have significant results from mindset interventions. They concluded "the evidence suggests that the 'mindset revolution' might not be the best avenue to reshape our educational system," but also acknowledged that "it is possible that unmeasured factors are suppressing effects" (p. 569).

Another recent study attempted to replicate two of Dweck's prominent studies which related mindset to student's academic performance and the type of praise they receive (Li & Bates, 2019). Li and Bates found no significant evidence to support teaching growth mindset to students. Studies such as this one garnered the attention of mindset proponents, with Dweck reanalyzing and publicizing her data, stating that "one thing we've learned in the past five to 10 years is how the nuances matter" (as quoted in Denworth, 2019). These nuances are now becoming a focus in growth mindset research. For example, Anderson, Boaler, and Dieckmann (2018) published a mixed-method study that examined the effects on Grade 5 students when teachers participated in a professional development course on mindset (particularly brain

science). Forty teachers across the US took the course, and the researchers saw evidence of student mindset belief changes, increases in national test scores, and shifts in the teachers' practices to adopt Boaler's mathematical mindset norms. One conclusion they came to was that the success of the course was due to teachers being given the opportunity to learn about how the brain can develop and to let go of the myths and negative mathematical identities they had previously held about themselves and their students. In another study, a team of 25 researchers, including Yeager, Dweck, Paunesku, and Romero, conducted the "National Study of Learning Mindsets" with low achieving Grade 9 students (n=12,490) in the United States using independent companies to draw the sample, run the two short online sessions, and analyze the results (Yeager et al., 2019). Students were randomly assigned to a growth mindset intervention or control session; the intervention used stories and guided reflections focused on how intelligence is cultivated through effort, changing strategies, and taking on challenges, and the control session focused on brain functioning without addressing beliefs about intelligence. For the students who were part of the intervention, the team found significant gains in student GPAs by the end of the school year but also claimed that the school climate – either supportive or unsupportive to adopting growth mindset – played a role in the extent of change. They speculated that "sustained change may therefore require both a high-quality seed (an adaptive belief system conveyed by a compelling intervention) and conductive soil in which that seed can grow (a context congruent with the proffered belief system)" (Yeager et al., 2019). This "soil" is perhaps school or classroom-based factors that foster growth mindset beliefs in students. I examine some of the research on these non-intervention approaches next.

Nonintervention studies of mindset influences. Without offering specific mindset interventions, is it possible to influence student mindset through school or classroom culture? To

explore this question, I widened my literature search to include research that supports the notion that students tend to adapt their beliefs about intelligence to the established culture of a community (Murphy & Dweck, 2010). In some rural US high schools (n=625), the perception of teacher support was the most significant indicator of ability beliefs and goal orientation (Hardre & Sullivan, 2008), implying to me that schools and teachers can develop growth mindset cultures that influence student mindsets. What could this support look like, outside of the intervention approaches described previously? In the following sections I consider how a growth mindset culture could be developed in a classroom setting by discussing the influence of mastery-oriented messages, using project-based instructional approaches, and shifting mathematics course structures.

Mastery-oriented messages. In attempting to understand where students acquire their mindsets, researchers have tried to establish a correlation between a child's mindset and the mindset of influential adults in a child's life, such as parents and teachers. However, the studies I found could not consistently connect adult mindset to child mindset (Haimovitz & Dweck, 2016; Park, Gunderson, Tsukayama, Levine, & Beilock, 2016; Sun, 2015). As a result of this inconsistency, Haimovitz and Dweck (2016) proposed that perhaps children's mindsets are influenced by a more specific aspect of parents' beliefs about intelligence – that is, the messages they convey when they, or their children, experience failure. Through the use of mindset scales explicitly targeting beliefs about failure, they found that children's mindsets are strongly related to parents viewing failure as either debilitating (performance-oriented) or enhancing (mastery-oriented). The authors suggest that since beliefs about failure are more frequently articulated to children than are beliefs about intelligence, performance-oriented responses to mistakes, such as expressing concern or consoling a child for a lack of ability, lead to fixed mindsets. Although the

study focused on parents, I wonder if teachers' responses to failure in the classroom might follow suit. Along these lines, Rattan, Good, and Dweck's (2012) study titled, "It's ok – Not everyone can be good at math," used scaled surveys with undergraduates and graduate instructors at a private US university and found that teachers who comforted students in their lack of mathematics ability actually decreased their students' motivation and expectations of success. The authors suggest that even well-intentioned teachers may convey fixed mindset beliefs, leading to an educational system "in which the forces pushing students to disengage from important fields of study are stronger than those encouraging them to persevere through difficulty" (p. 736).

Teachers' performance-oriented reactions to student success also seem to play a role in influencing fixed mindsets. Dweck (2006) claims that praise focused on an appreciation for talent rather than the effort put in by a student sends a message to students that their worth lies in their giftedness, and is something they have no control over. Boaler (2016) reiterates this idea for mathematics classrooms, saying that *performance praise* given for speed and accuracy accounts for perceptions of mathematics as a fixed ability subject, while *process praise* that acknowledges a student's persistence, strategy, or risk taking is credited with the development of a growth mindset. Based on a multiple case study analysis of middle-years mathematics classrooms in California, Sun (2015) suggests that teachers who promote growth mindset messages link praise to specific student behaviours like reasoning and justifying their thinking. When teachers used this type of praise, Sun observed that they typically allowed students multiple opportunities to practice and resubmit materials, as well as were more willing to accept nontraditional approaches of showing mastery. Her study provides a framework for identifying teacher actions that

influence growth mindset, and includes other practices like using math tasks and sorting students which I refer to later in this chapter.

Recent qualitative research in mathematics classrooms seems to confirm the premise that teacher mindsets do not predict student mindset, and are often at odds with the instructional practices taking place in their classrooms (St. Amant, 2017; Sun, 2015). That is, in the middle and high school classrooms observed, teacher-centered instruction, summative assessments and rigid grading practices undermined the growth mindset messages that these mathematics teachers believed they portrayed about the malleability of intelligence. In another math-related example with a diverse population of students attending Grade 1 and 2 in an urban US school district (n=424) and their teachers (n=58), Park et al., (2016) used questionnaires to examine whether a teacher's instructional practices in math, either mastery or performance-oriented, are linked to student efficacy beliefs. They found that performance-oriented practices (such as praising students for their ability, or displaying only the work of high-achieving students), but *not* mastery-oriented practices significantly related to student ability beliefs. The researchers further found that students who are exposed to multiple years of performance-oriented classroom instruction, even if they are taught a growth mindset, form fixed mindsets toward their ability to learn math. To me, the findings from these studies invite questions about the overall function and longevity of using growth mindset approaches, particularly if there is a disconnect between what teachers state they believe about student learning and the experiences of students in their classrooms.

Project- and problem-based instruction. In 1998, Boaler's seminal study comparing two secondary schools in Great Britain over 3 years found that students' mathematical identities, in the form of perceptions of ability, appeared quite different. The two schools had student

populations with similar demographics (n=290), but they differed in instructional approach; one school used open-ended, collaborative projects to learn mathematics and the other used a traditional lecture and textbook assignment approach. Students in the project-based school reported higher achievement and more positive attitudes toward mathematics than those in the school that employed traditional teaching practices. Years later, Boaler interviewed 20 of the original students from the two schools, finding that the adults who had attended the project-based school had maintained "more active and capable mathematical identities, growth mindsets…and adaptive expertise" (Boaler & Selling, 2017, p. 97). In a similar smaller study with eighth-grade students in the US, two mathematics classrooms at a school were compared, one using traditional practices and one using a problem-based inquiry model (Cobb, Gresalfi, & Hodge, 2009). All of the students viewed themselves as being capable of success in the inquiry class, but less than half reported the same sense of ability in the traditional mathematics class. From these studies I infer that growth mindsets can be acquired by a less traditional, more student-centered approach in teaching mathematical understanding.

Course structure influences. In light of the Applied mathematics course context of the OAME Project data I examined, I felt it was worthwhile to explore the literature concerning the effect of mathematics course structures on students' mindsets. By structure, I mean arranging mathematics content into two or more course routes, with completion of courses in each route leading to different opportunities for applying to postsecondary programs. This structure, often referred to as *streaming*, has been practiced for over a century in the United States and Canada, with the initial premise of preparing students for appropriate career paths by sorting them into levels using an intelligence test (Biafora & Ansalone, 2008). Streaming structures have been linked to increasing the achievement gap between high and low-level streams and perpetuating

social class divisions, as lower status students receive less knowledge and fewer opportunities to increase their status through postsecondary education (Boaler & Staples, 2008). In 2018, NCTM President Robert Berry spoke about streaming in a radio interview and highlighted the inequity of lower streams receiving "limited access to high quality mathematics instruction, limited access to high quality teachers, and also access to pathways that lead to college and career readiness" (Berry, 2018, 0:52). In Ontario, the previous practice of ability or achievement-sorting within a mathematical streaming structure has been replaced with an allegedly more equitable model: "pathways of choice," where students select a course route based on their future interests in postsecondary education or ways of learning mathematics; for example, the Applied mathematics course is for students who will not require mathematics courses in university (OME, 2005).

Despite the change to a choice-driven model, the composition of students in the Applied mathematics pathway continues to expose three educational inequalities. First, using demographic data from the Toronto District School Board, Parekh and Gaztambide-Fernandez (2017) discovered disproportionately high numbers of marginalized students, relating to race, immigrant status, disability, and income, in the Applied mathematics pathway as compared with the Academic pathway. Secondly, student interests in future occupations are often overshadowed by the students' achievement in Grade 8 mathematics when the choice of mathematics course is made, leading to Applied classes where students have a history of underachievement and gaps in mathematical understanding (Hamlin & Cameron, 2015). This pattern continues into the Grade 9 Applied course, where 44% or fewer Grade 9 students meet the provincial standard for the course whereas 84% of students meet the standard for the Academic course (Hamlin & Cameron, 2015). Lastly, mindsets have been shown to influence the difficulty level of mathematics courses

students choose to take in high school. In a study that analyzed intelligence theories with emotional and academic functioning among US middle school students (n=115) over three years, students with a growth mindset tended to choose more challenging mathematics courses, even when the researchers controlled for past mathematics grades (Romero et al., 2014). In the recent Yeager et al. (2019) study with low achieving Grade 9 students, those who were taught growth mindset were more inclined to take advanced mathematics courses in Grade 10 (Yeager et al., 2019). In other words, students with a fixed mindset more often choose a lower-streamed (or less challenging) course. This suggests to me that a higher percentage of students in Ontario's Grade 9 Applied mathematics course may have a fixed mindset than those in the Academic course.

Several studies claim that removing the streaming structure from schools positively affected the previously low-streamed students' engagement in mathematics classes, attitudes toward math, and overall achievement on standardized tests (Boaler & Staples, 2008; Burris, Wiley, Welner & Murphy, 2008; Horn, 2008). Boaler (2008) posits that students who are in lower streams sense that they are not as intelligent, or capable, as their higher-streamed peers, which intrudes on growth mindset development. Macaulay (2015), whose dissertation I describe in the next section, found that students in Ontario's Grade 9 Applied course "have low self-esteem in, interest of, and motivation to do well in mathematics" (p. 242) as a result of the negative stereotype surrounding the Applied course. In my analysis and discussion of the OAME Project data, I consider the ways the streamed structure of Ontario's Grade 9 mathematics courses may interfere with students in the Applied course fully embracing a growth mindset.

Enhancing Teaching and Learning in Ontario's Grade 9 Applied Mathematics Course

Two recent research projects in Ontario have investigated the underachievement of students in the province's Grade 9 Applied mathematics course. For her doctoral dissertation,

Macaulay (2015) examined one school in each of four regions in Ontario that had shown high scores or great improvement on the Education Quality and Accountability Office (EQAO) Grade 9 Applied province-wide mathematics assessment. Through observation, interviews, and collecting artifacts, she searched for commonalities between the Applied mathematics classrooms in these "successful" schools. Although considerable attention is given to school resources, professional development, and the leadership styles in the school, Macaulay emphasizes that reform-based teaching practices were found in each of the four case studies. Situating her findings in social constructivism, Macaulay asserts that these cases engage the learners in active, inquisitive mathematics learning, view students as competent learners, set high expectations, and seek to build students' confidence. Although she does not specifically mention growth mindsets, she calls for future research into the pervasive negative self-concepts of students taking the Applied mathematics course. Examining growth mindset approaches in Grade 9 Applied mathematics classes is one avenue of research that could meet this need.

The OAME Project is another study focused on enhancing teaching and learning in Grade 9 Applied mathematics in Ontario (Suurtamm et al., 2017). In this section, I summarize some of the findings reported by the researchers. In the remainder of this thesis, I describe my secondary analysis of some of the data from this project. The purpose of the OAME Project was to enable participating educators to increase their knowledge of the Grade 9 Applied mathematics curriculum, identify and share successful pedagogical strategies, cultivate leadership, and improve student achievement. Ten PLCs met during the 2014-2015 and 2015-2016 academic years. Each PLC had 8-12 participants made up of mathematics teachers, special education teachers, school or school division mathematics curriculum leaders, and school administrators. Meetings took place about once a month during the school year in the PLC's respective school

settings for a full day. At the outset of the project, each PLC discussed the challenges they encounter in teaching the Grade 9 Applied mathematics course and chose a few specific inquiry goals for the year. Subsequent meetings allowed the PLCs to discuss and modify goals, develop strategies, lesson plans, assessments, and learning activities, and debrief after new approaches were attempted. The collaborative approach was documented by research team members who attended PLC meetings and prepared year-end case study reports. The researchers also conducted focus group interviews and individual interviews with participants in each PLC. Data was collected in the form of audio recordings and transcriptions of the monthly meetings, focus groups and interviews, as well as related artifacts. The ten PLCs also got together to share their experiences several times during the project and at the end of the project the PLCs were invited to share their experience with teams from schools from across Ontario.

The areas of focus chosen by the PLCs were identified as using rich tasks, assessment practices, algebraic thinking, curriculum exploration, and creating positive learning environments, the last of which often emphasized shifting student mindsets (Suurtamm, Lazarus, & McKie, 2017). The researchers noted that "focusing on growth mindset includes believing that all students are capable of engaging in mathematics activity" and that teachers who "value students' ways of thinking" enable student success (p. 41). They recommended that teachers should have high expectations for students, and also made recommendations for increasing the engagement of students by providing a safe space for students to take risks, and using a variety of problem solving tasks as well as assessment strategies. These recommendations seem to me to tie into growth mindset as well. For this study I analyzed the data from a single PLC that maintained a considerable focus on growth mindset throughout the OAME Project.

Gaps in the Literature

In this literature review I have sought to reflect the broad nature of research on mindset, beginning with studies of the influence *of* mindset on achievement, and then discussing studies of the influences *on* mindset, through interventions that directly address mindset, as well as in the messages students may receive from instructional approaches and from course structures such as streaming. I have also drawn attention to the fact that the majority of the research has been conducted in the United States and focuses on factors that encourage growth mindsets with groups of students in non-streamed courses. This thesis aims to fill a gap in this research by exploring Canadian teachers' experiences with implementing growth mindset in a streamed course that is comprised of higher numbers of underachieving mathematics students. Toward the conclusion of the intervention study by Paunesku et al., (2015), the authors call for further research in different contexts to "reveal settings in which mind-set interventions are redundant with messages already present or in which students lack access to challenging learning opportunities" (p. 791). While this thesis is not an intervention study, it will provide insights that relate to Paunesku et al.'s request for research in varied contexts. Furthermore, while the studies conducted provide evidence to support the use of mindset resources, I have yet to locate studies that investigate why or how teachers are using these resources. As noted, Sun (2015) contributes a framework for what mathematics teaching for a growth mindset can look like, but she also invites further studies to "seek to understand the life span of a mindset norm, examining teachers over time and identifying when a mindset norm is established and how it is supported (or not) throughout the academic year" (p. 173). I believe my study helps to address the call of Sun as it explores the ways growth mindset might be taught over time and how teachers perceive the use of mindset approaches.

Chapter 3: Research Design and Methods

In this study I sought to explore educators' perceptions of using growth mindset approaches in Grade 9 Applied mathematics classes through secondary analysis of data from a single case study collected in the OAME Project (Suurtamm et al., 2017). In this chapter I begin with stating the specific research questions and offering a rationale for the methodology I have chosen. I also discuss my positionality with regard to this study. I then provide a detailed description of the case before I outline the methods for data selection and analysis. I end this chapter with a discussion of the study's trustworthiness.

Rationale for the Methodology

As I noted in Chapter 1, I learned of growth mindset as I was seeking to find the best practices to reach underachieving students in my role as numeracy support teacher. Through examining the research about mindset and mathematics, I was led to ask deeper questions about the use of mindset in mathematics and how understandings of mindset are formed. I determined that the best approach for this inquiry would be a qualitative study, since "qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences" (Merriam & Tisdell, 2016, p. 6). The data I had access to from the OAME Project consisted of transcripts from focus groups, PLC meetings, and individual interviews, and artifacts such as photographs. This collection of information from multiple sources also lent itself to a qualitative approach (Merriam & Tisdell, 2016). Therefore, I selected a qualitative case study research methodology to pursue my research questions which are stated with reference to the OAME Project data:

1. How do the educators in this PLC understand mindset as it relates to mathematics teaching and learning?

2. What strategies or approaches are used by these educators in their desire to foster a growth mindset in a mathematics classroom?

3. What are these educators' perceptions of the (a) value of and (b) obstacles associated with using growth mindset approaches in the context of an Applied mathematics course?

Qualitative research centers on the processes within and interpretations of a reality that is contextually bound and case studies can provide rich descriptions of those bounded units (Merriam & Tisdell, 2016). The case I chose to explore had its limits defined by the original OAME Project, namely the interactions that took place in a PLC at a secondary school in rural Ontario. I selected this case from among the other PLC cases in the OAME Project due to the participants' sustained focus on the concept of growth mindset. Yin describes a case study as "an up-close and in-depth inquiry into a specific, complex, and real-world phenomenon" (2015, p. 194) where "contextual conditions…might be highly pertinent" (Yin, 2009, p. 13). I believe the mindset phenomenon in mathematics education fits the "specific, complex, and real-world" conditions of Yin's definition of case studies, as does the influence of the context in which the phenomenon was explored (i.e. a Grade 9 Applied mathematics course rather than an Academic or non-streamed course).

Statement of positionality. The methodology of the study was inspired by my belief in a social constructivist epistemology for education (Charles, 2018). I value the knowledge created through the shared experience of the PLC members, and view teaching and learning as an interactive, dynamic process of meaning-making where individual and collaborative experience is key. I also recognize that any assumptions were created through my interactions with the data, and are very much influenced by my position as a Grade 9 mathematics teacher and support teacher as well as by my beliefs about growth mindset, which I discussed in Chapter 1. At the

same time, my experience working with Grade 9 mathematics students and teachers has given me a valuable lens with which to view the data; I understand many of the complexities of attempting to foster growth mindset with underachieving mathematics learners at the secondary level as I have attempted it myself. Therefore, the research questions I set out to pursue and the interpretations I make in this thesis have been filtered through the lens of my experiences and can be described as "the researcher's understanding of the participants' understanding of the phenomenon of interest" (Merriam & Tisdell, 2016, p. 25).

Selection and Description of the Case from the OAME Project

I used the research report provided by the OAME Project research team (Suurtamm et al., 2017) as well as a case study report prepared by the research assistant involved in the project to gather information on the case I chose to use. At the onset of the project, OAME invited applications from schools in Ontario where English is the language of instruction. OAME then selected 10 schools from the applications that were submitted. These schools each formed a PLC that participated in the OAME Project. The schools understood that the emphasis of the project was collaborative learning, and applicants had to ensure that their team included Grade 9 Applied teachers, special education teachers, mathematics leaders, and school administrators. Funding for the project provided one full day of release time per month and resources to support the PLC members as they discussed and attempted new strategies to align with the Grade 9 Applied mathematics curriculum (OME, 2005). The PLCs were also invited to take part in a research component of the project, which gave the research team permission to document the activities of the PLCs over the two years. As noted, each of the 10 school-based PLCs were assigned a researcher or research assistant to attend monthly PLC meetings, to record, observe, and report findings, and to support the work of the PLC.

Data selection. As I was writing my thesis proposal, the lead researcher on the OAME Project granted me access to a research report about the project. Given the massive amount of data gathered in the project, I wanted to locate the PLCs that included mindset-related discussions, both in quantity and quality. I identified six PLCs who described a mindset approach in relation to one of their goals during the project (Suurtamm et al., 2017) in my initial reading of the report. After I received Education/Nursing Research Ethics Board (ENREB) approval for secondary analysis of data, I read detailed case study reports from each of the six PLCs who indicated a focus on mindset. I then read the first meeting transcripts from some of these PLCs to gather further information as to which of the cases seemed to address my research questions. Throughout this process, I was careful to maintain the anonymity of the participants.

My original intention was to conduct a cross-case analysis using several PLCs, depending on the intensity of dialogue and engagement with mindset found within the PLCs. As I began to appraise the six cases using the reports, I realized that mindset goals seemed to be interwoven into a larger set of goals for most PLCs, or that mindset was discussed in the first few meetings but then usurped by other goals. One case, Case X, quickly came to the forefront as the PLC that kept mindset as a centrally-focused goal over the two years. For instance, I noticed that the Case X PLC engaged in many lengthy discussions of mindset and had planned and implemented many activities related to mindset as they participated in the OAME Project. I determined to move ahead with an in-depth analysis of a single case rather than a cross-case analysis. Thus, while case study reports from the project assisted with the selection of Case X as my focus, my own detailed analysis of the transcripts is the basis of this thesis.

Description of the case. Case X in the OAME Project involved educators at a mid-sized Grades 7-12 school attended by students from surrounding rural communities with a range of

demographics. From 2010-2014, students in the Grade 9 Applied course at the case study school were noted to be underperforming in the EQAO Grade 9 Applied Mathematics assessment in comparison to other Grade 9 students enrolled in the Applied course in the board. In the two years of the project, the school had one Grade 9 Applied course each semester, with class sizes varying from 16 to 26 students. The same teacher taught all Grade 9 Applied mathematics classes over the two years except for the last semester of the project.

The PLC had six members in the 2014/2015 school year, and eleven members in the 2015/2016 school year. Table 1 describes each member's job title, participation in the PLC, and any information about their teaching experience garnered from the transcripts. Throughout this thesis, individuals are referred to using their job titles as identified in Table 1. Attendance at each meeting in the first year was consistent for most members, except for the Special Education Teacher whose attendance dropped off by the end of the project, and the Vice Principal and Board Mathematics Lead who occasionally missed meetings or parts of meetings as their responsibilities called them elsewhere. In the second year, additional team members from Grades 7, 8 and 10 were invited to join the PLC, as listed in Table 1. At the end of the project, the Vice Principal expressed that they had expanded the PLC because they were aware of the value of growth mindset and wanted to collaborate with Grade 7, 8, and 10 educators as they continued to work on mindset (Meeting 2.7, line 67-68). Team members varied somewhat each semester of the second year, and attendance was more sporadic for several participants.

Table 1: Overview of Participants

Job Title	Summary of Participation	Teaching Experience
Vice Principal	PLC Facilitator; Year 1 and 2 (10 meetings); Summer Institute meeting; individual interview	no high school mathematics teaching experience
Mathematics Department Head	Year 1 and 2 (12 meetings)	no data available
Grade 9 Applied Teacher 1	PLC Facilitator; Year 1 and 2 (11 meetings); Summer Institute meeting; individual interview	20+ years in Grades 9-12 mathematics; 4 years as a board mathematics coach
Special Education Teacher	Year 1 and 2 both semesters (5 meetings)	no data available
Differentiated Instruction Coach	Year 1 and 2 (12 meetings); individual interview	10+ years in Grades 9-12 mathematics
Board Mathematics Lead	Year 1 and 2 (10 meetings); individual interview	no data available
Grade 8 Teacher 1	Year 2 only (5 meetings); individual interview	20+ years in elementary education
Grade 8 Teacher 2	Year 2 only (7 meetings)	no data available
Grade 8 Special Education Teacher	Year 2 only (7 meetings); individual interview	10+ years in elementary education
Grade 10 Applied Teacher 1	Year 2, first semester only (4 meetings)	no data available
Grade 9 Applied Teacher 2	Year 2, second semester only (2 meetings); individual interview	10+ years, new to Applied mathematics
Grade 10 Applied Teacher 2	Year 2, second semester only (2 meetings)	new to teaching Applied mathematics

In their application to join the OAME Project, each PLC was asked to describe a problem of practice, propose goals, and develop an action plan. The Case X team identified their problem of practice as how they could address gaps in students' understanding by using open tasks and discussion-based teaching while also addressing the curriculum requirements for the Applied

course. Given this problem of practice, the PLC proposed a goal of exploring approaches to fostering growth mindset with the students in the Grade 9 Applied mathematics course, anticipating increased engagement, risk-taking, persistence, self-awareness, and achievement on the Grade 9 Applied EQAO assessment. Growth mindset was already established as a goal at a school-wide level, and staff meetings included videos and discussion of mindset. The PLC members were familiar with mindset theory and seemed to have had some former experience with the approach prior to the start of the OAME Project. For their plan of action, the PLC determined to examine the Applied curriculum, review books on effective approaches for mindset as well as questioning, and create open tasks. They also proposed documenting their own learning as well as their students' by collecting evidence through formative assessments, observations, reflections, and student interviews. For the second year, the team's plan was to continue developing student mindset and consider teacher mindset as well.

Although the central focus of this PLC was growth mindset, other topics were discussed over the two years including using a discourse-based strategy for collaborative problem solving, and strengthening students' number sense and proportional reasoning as part of their curricular learning goals. As my analysis reveals, these topics intertwined with the PLC's goals and were sometimes connected back to mindset.

The team met six times in the first year of the project and seven times the second year. The OAME and project researchers also held a Summer Institute for the PLCs in the summer before the second year of the project but only the Vice Principal and Grade 9 Applied Teacher 1 from this PLC were able to attend. Toward the end of the second year, seven PLC members gave short individual interviews describing their experience in the project. For this thesis, the data I analyzed is the anonymized transcripts from: 13 team meetings, the meeting team members held

at the Summer Institute, and the seven individual interviews. I was also able to view two digital artifacts identified in the transcripts. A summary of this data is included in Table 2.

Table 2: Overview of Data

Date	Identifier Used (Year.Meeting #)	Transcript Length
Transcripts		
November, 2014	Team Meeting 1.1	67 pages (1823 lines)
December, 2014	Team Meeting 1.2	43 pages (1148 lines)
January, 2015	Team Meeting 1.3	17 pages (468 lines)
February, 2015	Team Meeting 1.4	24 pages (670 lines)
March, 2015	Team Meeting 1.5	38 pages (973 lines)
April, 2015	Team Meeting 1.6	28 pages (738 lines)
August, 2015	Summer Institute Meeting	26 pages (675 lines)
September, 2015	Team Meeting 2.1	60 pages (1625 lines)
October, 2015	Team Meeting 2.2	64 pages (1946 lines)
November, 2015	Team Meeting 2.3	50 pages (1354 lines)
December, 2015	Team Meeting 2.4	41 pages (1171 lines)
January, 2016	Team Meeting 2.5	28 pages (827 lines)
March, 2016	Team Meeting 2.6	21 pages (650 lines)
April, 2016	Team Meeting 2.7	45 pages (1173 lines)
January, 2016	Grade 9 Applied Teacher 1 Interview	7 pages (212 lines)
June, 2016	Special Education Teacher Interview	3 pages (89 lines)
June, 2016	Differentiated Instruction Coach Interview	3 pages (83 lines)
June, 2016	Grade 8 Teacher 1 Interview	4 pages (110 lines)
June, 2016	Vice Principal Interview	7 pages (207 lines)
June, 2016	Grade 9 Applied Teacher 2 Interview	4 pages (124 lines)
June, 2016	Board Mathematics Lead Interview	6 pages (191 lines)

Artifacts		
September, 2015	Growth mindset bulletin board photo (jpg file)	
March, 2015	Student self-reflection (pdf file)	

Methods

I engaged in an exploratory approach to interpreting the case study data to identify patterns and create codes (Merriam & Tisdell, 2016) using data tables and concept maps (Daley, 2004). Because this study is a secondary analysis of a case from a larger data set, the following methods section describes how I analyzed the data.

I acquired access to the OAME Project data for Case X (as summarized in Table 2) in two stages (year one transcripts, and then year two transcripts and artifacts), as the researchers had to ensure the data was fully anonymized. As I was not a part of the data gathering for the OAME Project, my initial goal was to immerse myself in every aspect of the team's conversations. I wanted to understand the process the PLC engaged in as they moved forward with their goal, the topics they discussed, and become familiar with the team members in this PLC. In the first read-through I used open coding (Merriam & Tisdell, 2016), making brief comments and reflections in the margins to indicate what concepts or ideas were being discussed. I attempted to use the participants' language as often as I could as I wrote these comments. I proceeded to do this for mindset and non-mindset related conversations (for example, some of my open codes were "defining mindset as effort", "students don't want to struggle" and "open task: patterns"); however, I also highlighted sections of dialogue that stood out to me as relating to mindset.

The second time I read through the transcripts, I began using a word processing program to organize the contextual conditions related to the case, as context is crucial to case study

analysis and important when considering the transferability of the observations (Eisenhart, 2009; Yin, 2015). I wrote a narrative describing the case in as much detail as the anonymized transcripts allowed, and created a timeline of events that included a descriptive sequence of key ideas discussed in each transcript. Through the timeline, I was also able to view which concepts were revisited over the two years of the project.

As I worked through the data again, focusing on the codes related to mindset, I entered an iterative process of reading, documenting, and organizing recurring ideas into categories. In order to stay flexible to patterns emerging from the data, I created a spreadsheet called 'Keywords' using the open codes I had jotted in the margins. I entered 95 mindset-related open codes into the spreadsheet as I read through the transcripts. During this process, I also engaged in analytic coding (Merriam & Tisdell, 2016) on the spreadsheet to group the open codes into tentative categories such as "mindset surveys", "streaming", "view of mistakes", "teacher challenges", and "strategies". Beside each code on the spreadsheet were columns for each of the 21 transcripts where I indicated if the code was discussed within that transcript. In that manner I could quickly see when a code emerged and which codes occurred in multiple transcripts.

At this point I returned to my research questions and considered how they related to the main category codes on the keyword spreadsheet (Yin, 2009). I then began to highlight with different colors the subcategories (open codes) that related most closely to each research question: PLC members' understandings of mindset (research question 1), strategies they used in their desire to foster a growth mindset (research question 2), their perceptions of its value in their classrooms (research question 3a), and their perceptions of obstacles associated with the approach (research question 3b). I then created a word processing document for each of the four colors, and went through each transcript a fourth time in order to cut and paste segments of data

into each document, making sure to note the identifying information to locate the dialogue within its context when necessary (Merriam & Tisdell, 2016).

After I had completed the transcripts from the first year of the project, I realized the four tables were becoming unmanageably long, and so I decided to create four concept maps based on the dialogue in each table, since concept maps can assist in condensing large amounts of data into one visual document that may expose patterns and aid in further categorization (Daley, 2004). Using the first year transcript segments, I took short data quotes and developed a diagram of their connections to other quotes and marked recurrent words or phrases. I considered the quotes that had many connections and/or were repeated to be emergent themes. In this way, I refined my tentative categories from the keyword spreadsheet by reflecting on the "levels of hierarchy, interconnections and repeated concepts" (Daley, 2004, np) in the four maps. I created new tables for each category from these maps, reorganized the data segments from the year one transcripts into the new tables, and began the process of cutting and pasting dialogue from the second year transcripts into these new tables.

With the year two data, I was able to test and amend my categorization system into eight categories and several sub-categories. For instance, I modified the category from year one titled "approaches to teaching growth mindset" to "explicit strategies" and "embedded strategies" based on year two transcripts. The revised categories that emerged were: measuring mindset, embedded approaches, explicit approaches, process of teaching mindset, barriers to mindset, concrete experience, educators' responses, and value for students. Since I had valued the effectiveness of concept maps to understand the connections and meaning that participants make among concepts (Daley, 2004), I decided to create new maps for each category and sub-category (see Appendix A for an example) and I referred to these maps as I wrote about my observations.

Trustworthiness

Creswell and Miller (2000) developed a framework of procedures qualitative researchers can use to increase a study's trustworthiness, as viewed through the lenses of the researcher, the study participants, and of external readers. As this study was a secondary analysis of data, I was unable to contact participants. Therefore, I focus on strategies that enhance the credibility of my inferences through the lenses of the researcher and of external readers.

Lens of the researcher. As a researcher, I systemically analyzed the data to develop emergent themes based on multiple evidence sources (PLC meeting transcripts, focus group and interview transcripts, and digital artifacts). Working with multiple sources (Creswell & Miller, 2000) allowed me to understand the different participants' perspectives and get a sense of the way their perspectives might have shifted from meeting to meeting or from the comments they made in a meeting to their individual interview comments. In the analysis phase I also sought out disconfirming evidence (Creswell & Miller, 2000) for the categories I had identified. These negative cases were highlighted on the concept maps I created and are considered in my discussion of the research questions. Throughout the analysis, I also kept a journal where I recorded the process I was using, my initial and ongoing observations, and any assumptions or connections I was making with the data, including my personal reactions. This act of researcher reflexivity (Creswell & Miller, 2000) helped me to engage in ongoing reflection and to be more aware of potential bias from my positionality. Providing the background for the study and the rationale for my methodology also helped me to identify these biases.

Lens of external readers. Creswell and Miller (2000) also indicate that detailed descriptions help establish credibility for external readers. I used my journal to construct a detailed account of the research procedures I used and provided a contextual picture of the case

setting and participants to enable readers to determine the transferability (Eisenhart, 2009) of the observations to other contexts. Lastly, I allowed the precise language from the PLC members to be reflected as much as possible in my data analysis and discussion of the research questions.

To verify the accuracy of my interpretations, I used a form of debriefing (Creswell & Miller, 2000) by sharing the analysis process and codes with my thesis advisor, who was one of the researchers on the OAME Project and had recently reviewed all of the transcripts. She was also able to communicate with the lead researcher and the research assistant from Case X to clarify details when ambiguity arose in the transcripts. Being knowledgeable about the project and the mindset phenomenon, she, as well as the lead researcher on the OAME Project who was on my thesis advising committee, were also able to challenge my interpretations. This debriefing adds credibility to interpretations I have made from the data.

Chapter 4: Observations

The purpose of this study is to explore educators' experiences using growth mindset approaches with underachieving Grade 9 mathematics students. Through 21 transcripts, I observed the conversations and interviews of a group of 11 educators as they met monthly over two years to discuss their approach to implementing growth mindset in a Grade 9 Applied mathematics course in Ontario. For the most part, I present these educators' perceptions as collective understandings, although I acknowledge distinct views and positionalities are held by some members of the PLC. When an educator's perspective did not appear to align with what seemed to be a shared view, I have drawn attention to it. I do not present the observations from the PLC entirely chronologically as my purpose was not to look at the progression of their mindset thinking over time, but to consider these educators' experiences as they relate to my research questions. My observations are discussed in three sections, one for each research question.

Question 1: Understandings of Mindset

The first question of the study focuses on how these educators understand mindset as it relates to mathematics teaching and learning. A broad range of understandings, all bundled under the mindset "umbrella", a term used by one participant, emerged as these educators identified and considered the development of growth mindset in their classrooms over the course of the project. Grouping these understandings into themes was an iterative process for me, as conversations often involved similar perceptions, with ideas overlapping or seeming to stem from each other. I have chosen to present the findings for this research question as five themes of understanding, each representing a perceived characteristic of mindset. I describe the understandings in a way that allows for the previous theme to inform the next, arranged as

follows: Mindset (1) is changeable, (2) is the redefining of success, (3) is rooted in experience, (4) is both knowledge and action, and (5) is measurable. After I share the observations for each theme, I reflect on how they may apply to my conceptual framework.

(1) Mindset is changeable. Throughout the data, these educators' view that mindsets can be changed was expressed in various ways. Some described the change to a growth mindset as developing optimism toward a given task. For instance, Grade 9 Applied Teacher 1 summarized her understanding of mindset in this way:

> Mindset is that whole idea about, to me, whether you're, whether you sort of think 'oh I can never learn that' or 'if I just sort of work at it a little harder maybe I can get some of it' so that's, there's that whole, there's fixed mindset and the growth mindset. The fixed mindset is that, I have that ability and I can't change. Versus in the growth mindset is, you can change. Like you can learn things, and you may not become, you know you may not excel at everything. But you can always be learning and moving ahead. (Meeting 2.1, lines 87-91)

Another educator embraced the idea of developing optimism by talking about changing mindsets as the process of discarding pessimism. She suggested, "What the students have to unlearn might be to automatically make negative comments" (Vice Principal, Meeting 1.5, lines 464-465) and at another time talked about giving the students new language to replace "I can't" sentiments: "I think these words are really important, to give them that. And . . . that's not going to happen overnight. But I think it's fair enough that we spend a little bit of time, trying to un-program that" (Vice Principal, Meeting 2.5, lines 110-112). This statement also points to a perception that changing mindsets is a slow process, or may follow a continuum. For example, at the end of the project, one PLC member reflected, "So I think to really see the effect [of the

mindset approach], we would have to keep coming back to it long term, over a number of years. And even mindset, mindset you can't do that in one year, you start in grade 7, but really, it's a process" (Differentiated Instruction Coach Interview, lines 37-42). Similarly, Grade 10 Applied Teacher 2 reported that he asked his students, "What your mindset is when you start this class today – are you trying? Are you giving up? . . . This is your life experience, we're always on a continuum" (Meeting 2.6, lines 53-55). The belief in a gradual transition from fixed to growth mindsets sometimes seemed to fade for these educators when students did not embrace growth mindset immediately or when they seemed to revert to fixed mindsets. While the PLC may have agreed that mindset change is "not a light switch" (Vice Principal, Meeting 1.5, line 462), some of the ways they anticipated change also suggest otherwise. I consider this tension when I discuss the view that mindset is measurable.

(2) Mindset is the redefining of success. These educators also seemed to recognize that to establish a growth mindset culture, they had to redefine what success looked like in this mathematics learning context. Particularly in the second year of the project, they often talked of replacing the performance-driven definition of success with a progress-based definition, and related these definitions to their understanding of mindset (i.e. to have a fixed mindset meant you are focused on attaining high marks, and to have a growth mindset meant you are focused on effort and improvement). The following excerpt exemplifies this notion of success-as-progress.

> Grade 10 Applied Teacher 1: [It's] incremental improvement each time, again that's the thing where we go out to the growth mindset, we're not going to get to our destination in one step, we have to take many many small steps, the Japanese kaizen. I don't know if you've heard of that word before, it's the idea – the Japanese word, phrase – that means incremental improvement. We're not going to

> get there in 10 seconds, it could take a while to get there but we're making progress every time we try something. We get a tiny bit closer.
>
> Vice Principal: Maybe what we need to do is take a look at what mindset would look like, then. What would a growth mindset look
>
> Differentiated Instruction Coach: Oh, I have an idea.
>
> Vice Principal: Oh [name of Differentiated Instruction Coach] is excited.
>
> Differentiated Instruction Coach: Growth mindset, to me, is this huge thing, this huge umbrella. As, while you guys were all talking, I was thinking about, what about redefining what success looks like. So if we can put that in concrete accessible terms, then the growth mindset kind of follows along with that . . .
>
> Grade 10 Applied Teacher 1: 'Have I gotten further than I did yesterday,' that's success. (Meeting 2.1, lines 565-582)

Several notions of success emerged in the dialogue over the two years, but the idea that redefining success meant reforming assessment strategies is one that was revisited time and again. The Vice Principal voiced her opinion of the change in assessment by saying, "I think I really like this idea and I like the idea of not making it cumbersome – just providing some evidence that they've grown, and maybe it's not, you know all of a sudden getting an 80, but you know what, I learned from this little task here" (Meeting 2.4, lines 457-459). While incorporating mindset teachings into their assessment practice, the PLC members identified success as a willingness to try and being better than before. The excerpts below were taken from a longer conversation at the end of the second year where several participants talked in comparative language about their definitions of success prior to their awareness of mindset theory and as it

relates to their current views. They discussed success from the perspective of an athlete, and continued the conversation this way:

> Differentiated Instruction Coach: I don't know, but maybe taking that [notion of success in sports] to math, that success isn't always being right. It's trying and learning the big ideas. Anyway.
>
> Grade 9 Applied Teacher 2: Redefining what the outcomes are . . .
>
> Grade 10 Applied Teacher 2: I can do one of the problems today, that's a success. I couldn't do any yesterday. And it's like, 'What's your measure of success?' . . .
>
> Grade 8 Teacher 1: Yeah, the more success they get is breeding the desire to have more success.
>
> Vice Principal: Our definition of success, to the teachers who're working on mindset, it wasn't about, oh you know, not all getting 95%, is that the kids were trying, that's it. That trying what can we do to support trying? And I know [Grade 9 Applied Teacher 1] tried portfolios and I think she said the kids found it a struggle to do, but in the portfolio . . . what you talked about is getting the students to reflect, I don't know, that all comes back to assessment, right? (Meeting 2.6, lines 426-465)

The mindset-oriented assessment strategies discussed by the PLC are described in more detail in the discussion for the second research question.

(3) Mindset is rooted in experience. My analysis also revealed a perception held by the participants that mindset beliefs stem from personal experience. This understanding is explained in two parts: their views of how mindset is shaped by past experiences and then by present experiences.

Past experiences. These educators seemed to feel that students in Grade 9 Applied mathematics have fixed mindsets toward their ability to do mathematics because of their prior experiences with mathematics. This view emerges first in the data through inquiries made about parents' mindsets as well as experiences with mathematics at home. Several of the PLC members drew on their experiences to make this association in the first PLC meeting.

> Special Education Teacher: It is, it most certainly is [about the math you do as a family]. But also it depends on, like, I think . . . these kids are coming, they, in their homes, their parents, they subscribe to the theory, I'm going to say generally speaking, you can either do it or you can't. You were born with it or you weren't.
>
> Board Mathematics Lead: Absolutely.
>
> Researcher: And I wasn't good at it, therefore you
>
> Special Education Teacher: And that's how I was raised up, is that your big brother can do math, and you can't. But you can read novels and write about them, but he sucks at that, like it was funny it was just the understanding was that he was a boy and he can do math, and I was a girl and I was going to have a math issue, and I did. (Meeting 1.1, lines 993-1001)

In year two of the project, the suggestion was made to survey students about their parents' views of mathematics and how mathematics is talked about in the home. Further evidence of the PLC's view that fixed mindsets may stem from parental beliefs about mathematics ability is found in the fact that they proposed extending their growth mindset instruction to parents through conversations at parent-teacher meetings, student-parent mathematics nights, and adding a simple growth mindset information page to the school website.

Participants also felt that mindsets could be influenced by prior experiences in school. They suggested several educational experiences as reasons that Grade 9 students enter the Applied mathematics course with fixed mindsets, discouraged, with anxiety and avoiding mathematics. In one conversation half way through the first year, the PLC (who had yet to extend their group to include other grades) discussed how Grade 7 and 8 teachers may feel pressure to prepare students for high school. They surmised that this pressure may lead teachers to have higher expectations for students' independence and offer fewer scaffolds for learning. They felt this would have an effect on students' perceptions of themselves as mathematics learners, as noted in the following excerpt.

> Board Mathematics Lead: I think sometimes those teachers try to make the kids fit the high school mold. And that's a big jump for an 11 year old. Or 12 year old . . . So it might be a transition that's just too hard . . .
>
> Differentiated Instruction Coach: So you're saying that harsh transition the students are internalizing that and becoming overwhelmed and scared and putting up a wall.
>
> Board Mathematics Lead: Maybe. (Meeting 1.4, lines 132-163)

The perception seems to be that the students carry these mathematics fears with them into high school, where they resist changing to a growth mindset. I elaborate on this idea when I discuss the view of ingrained mindset beliefs for the third research question.

This research also indicated that labelling students according to ability in earlier grades may also affect students' mindsets when they reach Grade 9. In the first meeting of the first year, when an anecdote was shared about a student excusing herself from trying on a test by saying she had memory difficulties, one PLC member commented, "I feel like someone has told her that in the past" (Board Mathematics Lead, Meeting 1.1, line 1422) and on several occasions in the

second year the Grade 8 educators in the PLC associated labelling students according to learning styles with supporting a fixed mindset in students. The following conversation occurred as Grade 10 Applied Teacher 2 wondered where his students' understandings of mindset came from.

> Grade 8 Teacher 1: Well I think this is where there's a gap with the learning styles information that we give them. So when you do that learning styles they say, 'I'm only this type of learner.' They start to put themselves in a box. So somehow we have to get them to say, 'Well no, that's a strength that you can you're comfortable but you can learn every style.' But they've pigeon-holed themselves from that. Some of them. And I find that really interesting, because they'll come in and say, 'Oh no no, I can't do that, I'm only auditory,' or, 'I'm only visual.' And I'll say, 'No, we're all everything. But you like to play your strengths.' And they do that with math. They say, 'Well I wasn't logical this, so I'm not good at math.'
>
> Grade 8 Teacher 2: That's from doing those learning things.
>
> Grade 8 Teacher 1: Yes. That's kind of backfired. They've put themselves in a little 'no, I'm this, and that's all I am.' [laughs]
>
> Grade 10 Applied Teacher 2: You're right. It's not intended, but they see themselves as 'I'm not this person anymore. I can't do it.'
>
> (Meeting 2.6, lines 81-93)

These educators seem to be aware of labels students have endorsed in the past, and how those may have contributed to students' fixed mindsets. Discussions of labelling students by pathways (Applied or Academic) and as modified or learning disabled are interspersed throughout the data, and are also addressed as part of the discussion of the third research question.

Some participants also suggested that past experiences with not being allowed to struggle in mathematics may have had an impact on the students' development of mindset. As the Board Mathematics Lead expressed during the first meeting of the project,

> Well, they're not used to being, I don't think they've had that exposure to the grit, to stay in the problem. I think a lot of the times, [Grade 9] is the first year they've been streamed . . . So the [Grade 8] teacher's usually teaching to the middle of the road and feel like the time pressure, well, you've got to move on. So the teacher sometimes succumbs to that. And they're just trying their best, and, just trying to bring everybody with them? My hypothesis. (Meeting 1.1, lines 113-118)

Her statement posits that prior to high school, teachers may not have allowed students to experience as much struggle due to perceived time constraints to complete curricular goals, and the PLC seems to agree that this may contribute to students' fixed mindsets about learning mathematics. Another suggested reason for avoidance of struggle had to do with teachers trying to reduce unpleasant feelings in themselves or their students. For example, the PLC talked about the need for helping teachers to resist the urge to "rescue" frustrated students, and to encourage students to stop expecting to be rescued, exemplified in this excerpt.

> Grade 8 Teacher 1: But some of them just really fall into that trap of
>
> Vice Principal: Oh for sure.
>
> Grade 8 Teacher 1: Of, and it's not all of them.
>
> Board Mathematics Lead: Helplessness. And they've clearly had someone come and rescue them.
>
> Grade 8 Teacher 1: Yeah, helplessness.

> Board Mathematics Lead: Right? And it's really uncomfortable to let a kid struggle, because it's not in any of our nature, because we're teachers.
>
> Grade 9 Applied Teacher 1: And we have to retrain ourselves.
>
> Board Mathematics Lead: That's right. So there's value in the struggle, and it's not comfortable or fun.
>
> Special Education Teacher: And parents don't like it.
>
> Board Mathematics Lead: No, but it's not necessarily bad. (Meeting 2.1, lines 831-841)

These educators connected the idea of past experiences of being "rescued" to students entering Grade 9 with fixed mindsets. I reconsider these ideas in relation to the third research question when I address the barriers to students in the Grade 9 Applied course adopting a growth mindset.

Present experiences. Participants also expressed the view that current experiences with mathematics can influence students' mindsets towards mathematics. This impression seems to stem from the educators' belief that growth mindsets can exist within every student in different scenarios. For example, making reference to students who demonstrated growth mindset while playing sports or video games, Grade 10 Applied Teacher 1 said,

> They don't go 'failed that. I'm gonna, never going to play it again.' Oh my. They get straight back on it, you know. They do have that desire to win and succeed . . . They do have that, it's human nature, it's in them, it's in all of them . . . It's just trying to channel it into the direction we wanted. (Meeting 2.1, lines 703-708)

Interestingly, this participant suggested that teachers are the ones responsible for establishing an environment that fosters growth mindset and that they need to "channel" growth mindset from other situations into a mathematics context. Related to the responsibility for developing growth

mindset, the Board Mathematics Lead wondered aloud where student mindset originates, saying, "I'm starting to think about which comes first, the chicken or the egg, right? And I'm beginning to believe that it all starts with the teacher" (Meeting 1.4, lines 327-328). The sentiment that "it all starts with the teacher" seems to motivate these educators to develop and use strategies to help students experience growth mindset behaviours and then connect those behaviours to mathematics tasks. These strategies are discussed more fully in relation to research question two.

(4) Mindset is both knowledge and action. A theme that surfaced repeatedly during the two years of the project but was only given a label by the PLC members toward the end of the project was the understanding that growth mindsets could be approached from either a knowledge or action position. This idea often emerged in conversations about whether to measure mindset change in students through questioning their knowledge or through observing their behaviour. These two facets of mindset are also discussed in relation to the second research question. The PLC generated specific terms to describe the two approaches in January of the second year as they reviewed students' responses to questions about mindset. The PLC members began to refer to "thinking" as students' grasp of knowledge about mindset and "doing" as students' application or enacting of that knowledge in their learning. The following conversation suggests some ways the participants understood this distinction.

> Grade 8 Teacher 1: And it's interesting because then when I think about how do I approach it [growth mindset] as a teacher. I think I approached it through doing. I didn't really talk about the thinking. Because I thought through the doing, they would get to the thinking after.
>
> Vice Principal: Yeah.
>
> Researcher: Right. And they did. It seems like.

> Grade 8 Teacher 1: Some did, but, do you know what I mean?
>
> Grade 8 Special Education Teacher: I approach it more as thinking…
>
> Grade 8 Teacher 1: Yeah, I did the opposite, because for me I don't like to think about things. It requires action. You do stuff and you learn from your experience. (Meeting 2.5, lines 72-80)

In the final meeting as the PLC was reflecting on the project, they noted that they wanted to be sure that students are "not just identifying the word mindset" but that they can "actually see it in action" (Meeting 2.7, line 91). I found this pattern of looking at mindset as both knowledge and action working itself into many different aspects of these educators' inquiry with mindset, including their perception that mindset is measurable.

(5) Mindset is measurable. The final theme I have chosen to share in relation to these educators' understandings of mindset is the idea that mindset is measurable. The PLC's inquiry into developing growth mindset included several attempts to gather evidence that would show if their efforts were having an influence on students' beliefs. The participants considered explicit forms of measuring growth mindset such as surveys as well as observations of growth mindset behaviours. I present these two strategies separately.

Measuring mindset through students' beliefs. In the first year, the PLC focused on measuring students' current beliefs about their abilities in order to establish a "baseline", as they called it, from which they might later measure students' progress. Their use of mindset surveys and questionnaires, discussed more fully in relation to the second research question, provides further evidence that these educators' see mindsets as changeable, and suggests that at this point in their inquiry they felt a measurable change was possible within a four-month semester. However, after the first year there was a gradual shift away from the use of explicit measurement

and during the first meeting with the new PLC members in the second year, Grade 9 Applied Teacher 1 commented that measuring student ability beliefs had not provided the evidence the PLC expected. “I don’t know if we saw a change in mindset, you know, whether we had any results from our surveys last year, whether we can actually say anything because there was a little bit of iffy-ness about them” (Meeting 2.1, lines 9-11). However, later that year the Vice Principal returned to the idea of using surveys, asking, “I just wondered if it would be valuable – maybe I’m jumping ahead to like counting and stuff like that, to know who actually could tell us, how many kids could tell us what open and closed [mindset means] and kind of get it right” (Meeting 2.5, lines 145-147). I wonder if, as a school administrator and project facilitator, the desire to see clear evidence of the success of students’ understanding mindset, and then moving from a fixed mindset to growth mindset prompted her push for using “the survey just for speed” (Vice Principal, Meeting 2.6, line 99).

I also noted that these educators were still attempting to define mindset halfway through the final year of the project. I wondered if not having a clear definition of mindset made it more difficult for them to decide how to measure it. The following excerpt exemplifies the variety of ways growth mindset was described in January of the second year.

Vice Principal: What’s an open mindset? What’s a mindset?

Grade 8 Teacher 2: Just, power of positive thinking, being able to do things.

Persevere when you fail.

Grade 8 Special Education Teacher: Practice.

Grade 8 Teacher 1: I think it’s more, that purposeful action . . .

Board Mathematics Lead: Just be more reflective.

Grade 8 Teacher 1: Yeah.

> Board Mathematics Lead: About your
>
> Researcher: That's a nice phrase, purposeful action. [others agree]
>
> Vice Principal: And Carol Dweck just defined it as, do you really think intelligence is fixed or is it something you can build on after hard work and all those things. So that's, that's pretty simple . . .
>
> Grade 8 Special Education Teacher: and it also is looking at the [positive] stuff that is happening. (Meeting 2.5, lines 438-470)

This is the only occurrence in the data where these educators' defined mindset in relation to beliefs about intelligence, otherwise the meaning of mindset was expressed mostly using verbs indicating various student behaviours. I discuss the idea of extending the definition and measurement of mindset into behaviours next.

Measuring mindset through student behaviours. The second way these educators sought to measure student mindset was through observing behavioural change as students tackled mathematical problems. In a meeting early in the first year, there were several attempts to create a focused list of observational criteria to measure student behaviours, which they called "look-fors". For example,

> So one discrepancy I noticed was it seems that student engagement is part of this one [PLC's inquiry goal], and we kind of put confidence and perseverance in this one. Well, yeah, they go together, but there's a whole different – we don't have that. I think we would follow for student engagement? I just want to know, moving forward, are we sticking to mindset, confidence, and perseverance? Or do we want to start looking at engagement? I know they're together, but, it seems to me just based on what we've talked about, we're looking for more confidence,

> perseverance, and mindset, which is what we said here, so we should probably put our goal statement – not that we have to make it all beautiful and fancy, but we should probably revise it. (Vice Principal, Meeting 1.2, lines 168-176)

I also noted that at times it seemed as if these educators were wrestling with where and how to fit the concept of mindset alongside mathematical processes in their perception of these behaviours. To better understand this dilemma, I created a list of all of the behaviours these educators linked to growth mindset in the transcripts across the two years of the project and classified these "look-fors" into three categories (see Table 3). I explored the data to uncover which terms were used more predominately and which terms were regularly connected to a predominant term. The predominant terms became the headings of each category. The connected terms are listed in no particular order.

Table 3: Mindset Look-fors

Willing to try	Persevering	Having a Positive Attitude
Engaged	Practicing	Using positive language
Participating	Accepting feedback	Using mistakes to learn
Having confidence	Being resilient	Having self-awareness
Showing interest	Adapting	Knowing strengths and
Risk-taking	Not shutting down	weaknesses
Asking questions		Setting goals
Not leaving blanks		

A comment from the Board Mathematics Lead during that same meeting may offer some insight into why the PLC was struggling to measure student mindset through their actions. She said, "It's more of a feeling that a teacher gets, right? It's more of a nuance that, you know, you'll start

to see kids volunteering a bit more. Or not shutting down as long. You know? Things like that" (Meeting 1.2, lines 279-282). To this educator, mindset change seemed to be more about teacher perceptions and less about specific measurable outcomes.

From the outset it seems these educators recognized the complex and multifaceted nature of mindset as it overlapped with the subtleties of students' behaviours; they also recognized that mindset may overlap with content attainment. During the Summer Institute meeting between the two years of the project, the Vice Principal expressed a desire to integrate mindset into the assessment of the curriculum's learning goals including the mathematical processes and the content outcomes.

> Vice Principal: [Name of another school] had a really nice template for how they approached learning goals and gap closing. And I think that really dovetails nicely with mindset. Because we didn't find that we necessarily made as clear a connection between doing math and mindset. They were kind of two separate things.
>
> Researcher: Hmm.
>
> Vice Principal: Whereas if the students see the learning goals, and then they can say, 'Am I moving towards that learning goal, or am I shutting down,' you know what I mean? That there is a concrete link there? For the students and I really liked what you were just starting, we're starting to look at the activities that would bring out the learning goals and tying the mindset to that learning goal, so giving the students a context.
>
> Grade 9 Applied Teacher 1: Yeah.

> Vice Principal: And then I started looking at learning skills, and the words that we tied to mindset, so challenges, making mistakes, accepting feedback, perseverance, questions, taking risks, and they fit.
>
> Researcher: They fit nicely, yeah. (Summer Institute Meeting, lines 125-138)

These educators rationalized that giving the students specific content learning goals as targets may allow them to more accurately evaluate their students' mindset behaviours which are similar to the learning skills. Toward the end of the project, Grade 8 Teacher 1 suggested creating a "mindset-friendly" content rubric to speak to the progress made in mathematics learning as well as mindset behaviours, such as saying, "I like how you tried this, you made an arithmetic error, but your thinking was good" (Board Mathematics Lead, Meeting 2.5, line 713). Grade 9 Applied Teacher 1 was skeptical of a combined rubric, and recommended two separate rubrics.

> But don't we have to separate it somewhat? In terms of their academic achievement . . . And their effort of perseverance . . . So if you go through the test, right? And you've got the rubric separate . . . You know, it might be 'I see you tried this problem a few times, or you know, I see a lot of erasing there, so you persevered to try and figure out what it is you want to do,' you know something like that and then, the final mark, so you give them the stuff back with the comments. (Meeting 2.5, lines 769-775)

I discuss more of these educators' conversations around shifting assessment practices in relation to the second research question.

Question 2: Mindset Strategies and Approaches

My second research question asked what strategies and approaches were used by these educators in their desire to foster growth mindset in a mathematics classroom. The observations

appeared to fall into two categories, which I classified as an "explicit" approach and an "embedded" approach, borrowing terms used by the PLC members. The Research Assistant who worked with this PLC made a comment during a PLC meeting that illustrates this perspective.

> I think generally we were talking about, like, we were thinking of explicit activities that we would do with kids, that lets them do these things and practice these things and think about these things. But also another thing is like embedding it throughout the things that we do that's not just the explicit activities. (Meeting 2.5, lines 498-501)

Although at times the line between the two is blurred, I decided to include in the explicit approach those strategies that directly taught about the mindsets, involving formal, whole-class instruction. The embedded approach includes other strategies that indirectly support mindset theory, usually pertaining to mathematical teaching practices. In year two of the project, conversations around ways to facilitate growth mindset extended to the grade levels around Grade 9 and some PLC members mentioned strategies they had seen or heard about in other schools but had yet to try themselves. While my intent for the analysis of this question was to focus on mindset approaches in Grade 9 Applied mathematics, many times there were strategies implemented in other courses that I felt were important for the PLC. Thus, at times I include mindset practices used outside the Grade 9 Applied course but discussed in the PLC meetings.

Explicit approach. Teaching growth mindset to students directly was an approach discussed and used by the PLC as a way to increase students' knowledge and understanding of mindset. I classified the various explicit strategies the PLC members used into three categories: data collection, visuals, and concrete experiences.

Teaching mindset through data collection. The PLC tried several methods of collecting mindset information from the students. As noted earlier, a likert-scale survey was used at the beginning of the Grade 9 course to measure the students' mindsets and compare these with other students in the board who had taken the survey. Grade 9 Applied Teacher 1 also created a 4-item mindset questionnaire (see Appendix B), and used it several times each semester to check for progress. In addition, the students in her class kept mindset reflection journals which were sometimes assessed by PLC members to see if mindset understanding was increasing.

In the second year of the project, discussions around data collection strategies were less frequent. In the first meeting of the second year, as she was recapping the project aims for the new PLC members, Grade 9 Applied Teacher 1 expressed some concerns with the data collection strategies that had been used,

> So last year we were, so we were trying to get some information about whether we could change kids' mindsets, especially about math or just about learning in general. So that, there were a couple of activities that we did, and we, and so one of the things that I tried to do last year was to have kids do a little bit of reflection, which when it comes to 9 Applied students, they weren't wonderful at giving me a lot of, in a lot in writing . . . and I don't know if we saw a change in mindset, you know whether we had any results from our surveys last year, whether we can actually say anything because there was a little bit of iffy-ness about them, just about the questions that were there. (Meeting 2.1, lines 3-13)

Despite her misgivings, other PLC members attempted to collect data in the second year around mindset. One Grade 8 teacher talked about using surveys at the back of the students' journals so they could "gauge where they are now to see whether they moved at all" (Grade 8 Teacher 1,

Meeting 2.4, lines 528-529) and a Grade 10 Applied teacher gave his class the introductory survey to compare the results with results from the same students the previous year, but unfortunately no further mention was made of these follow-up survey results.

The data collection strategies continued to evolve in the second year. Grade 9 Applied Teacher 1 explained how she adapted the individual journal reflections strategy she had tried the first year: "Instead of having them write, I wrote on the Smartboard . . . But I found that towards the end of the second week, they're, you know, tired of doing that. So I've stopped doing [journal reflections] for good." However, she also noted that students continued to make statements that reflected a fixed mindset (e.g. "I'm stupid" or "I can't do this"). Having seen a photo of a mindset themed bulletin board from another school, she commented, "I plan to do that, capturing some of those 'I'm stupid at math' or 'I'm stupid,' 'I don't know this,' that kind of statements and what can we say in place of that, and so, getting the idea of retraining them" (Meeting 2.1, lines 213-221). Thus, the students' negative reactions to the written reflections and their continued fixed mindset comments led this participant to shift to another explicit approach: the use of a visual reminder.

Teaching mindset through visuals. Early in the second year of the project, Grade 9 Applied Teacher 1 decided to create a bulletin board with her students titled "Change your words, change your mindset" (see Appendix C). She emphasized the importance of not creating the bulletin board herself, but inviting students to sort through common mindset statements to put up on the wall. On two occasions she explained to others in the PLC, "You actually have students separate statements that are fixed mindset and open or growth mindset," (Meeting 2.1, line 229) and, "I didn't want it to be put up just by me. So, at least this way, the kids can decide which ones" (Meeting 2.2, line 1665). The Vice Principal added that the chosen statements were

"definitely going to address some of the [negative] statements that the students have made" (Meeting 2.1, line 457), indicating to me that fixed mindsets were again evident in the group of students taking the Grade 9 Applied course in the second year of the project. Using visual materials to increase awareness and help change students' mindsets emerged several more times in the first meeting of the second year as these educators tried to clarify the look and purpose of the bulletin board. They also discussed using bulletin boards in all mathematics classes, not just Grade 9 Applied, as a way to promote consistency and unity as students learn about the mindsets. Several of the PLC members expressed an interest in creating their own visual growth mindset reference point. The Board Mathematics Lead wrapped up that conversation by explaining her opinion on including mindset visuals to the classroom teachers when she stated,

> I like the idea of having them individual, in a room. Because the things on your walls are the things you value. And kids, kids the first things, especially the savvy kids that typically give us a hard time, are the ones that'll look around and they'll figure out what you value as a teacher. So just having something very visual and explicit whether it's generated by the group and it's the same, or generated by the class and you reference it a lot. (Meeting 2.1, lines 1226-1234)

As the second year progressed, a few other "explicit" mindset visuals were created and these teachers followed the Grade 9 teacher's lead by letting students participate in the design. For example, one Grade 10 Applied teacher decided to have her students create a bulletin board of inspirational mindset quotes, and a Grade 8 teacher discussed letting her students decorate their journals with growth mindset images. Grade 9 Applied Teacher 1 also brought up creating two mindset bulletin boards elsewhere in the school, with "one up in the library where other kids would see . . . and also one in the staff room for the staff to see . . . how we can maybe change

[mindsets]" (Meeting 2.1, lines 527-530). I elaborate on the importance of changing mindsets as not just a mathematics goal but as an entire school goal in the embedded approach section.

Teaching mindset through concrete experiences. As I indicated in the first section of this chapter, the participants' view of mindset as rooted in experience seemed to influence how they approached the explicit teaching of mindset. As I examined their conversations, I found that they either used outside events to transfer growth mindset experiences into mathematics contexts, or set up in-class activities to elicit mindset-inducing reactions from students. There were many conversations about the use of these two approaches in various grades. Given my research question, in this section I focus on activities in the Grade 9 Applied mathematics classroom.

Transferring growth mindset from other contexts. One way the PLC members explicitly taught growth mindset was by talking about growth mindset experiences from contexts such as sports, music, drama, or video games. The Board Mathematics Lead shared with the group how having students draw on moments when they have growth mindsets in other areas of their lives may help with a growth mindset in mathematics. She said,

> Sports is a great example of that. Because you'll have a little guy that would stay on the ice for 12 hours, or a little girl for 12 hours and trying [to] land a jump, or score, or do this like toe drag or whatever it is. But when it comes to something else, it's not going to happen. So if you can have them explicitly say somewhere in their life where they had a growth mindset, and then if you can – and I've seen – I haven't done this, but I've seen teachers do this, where they say, 'Remember when you talked about your hockey and how you did that and how you did a lot of work? Keep it up. You can do this' . . . When you guys were asking your kids

> about what, they didn't see how growth mindset affected their math class . . . 'What does this have to do with math?' right? So you have to make that explicit. And one way to do that is to connect it to a real thing, right? Like something they've experienced explicitly. Success after persevering. (Meeting 2.1, lines 686-716)

The participants also talked about using this "remember when" tactic after students watch videos of other people persisting through struggle. Similarly, they suggested using videos highlighting successful celebrities who had overcome hardships or failure such as Steve Jobs, Oprah Winfrey and Michael Jordan, or other role models to inspire students to persevere in mathematics. In multiple PLC meetings in both years of the project, these educators referenced an online home video of a boy who takes 17 attempts to successfully do a flip with his bike after going off a ramp. The PLC members identified positive behaviours in the video that they felt helped with growth mindset such as using feedback, modifying goals, practicing, and not giving up. The following interchange took place early in the second year of the project as these educators were updating each other on their current mindset practices. In this excerpt, Grade 10 Applied Teacher 1 stressed the importance of transferring growth mindset behaviours into the mathematics classroom from other contexts that relate to students' interests and others agreed with his idea.

> Grade 10 Applied Teacher 1: I keep using sporting analogies with my kids. All these great players, are they great because they're really gifted, or are they really great because they work really hard? . . . They don't hit the one to four slap shots and that's it, 'I've mastered it.' They go out, they go out there, you know . . . and I always find to put stuff in their language, what they connect to, and you know, people they know or they look up, or they're into video games, and the video

gamers, do they stop when they, the kids, they've got persistence. They do it in other things, they might not do it in the stuff that you want [them] to do it, but they have persistence elsewhere . . .

Board Mathematics Lead: So when . . . a kid is struggling, actually say to them 'remember the bike video.' That was, you know, 'Remember that?' 'Remember that?' And trying to explicitly connect it back. So some teachers are going to try that next year.

Grade 10 Applied Teacher 1: Well that's good. Well now look back I say, the class, you know, they kinda get in there, but they're struggling and they're getting disheartened. 'But look where you were three days ago.'

Board Mathematics Lead: Yeah.

Grade 10 Applied Teacher 1: 'You almost basically didn't have a clue, look how far you've come in that time.' You know, it's

Lead Researcher: I wonder if that video game metaphor is a better one than the bicycle one?

Board Mathematics Lead: Yeah, I think it would just depend on the kid. You've gotta figure out what's interesting to them.

Lead Researcher: What's gonna, yeah.

Board Mathematics Lead: Or even share their ideas of persever – persistence and bring it back to them.

Vice Principal: And notice when they are persevering in the class.

Board Mathematics Lead: Yeah, be explicit.

> Grade 10 Applied Teacher 1: Like when they are, video game, or drama or music, with drama your first performance is not going to be – you haven't mastered that have you? You know, they are constantly tinkering, the director . . . You know, 'project your voice more, use more of your arms' . . . Again with music, instrument, you haven't quite got the note right, or you haven't quite hit the note when you're singing, it's all there, isn't it. It's practice, practice, practice. (Meeting 2.2, lines 1318-1370).

I also noticed that the PLC members recognized the challenge that existed when students did not link their outside-context growth mindset to mathematics and they seemed to feel that the students in the Applied course in particular had a difficult time relating the two contexts, even after being asked to "remember when." Toward the end of the first year when these educators were first discussing the students' motivation to succeed in tasks they like, one PLC member questioned, "How do we get them to feel that success in math?" (Board Mathematics Lead, Meeting 1.5, line 284). The mathematics context appears to be less hospitable for students' developing and applying a growth mindset than contexts such as sports and video games. I discuss these educators' perspective on this in the observations for the third research question.

In-class activities to elicit mindset. Over the two years of the project, there seemed to be a growing recognition among these educators of the value of bringing out growth mindset using mathematically-based tasks. The PLC explored many mindset-mathematics activities including Boaler's Youcubed website as well as lessons sent to the group by the Board Mathematics Lead. Boaler's lessons received some negative comments, with Grade 9 Applied Teacher 1 objecting to the time commitment and "wide open" structure of the lessons (Meeting 1.2, line 144) and Grade 10 Applied Teacher 1 being concerned it was not "snazzy enough" for high school students

(Meeting 1.3, line 460). Since Boaler's open tasks allow students to move at their own pace and use their own strategies, the lessons on the website may have felt chaotic to some PLC members who might be more accustomed to traditional mathematics instruction. To illustrate, in the first meeting of the project, another member had observed a lesson and commented to Grade 9 Applied Teacher 1, "My perspective was different from your perspective . . . I think you were stressed over some of the behaviour that was going on, but there was still a lot of math happening. So I saw them enjoy math a lot" (Differentiated Instruction Coach, Meeting 1.1, lines 1789-1792).

In March of the first year of the project, Grade 9 Applied Teacher 1 described how she was beginning to structure and incorporate various video lessons into her course. She explained,

> I decided that I would show a mindset video every week, so on Monday morning they see the video and they write down something that grabbed them in the video that they're going to try and put into effect during the week, and then on Friday they re-see the video, and they write down how they've used it . . . we're on our third mindset video doing this, I believe . . . Last week it was *Grit*, this week was *You can learn anything* and next week will be the *Steve Jobs* one and so for those three videos we will tie up together for those mindset activities too . . . Sometimes I actually have the video playing when they walk in on Tuesday, Wednesday, and Thursday too, right? (Meeting 1.5, lines 12-122)

The regularity of the mindset lessons is quite evident in her approach, as is the use of student reflections that focus on the process of learning. At the end of the project the Vice Principal described how the PLC incorporated reflections to explicitly teach growth mindset: "like using

reflection in general in the classroom, not just about math, but how you learn math. And so that's come up. Like using reflection as a tool, as a part of the lesson" (Meeting 2.7, lines 437-439).

An example of a non-video based explicit mindset lesson was a timed puzzle activity involving tangrams introduced during the second year of the project. The students would rotate through tangram stations and record how many puzzles they completed after the allotted time. This was done several times over the course of the semester to give students the experience of success after struggle. The Board Mathematics Lead advocated for the activity by saying, "It's just natural to improve because you start to understand how the [tangram] pieces work" (Meeting 2.1, line 103). To establish the activity's relationship to mindset, Grade 8 Teacher 1 described the experience with her class in this way.

> So we actually did an activity where the kids felt that frustration for the first time. They had to circulate through these tangrams, and was timed, and timer was up on the wall, yeah and they were frustrated, and some of them just gave up, and then we talked about it and what we feel. 'I was frustrated, angry, this is stupid' da da da. And then we talked about, 'Well that's mindset,' right? So next time you do it, you have to have a strategy. What are you going to do? So we talked, then we shared some strategies . . . and then we did it again. (Meeting 2.2, lines 1403-1408)

The students in the Grade 9 Applied course attempted the activity several times during the first semester of the second year, and the teacher noted that "they keep wanting to do it more" (Meeting 2.4, line 951) suggesting it was effective for these learners as well.

The PLC members endeavored to provide explicit mindset teaching rooted in concrete experiences based on contexts inside and outside mathematics. These experiences seemed to be used as a reference point by these educators – a "remember when" moment – to transfer growth

mindset into the mathematics tasks students were undertaking. During the final PLC meeting, several participants noted that drawing students' attention to their experience with growth mindset was an effective strategy as they summarized their view of the value of this approach.

Embedded approaches. As noted earlier, the line between explicit and embedded approaches is sometimes blurry. To distinguish between the two, I focused on the purpose behind a strategy. If a strategy had the sole purpose of fostering growth mindset, I classified it as 'explicit'; if a strategy wove mindset into teaching practices or mathematics content, I classified it as 'embedded'. To embed mindset theory into mathematics classes, the PLC members endeavored to "shift" (a term used frequently by the participants to describe the changes in their approaches) their teaching practices in three ways: shifting language, shifting mathematical tasks, and shifting assessment practices.

Shifting language. I observed the PLC members shifting the language around mathematics learning to encourage growth mindset, particularly with incorporating the word "yet" into their conversations with one another as well as with students, parents, and other staff. For instance, at the beginning of the second year the Board Mathematics Lead expressed a desire to learn how to code, saying, "But I'm nervous about it, because I'm not very great with computers… yet [laughs]. Trying to not be fixed" (Meeting 2.1, lines 1449-1450). They used the word increasingly over the duration of the project to describe student competence with mathematics in a way that did not limit the student's learning potential and frequently reminded one another to add "yet" to their statements, such as when Grade 8 Teacher 2 commented about students' engagement with homework, "[it's] just unfortunate, can't get them all anyways" to which the Vice Principal replied, "yet," drawing laughter from the group (Meeting 2.6, lines 39-

41). Another notable example of a mindset language shift occurred when Grade 9 Applied Teacher 1 recognized her need to alter her language when referring to the Applied course.

> Grade 9 Applied Teacher 1: Maybe we don't say, 'drop down to Applied' it's just 'changed to Applied,' you know, it could just be those little things. To imply that it's not as good or something like that, it's just a, just a different type of course, you know, so that it's even kind of addressing that. I mean I used to say stuff to kids that I know that would indicate that I had a fixed mindset, you know, and it's, you've gotta
>
> Research Assistant: The stigma is huge.
>
> Grade 9 Applied Teacher 1: You have to catch yourself, sort of, no I don't want to say that. I want to say that everyone can do it. So it can be difficult sometimes, and then yeah, it takes a lot of work to change your own way of thinking about stuff. (Meeting 1.4, lines 337-344)

These educators' awareness of the language they used to describe the Applied course continued to grow throughout the project. By the last meeting, the Vice Principal noticed, "But we talk like that too. Like that drop down language isn't just their language. It's, you know, it's language we use too, which this project has been helpful in saying you switch your destination" (Meeting 2.7, lines 182-183).

Additionally, being positive, or speaking positively about ability was repeated often among these educators in association with having a growth mindset. One example of this is the following suggestion of how teachers may rephrase common negative student responses.

> Board Mathematics Lead: Switch from like
>
> Vice Principal: 'I don't understand' to, this is –

> Board Mathematics Lead: 'this is what I what do I understand' 'I don't get it' [to] 'this what I get.' Like focus on the positive. (Meeting 2.1, lines 950-952)

Changing fixed mindset statements into growth mindset statements in this way was also emphasized when Grade 9 Applied Teacher 1 had her students construct a mindset bulletin board. The bulletin board was discussed as part of the explicit approach but can also be seen as an embedded approach showing the PLC members' understanding that the language they used when interacting with students and other staff members was a valuable part of changing mindsets. As the Vice Principal suggested during the final project meeting, "I think that language is something we can draw from when we're in the classroom to turn things around maybe a little bit sooner" (Meeting 2.7, lines 208-210). Despite this awareness, I also noted that the PLC seemed to have an ongoing challenge with consistently embedding growth mindset into their language and I consider some of these inconsistencies at the end of this chapter.

Shifting mathematical tasks. One of the original goals for this PLC was to shift away from traditional approaches to teaching mathematics toward an approach that increased student engagement (Suurtamm et al., 2017). Once the mindset goal was set as a priority, the PLC found that mindset ideas, particularly persistence and engagement, could be embedded into mathematics teaching practices. Many of these strategies were separate agenda items from mindset during the meetings and this seemed to result in explicit dialogue linking the strategies to mindset occurring only rarely. However, I feel it is valuable to share some ways these educators changed their instructional approach to support students' persistence and engagement particularly through the use of collaboration, open questions, and mathematical discourse.

Tasks involving collaboration. From the start of the project, Grade 9 Applied Teacher 1 explained that she used groups with defined roles as set out by Boaler to monitor and increase

participation in problem solving tasks. The students in the Grade 9 Applied course were also given collaborative tasks to complete on wall-mounted white-boards, a strategy called vertical non-permanent surfaces by Lilijdahl (2016). The following exchange took place in the context of students using whiteboards. It highlights the connection participants made between collaborative problem solving and the open nature of learning and growing in knowledge.

> Board Mathematics Lead: It builds the idea that it's a community, and that you're, it's a knowledge building community, it's not working in isolation. It's not competitive, it's collaborative.
>
> Vice Principal: And I think that it also teaches people that it's not finished. We're never finished learning. We're just building on that . . . it's that your understanding gets deeper and deeper, you're not finished understanding stuff . . . And it's okay one person doesn't know something, you're just getting it from someone else and now we're all smarter kind of thing. So that's kind of neat.
>
> (Meeting 1.2, lines 786-792)

Tasks involving open questions. The PLC members explored and used rich tasks that have access points for students at all levels of understanding, often in a collaborative format. Again, most of these activities were not overtly linked to teaching mindset, but were used as a way to engage students. Marion Small and Dan Meyer were mentioned sources for open tasks, and at the end of the first year, Grade 9 Applied Teacher 1 and the research assistant developed a proportional reasoning task involving a "Minions" character made out of sticky notes. The teacher was disappointed with the responses of students, however, mentioning, "they don't like it when I ask them questions" and "they just don't want to do anything" (Meeting 1.6, 67-68),

when describing the task. I discuss perceived reasons the open problems did not have the positive effect on engagement as the PLC had hoped for in relation to the third research question.

Tasks involving mathematical discussions. Early in the second year of the project, the PLC members engaged with the NCTM publication called *5 Practices for Orchestrating Productive Mathematics Discussions* (Smith & Stein, 2011), which was presented at one of the province-wide OAME Project meetings. Almost an entire meeting of this PLC was devoted to discussing and planning a sample lesson using the method of observing students' use of different strategies for problem solving and then presenting and connecting the strategies with the students. The mindset concept that came up during the PLC's conversation about this approach was linked to student engagement. The Board Mathematics Lead had the perception that the problem solving discussions were successful because students weren't focused on "the stress of needing the right answer" (Meeting 2.3, line 426) and were more willing to participate. Although Grade 9 Applied Teacher 1 participated in the planning of the activity with the PLC, there is no further mention of her attempting the strategy with students in the Applied course.

Shifting assessment practices. One of the focuses of the PLC was shifting their assessment practices to embed mindset values into their classroom. The PLC devoted an entire meeting in the second year of the project to discussing ways to think about and implement assessment. During the meeting, the Board Mathematics Lead described her perspective on how assessment may be the key to shifting from fixed to growth mindsets.

> I don't know, your perspective was that it was a little bit fixed, either the kid can do it or can't do it, so there wasn't a lot of grey area. And I was, I'm bumping into that a lot, but it's about assessment, the root of it is assessment . . . and teachers are a bit anxious to change the way they look at assessment because they're still

seeing it as they want to prove what they're noticing about students' ability. (Meeting 1.4, lines 3-7)

The other educators seemed to be in favour of moving from practices that are summative or proof of what they're "noticing," to practices that are formative and can be "used to move kids along" (Board Mathematics Lead, Meeting 1.4, line 8). To describe how the PLC shifted their assessment practices, I first consider the strategies they used to embed the redefinition of failure into their practice and then describe some strategies they used to introduce nontraditional forms of assessment into the classroom.

Redefining failure. Following the theme that emerged in the first research question that looked at mindset as the redefining of success, it appears that the enactment of that understanding in the classroom involved these educators looking at – and encouraging the students to look at – failure as a learning opportunity. For example, several members of the PLC deemed students seeing their Vice Principal make a mathematical mistake during one of her visits to the Grade 9 Applied classroom effective at influencing students' mindsets. They shared,

> Vice Principal: And I liked the fact that they saw me messing up, like I really liked that. Because I think that some of them just assume that they're only messing up.
>
> Research Assistant: And that's helping their mindset too, I would think.
>
> Grade 9 Applied Teacher 1: Which is why I did that, right?
>
> Mathematics Department Head: Mistakes are okay.
>
> Vice Principal: They're okay! (Meeting 1.2, lines 926-931)

Reducing the negative stigma around mistakes was generally accepted by all members of the PLC. At the same time, when it came to embracing mistakes in the classroom, a few of the

educators were a bit more cautious. For instance, Grade 10 Applied Teacher 1 was talking about how he used student exemplars to teach problem solving strategies and said,

> [I'd] throw one of, a made up one, maybe an incorrect one, because you don't maybe want to embarrass the group by getting it wrong, you might want to . . . say . . . 'somebody from last year, or somebody from the other class' or whatever, and just get them to say what do we like about this, what do we not like about this. (Meeting 2.1, lines 1561-1564).

In a meeting later that year when the PLC was creating a lesson using the *5 Practices* book, Grade 9 Applied Teacher 1 was asked which order she would present students' solutions. She responded, "No, you don't need to show those," referring to the "worst" solutions. The Vice Principal countered with, "Then it goes back to mindset, right? Which is 'we can all learn from this'" (Meeting 2.3, lines 1258-1268). In both of these situations, the negative view of mistakes seems to be deeply rooted in these participants' beliefs about mathematics learning.

The Vice Principal suggested another strategy to try to counter the negativity toward mistakes when she proposed that the students' journal reflections, mentioned earlier as an explicit mindset approach, could also explore moments of failure during classroom experiences with mathematical tasks. This is another way that the members of the PLC tried to help the students view failure as an opportunity to learn.

Forms of assessment. At the start of the second year of the project, the Board Mathematics Lead posed the following dilemma to the PLC. She said, "So does assessment practice – if you do all this work with mindset, about growth – does your assessment practice stop it in its tracks? . . . Like are you willing to do that, in a way, revisit your assessment practices, that fosters a growth mindset, and that's a very difficult step" (Meeting 2.1, lines 276-

279). Moving to assessment practices that foster growth mindset seemed to be relatively new to the PLC and I found most of the assessment methods mentioned in the transcripts were suggestions made by PLC members or their observations from other schools rather than strategies they actually tried in their classrooms. For example, the Board Mathematics Lead, who visited many schools, mentioned in the first year, "I've seen a lot of success in some teachers that have embraced the only written feedback on assessments. I've seen that change they're reporting, some big changes, and it didn't take as long as we thought it would" (Meeting 1.4, lines 86-88) and then in the second year, "We see more and more teachers sort of, conferencing, and things like that. It's very untraditional in the sense that we're used to, but we're seeing that that does growth mindset" (Meeting 2.1, lines 317-318). Conversations and feedback, as opposed to marks, were forms of assessment that were generally talked about by these educators as a way to move from a performance to a progress view of learning.

Embedding mindset values into assessment also seemed to mean to the PLC that content tests should become tools of development, rather than demonstrations of competence, and a few participants mentioned that allowing students to retake tests likely reinforces growth mindset. For example, "That teacher that returns that test and says, 'Do it again' is pretty much saying, 'I know you can learn this, so you didn't learn it yet but here you can do it again. I know you can learn this'" (Differentiated Instruction Coach, Meeting 1.5, lines 486-487). Over the course of the project, the Board Mathematics Lead perceived a shift in the assessment thinking of teachers in the PLC. In her interview, she stated, "Okay so [the students] didn't do well on this assessment; [the teachers are] not just moving on. I think they're actually thinking, 'Well why, and if there's another opportunity I can give them to do well.' Like kind of working toward mindset, like that idea, they can succeed" (Board Mathematics Lead Interview, lines 132-135).

At the same time, the data suggests that moving away from a using tests as a summative assessment tool may not be easy. For instance, the Mathematics Department Head described his experience focusing on progress over achievement with a Grade 10 Applied class in this way.

> So Monday they started off with similar triangles and there was not a lot going on there, but by Wednesday, Thursday, a lot of them would get, not quite there, but looking at, 'look back where you were on Monday, think about what you [did] on Monday, you've come so far in those few days.' Now unfortunately during tests it all fell apart, but they've come so far in those few days, and again it's 'look what you've achieved, look how far you've come.' (Mathematics Department Head, Meeting 2.1, lines 604-608)

According to these educators, shifting their assessment practice also meant looking at assessment as a "picture" or "snapshot," describing students' achievement as "only where they are at that moment in time . . . It's continually changing" (Grade 10 Applied Teacher 1, Meeting 2.2, lines 1245-1246). These educators seemed to value identifying moments of progress, no matter how small, and trying to separate progress from achievement on a test. They also seemed to feel that students may not be aware of when they are improving if the gains are too subtle or are only tied to test or assignment scores, and wondered how to help students become more aware of their progress. One suggestion was made as the Vice Principal and Grade 9 Applied Teacher 1 were attempting to figure out if they might use a reward system for growth mindset behaviours.

> Vice Principal: And then I come up with an idea that [Grade 9 Applied Teacher 1] is not sure about, because the work is like, giving them little certificates, or little. I

> just find that, like, I'm always phoning bad news with some of these kids. And some of them
>
> Research Assistant: Good calls home are powerful.
>
> Vice Principal: Well if you call and you say that, you know, 'Your child won the perseverance award!' (Summer Institute Meeting, lines 159-163)

The PLC did not revisit this idea in subsequent meetings; however, the notion of purposefully calling out students' moments of progress continued to be discussed throughout the second year. In fact, the term "in-betweens" emerged from their conversations to describe how these educators might acknowledge students' progress in-the-moment. For instance, the Vice Principal wondered how the PLC could tie these "in-betweens" to their assessment practice, asking,

> How can we look at those little pieces, those little successes along the way which would really help the students recognize that they are making progress, and they are learning? It just might be not at the speed that they want, or they might not be able to recognize it, so how can we break it down further, so that they can see that that mindset is happening, and that they are being successful, even if it's just one tiny step? (Meeting 2.2, lines 11-15)

The PLC members continued to discuss this idea in other meetings. For example, the Vice Principal suggested, "A big part of it is starting to identify what those little steps are, and then for them, if we're linking this back to mindset it would be 'when I started this, I can't do this, but now I can'" (Meeting 2.3, lines 691-693). Along similar lines, Grade 9 Applied Teacher 1 described her challenge with identifying the "in-betweens" when they arose during class. The Special Education Teacher encouraged her by saying, "I think you do recognize it but you're in the process of going somewhere else" (Meeting 2.5, line 395).

An interactive model. My analysis of the data also suggests the explicit and embedded approaches to teaching mindset interact in complex ways. At times these educators acknowledged the importance of explicit teaching about mindset, but that often came into tension with the immense value they seemed to perceive in embedding growth mindset beliefs into mathematics learning. I interpreted the data related to this interaction both as an evolving interaction and as a balanced interaction.

Evolving interaction. For a few of these educators, their approach to mindset seemed to be evolving from explicit to embedded strategies. In the following example from early in the project, the Board Mathematics Lead offered her perspective on moving from explicit mindset instruction to students self-reflecting when they struggle in a mathematics task. She explained,

> Like you do some mindset ideas right at the beginning. This is grit and perseverance and this is how the brain works. You expose them right away. And then almost do a class . . . where they say that this is what it means to have a growth mindset. So when I'm faced with a challenge, I can do this this or this . . . That way they can evaluate themselves and then maybe keep looking back on that, and keep evaluating themselves when they hit a roadblock, or when they're successful. (Meeting 1.2, lines 380-386)

Months later, the Board Mathematics Lead spoke about seeing "this sort of mindset thing is sort of evolving over time. So we've educated them on the brain, we're showing them examples of perseverance . . .at some point, we have to be pointing out times when they are successful in math, and really celebrating it" (Meeting 1.5, lines 391-394). In the same meeting, one of the educators wondered if students in the Grade 9 Applied course will retain their mindset knowledge for the Grade 10 Applied course, leading the Vice Principal to comment, "I think

that's, you know, not sure what it will look like, but I think those students will already have that [mindset]. Not that it's perfect, but they'll have that and it makes me wonder if we should be looking at a grade 7, 8, 9 plan" (Meeting 1.5, lines 523-525). These educators seemed to see value in including students in the previous and subsequent grades in order to build a culture around growth mindset. As noted, the PLC explored this concept further by inviting Grade 8 and 10 mathematics teachers into the group for the second year. In the last meeting of the project, the Vice Principal brought up the idea that years of explicit instruction in growth mindset will eventually render explicit teaching unnecessary in Grade 9 courses. She wondered "if things will change just given that a lot of our elementary schools are focused on mindset. So perhaps in five to six years, it won't be something that needs to be taught explicitly. I think it'll be something that needs to be, you know, woven into what we do" (Meeting 2.7, lines 206-208). Thus, we see ways that these educators' approach to mindset might evolve for one teacher within a single course and might also evolve across grades from an explicit to a more embedded approach.

Balanced interaction. At other times there seemed to be a question of balance between explicit and embedded approaches. Some participants seemed to feel that the embedded approach was more valuable than the explicit approach, while others saw the necessity of teaching mindset theory explicitly. I highlight this tension with excerpts from the first meeting of the second year, where several new PLC members did not seem to embrace the explicit mindset approach in the same way as the founding PLC members. One new member stated, "The part that is missing for me is instead of just talking about growth mindset [explicitly], I don't, like, putting a poster in my room is not going to change [it]" (Grade 8 Teacher 1, Meeting 2.1, lines 538-539). Similarly, when another Grade 8 teacher was asked what he was going to do explicitly in his classroom to teach mindset, he responded,

> Grade 8 Teacher 2: I don't know if it's something, it's just something that's going to be embedded in everything we do whether it's math, whether it's language, whatever. That kids need to try and, and you know . . . it becomes embedded into a classroom where you've got an environment that you've created that's hopefully open, safe, fun, kids can ask questions . . . Be positive.
>
> Vice Principal: But I think we also, I think they need to understand – they need to check that at some point that they know what fixed, growth means and where our goal is, is to have them have more open [growth] mindset, and then, I think all that stuff that you're talking about is reinforced on a daily basis. But some of them may have that language, some of them may not. Now I'm not saying thousands of hours of lessons here, but I do think at some point, each classroom needs to have something explicit. (Meeting 2.1, lines 1192-1210)

Another similar exchange happened between the Grade 8 Special Education Teacher and the Vice Principal midway through the second year.

> Vice Principal: So what should we do with our classrooms that like, um, in terms of helping? Do we need something visual in every class, what do we need? What do you think?
>
> Grade 8 Special Education Teacher: I think it's just knowing when to say, 'Hey, this is a good example of positive mindset.' (Meeting 2.5, lines 389-391)

The subtle resistance to an explicit approach in the above interchanges could suggest a belief that it is what teachers do in the classroom that matters more than what they talk about. For instance, "Here's a survey, do a survey. But it has to be in everything, right? How you teach, like you know" (Grade 8 Special Education Teacher, Meeting 2.7, lines 472-473). Interestingly, despite

advocating for the teachers to teach mindset explicitly, the Vice Principal reflected during her interview at the end of the project that "what made the difference was the little in between comments they [the teachers] made, it wasn't the big formal fancy lesson. Or even two or three formal fancy lessons, or even a video or anything like that" (Vice Principal Interview, lines 177-179). I think the perception that the explicit and embedded approaches may or may not work in balance connects to these educators' view that growth mindset involves both knowledge and action, and the way teachers interpreted encouraging both "thinking" and "doing" in the classroom differently, as introduced in my observations for the first research question.

In the end, my analysis suggests that the underlying interactive model between the two approaches is iterative, as expressed in the following comment made by the Vice Principal at the beginning of the second year of the project.

> I kind of see a need for some kind of explicit mindset teaching . . . Something explicit has to happen before the next session, and then I see that all of us are, all of us are kind of thinking of ways, you know, those in-between moments in the class that are the most important things. We're all coming up with little ways we reinforce mindset in little in-between ways and we're also seeing a trend towards something visual or something like some kind of anchor or something [explicit]. (Meeting 2.1, lines 862-867)

At the last project meeting when these educators were asked to summarize what they learned about mindset, the first two comments were "it needs to be taught" and "explicitly and woven into" (Meeting 2.7, lines 156-157). These comments suggest a general acceptance for the explicit and embedded approaches to coexist, in some form, to foster growth mindsets in students.

Question 3: Mindset Value and Obstacles

The PLC maintained a focus on developing growth mindset with students in the Grade 9 Applied course over the two years of the project. Despite the freedom within the OAME Project to change their inquiry at any time (as some of the other PLC's who initially set a mindset goal seemed to do) and the obstacles encountered along the way, these educators' persistence with a growth mindset goal indicated to me that they saw value in the approach. I address my third research question in two parts: what are these educators' perceptions of the (a) value of and (b) obstacles associated with using growth mindset approaches in an Applied mathematics course.

Perceptions of value. These educators seemed to ascribe a general, somewhat ambiguous sense of value to growth mindset. That is, the PLC members seemed to accept that for many students, their underachievement and negativity toward mathematics stemmed from an underlying motivational issue that could be addressed through teaching about growth mindset. In the discussion for the first research question I suggested that the PLC members understood that mindsets change slowly and along a continuum. This realization may be partly why these educators were not willing to let go of the mindset goal. In fact, at the end of the project the Differentiated Instruction Coach stated in her interview that the PLC "discovered as time went on that mindset is a huge component to learning math, more so than we had expected" (Differentiated Instruction Coach Interview, lines 46-47).

My analysis of the data also suggested some specific ways these educators perceived the value of growth mindset for students taking the Grade 9 Applied course. While support for the perception that students in the Grade 9 Applied course, collectively, changed their effort or increased their achievement due to the mindset approach was quite limited in the PLC's conversations, individual teachers' anecdotes indicate that growth mindset was perceived to have

had a positive impact on some students. In the first meeting of the project, Grade 9 Applied Teacher 1 recounted her efforts with one struggling student. She expressed,

> She has always struggled with math, and she is almost afraid to do something until she knows what she's going to do is going to be right. You know? Like that kind of thing, and I'm trying to sort of say, 'It's okay, you can try, take a risk and see whether it's, you know, see how it works out,' as opposed to see whether it's right or not, but see how it works out. So she's doing a little bit more, but, it varies. (Meeting 1.1, lines 1415-1417)

Noticing the small changes – the "little bit more" – in individual students' efforts seemed to be a common way these educators conveyed the value of growth mindset. When the new Grade 9 Applied teacher joined the PLC half way through the second year, she adopted the embedded mindset strategy of pointing out moments of progress following effort to her students and described the impact that practice had on one student as follows.

> Another thing that I've been doing, is like individually very quietly in the class, you know when they're trying, and being like, 'You couldn't do this and you just did it.' And they're like, 'Yeahhh!' . . . So there's one girl and I said this to her . . . 'Do you know, I went and I looked at your IEP, and last year you were working at a Grade 5 level. And what you just did is like a Grade 9 Academic level. And you worked really hard and you did it.' And she's like, 'Yeah I did!' . . . Since that day in math class, she has been nose to the grindstone. Every time I look over, she's trying to write stuff down, she's re-writing her notes, she's like all over it. That's really good, right? (Grade 9 Applied Teacher 2, Meeting 2.6, lines 404-416)

The Vice Principal echoed the idea that one value of growth mindset is increased motivation for many students in the Applied course in her interview at the end of the project when she stated, "I think the kids are more willing to try. I think they know what mindset is. When they start complaining and making fun of it, then I think they get it" (Vice Principal Interview, lines 174-175).

There also seemed to be a perception of the value of mindset in positively changing the teachers' interactions with students. For example, one PLC member claimed she was more aware of her dialogue with students. She said,

> I think I'm going to be more careful in choosing my vocabulary when I speak to students about their successes. In terms of praising the effort rather than the outcome. Putting more emphasis on the process . . . I think students, when we speak to them in very deliberate ways about mindset and their ability to do math, I think, even though at first they might appear to brush it off, they might appear to like it doesn't hit home, I think it does make a difference. (Differentiated Instruction Coach Interview, lines 50-67)

Along the same lines, the Board Mathematics Lead noted the value of teachers' increased awareness of students' progress and learning needs. She reflected during her interview,

> I feel it's caused teachers to kind of look at their students more than they might have . . . So I think it has had an impact on student learning, through the teachers' willingness to try something new, or if the student isn't successful, come at it from a different way. I do think it has had an impact, I think in that sense, for sure, they've become a little bit more reflective and responsible. (Board Mathematics Lead Interview, lines 128-138)

During the final meeting, one educator suggested another value related to the shift to growth mindset-friendly assessment practices. He acknowledged that changing from an achievement view of success to a progress view of success helps teachers feel they are more effective. He commented, "And that's sort of taking some of the pressure off [me] . . . I'm not failing as a teacher" (Grade 10 Applied Teacher 2, Meeting 2.7, lines 535-539).

These educators' considerations of the value of mindset included both the general perception of its influence on students' willingness to try as well as some specific ways the approach may have affected individual students and themselves as teachers.

Obstacles associated with using growth mindset approaches. Although the PLC members clearly valued the time spent fostering growth mindsets, there were also many indications in the data of their growing realization of the obstacles that may hinder students from fully embracing growth mindsets. At times these educators described the students as "shutting down" when growth mindset was talked about. I explored the data to seek out the reasons they suggested for students sometimes resisting growth mindset. There appeared to be a general perspective that the resistance was a form of "disconnect", as they expressed it, between students' mindset beliefs and their actions. I begin this section by tracing the notion of this disconnect through the two years of the project before sharing the observations the participants made about why the disconnect may exist.

Student disconnect between mindset beliefs and actions. The perception that the students in Grade 9 Applied mathematics had a disconnect between their mindset beliefs and how those beliefs might relate to mathematics learning emerged early in the project. At the first meeting one participant observed that the students "enjoy the [mindset] activities, they enjoy coming to class, but they don't connect it with, I guess, 'this is math'" (Differentiated Instruction

Coach, Meeting 1.1, lines 171-172). Many times I sensed disappointment from some of these educators when they discussed students' lack of motivation to attempt problem solving without teacher scaffolding. They seemed to expect that their growth mindset lessons would immediately decrease students' helpless behaviours and/or increase their problem solving strategies. For example, Grade 8 Teacher 1 described her experience as, "you go through some of the activities . . . me talking about growth mindset, as soon as we come to the math problem, they're still going to say 'I'm stuck'" (Meeting 2.1, lines 557-558). In that same meeting, other participants were reflecting on the previous year, and expressed this disconnect as students understanding growth mindset but not applying it. Part of the conversation went as follows:

> Vice Principal: One of the things that came out of our, the interviews with the students last year was that they could tell us what mindset was, they could tell us what a growth mindset was, they could, 'that is a growth, that's a fixed. Fixed is bad, growth is good.' But when it came to
>
> Special Education Teacher: Actually putting it into
>
> Vice Principal: Actually doing a difficult task, they would still say
>
> Grade 10 Applied Teacher 1: Still revert back to, yeah.
>
> Vice Principal: Things like 'I can't do it,' 'I'm stupid,' 'I'm this, I'm'. Do you know what I mean?
>
> Grade 9 Applied Teacher 1: 'I can't do this,' yeah. (Meeting 2.1, lines 346-354)

Similarly, Grade 10 Applied Teacher 1 explained how he showed the bike flip video, and that the students were able to see "he's [the boy in the video] persistent and perseverance and he kept going with it, and they could definitely find that link to it, but again, applying back to, as you said, applying it back to math, again they're not quite making that link with it there" (Meeting

2.2, lines 1287-1289). In that same meeting, while relaying mindset teaching strategies that were tried with Grade 8 students, one educator expressed that the students had responded well to the tangram puzzle activity, but when they attempted a proportional reasoning task, the students were not able to draw on their growth mindset learning. The conversation continued in the following manner.

> Grade 8 Special Education Teacher: So whatever growth we made with the tangrams, that activity [the proportions task] and the mindset did not translate.
>
> Grade 8 Teacher 2: But you can't, teach mindset in a, in a video and kids
>
> Grade 8 Special Education Teacher: No.
>
> Grade 8 Teacher 2: It takes years, and for some kids, unfortunately, and maybe an embedded thing, that you know they're surrounded.
>
> Vice Principal: It's harder than one day.
>
> Grade 8 Special Education Teacher: And we figured out in this activity that kids really do not have a lot of problem solving strategies. They don't. Soon as they don't get it, that's it.
>
> Board Mathematics Lead: Kids have a hard time entering into a problem. I find that's the, for a lot of kids, that's, the first step is the hardest. And you have to do a better job of giving them strategies, or helping them through that. That's not a, we're seeing that a lot, in a lot of spots. So don't feel too bad.
>
> Vice Principal: Just in case.
>
> Grade 8 Teacher 2: yeah.
>
> Mathematics Department Head: Is it strategies, or is it mindset?
>
> Board Mathematics Lead: It's probably both.

> Grade 8 Special Education Teacher: Both, yeah I'd say both. (Meeting 2.2, lines 1446-1462)

Several features of the "disconnect" the participants perceived are evident in this conversation. The educators felt that students were exhibiting a growth mindset in mindset tasks and this led to an expectation that the students would persist more when they became stuck on a mathematics task. However, when the students did not exhibit persistence, the PLC members wondered if it was because the students didn't have the mathematical strategies or if they didn't have the growth mindset to continue moving forward. They concluded that it was probably a combination of these two elements. The participants also acknowledged on several occasions that shifting mindset takes time. As one educator put it, "In fairness it's not something that happens overnight. I think that culture needs to be cultivated very young, and sort of, expected, and that expectation throughout lots of levels – 7, 8, 9. It's hard" (Board Mathematics Lead, Meeting 1.1, lines 128-130). Similarly, in the Vice Principal's interview at the end of the project, she commented on the success of the student interviews in the first year as being "a big eye opener for the students to say 'yeah I get what my mindset is.' But then there was a disconnect in the sense that it didn't mean that they were all fantastic mindset-ty when it came to math" (Vice Principal Interview, Lines 26-28). So, what did these educators think was standing in the way of these students embracing a growth mindset in mathematics? The next four sections share some of my observations from the data that address this.

Ingrained mindsets. The notion that these educators were fighting against the students' deep-rooted fixed mindsets seemed to emerge as an obstacle for the PLC as they sought to shift student mindsets. They tended to accept that students enter Grade 9 Applied mathematics with a fixed mindset about mathematics formed from past experiences, as I mentioned in relation to the

first research question. The challenge these educators seemed to realize over the course of this two-year inquiry was that changing an ingrained mindset was dependent on many factors, including several which were out of their control. At the start of the project while the PLC was discussing how to measure growth mindset in students, some participants suggested that the students' responsiveness to growth mindset was dependent on what happened outside the mathematics classroom. Part of the conversation went as follows.

> Board Mathematics Lead: I find it hard with a checklist with mindset, because it's so dependent on the day, dependent on –
>
> Vice Principal: Oh absolutely.
>
> Board Mathematics Lead: – how they walk into the room . . . dependent on like, what happened the night before.
>
> Research Assistant: What happened at breakfast.
>
> Board Mathematics Lead: I find it such a –
>
> Differentiated Instruction Coach: It's nebulous. (Meeting 1.2, lines 267-274)

In that same meeting, the dynamics within each class was also brought up as a factor influencing mindset change: "We've seen as teachers that one cohort just buys in and next year is a completely different animal. So like, this is going to work with some kids and it isn't going to work with others. And that's the reality" (Board Mathematics Lead, Meeting 1.2, lines 424-426). For a few of these educators, the background of certain students was also described as impacting how growth mindset beliefs were embraced. They wondered about one student in this excerpt.

> Grade 9 Applied Teacher 1: He may have seen and done the [growth mindset] activity twice, but he's still needs to, he's not there yet, in terms of the growth mindset.

> Grade 8 Special Education Teacher: You know and he's such, because, when he was younger
>
> Grade 8 Teacher 2: He's had it tough.
>
> Grade 8 Special Education Teacher: I remember him from [school name] yeah, so there are extenuating circumstances.
>
> Grade 9 Applied Teacher 1: Right, and some of them family wise . . . He understands some math, and yet he'll stop at the first answer. (Meeting 2.2, lines 1642-1650)

As I analyzed the data, it appeared that the PLC members found it difficult to navigate implementing growth mindset approaches when students were often stuck in a fixed mindset and were influenced by factors outside the control of the teacher.

Although the collective view seemed to be that students had difficulty shifting ingrained fixed mindsets, one of the Grade 10 educators had the opinion that some students did not want to admit their lack of success in mathematics had to do with their own lack of motivation rather than their innate ability. In the first team meeting he explained,

> Kids were very receptive at the beginning, you know, I can say, 'Oh you can do math, you can do math, you can do math.' But now in my 2P class I've got a couple of students who are very uncomfortable with that notion that you can do math, and I'm wondering why, and I am starting to think it's because, well, I can't hang my hat on that little peg anymore saying 'it's okay I can't do math, because I'm not a math person'. Well if I'm not doing math, then there has to be another reason. What's that other reason? I think I need to start exploring that, and they're uncomfortable exploring what those other reasons might be. (Mathematics Department Head, Meeting 1.1, lines 354-363)

According to his comments, perhaps it was easier for students to explain their struggles in mathematics learning with a fixed mindset belief and say that their mathematics ability is lacking, rather than to be held accountable for a lack of effort. It was not clear from the transcripts whether or not other educators in the PLC agreed with this view.

The PLC continued to discuss the ways that fixed mindsets persisted despite growth mindset instruction in the second year of the project. In the first meeting of the second year, the PLC discussed a growth mindset lesson where the students were asked to reflect on their own mindsets, and then state what they would like to change. The following portion of that conversation highlights the view that shifting mindsets may need to be a conscious decision.

> Grade 8 Teacher 1: But I think it's important to ask the question 'do you want to change it' . . . I mean just think about how hard it is to change a bad habit of your own, like I talk to, you know, like when you talk to kids like change is hard, change is hard work. I have a bad habit, like if I want to make it a good habit, I have to do it for, they tell me I have to do it for 3 weeks every day to make it a good habit.
>
> Grade 10 Applied Teacher 1: Well, habits are habits, good or bad. Aren't they something you do frequently?
>
> Grade 8 Teacher 1: But they're very hard to change. So it does take hard work to like if you talk negatively to yourself you might not admit it to other people, but if you say 'aw, I suck at this" and you're always saying that, that's a hard thing to change. If you really want them to work at it, they have to acknowledge it, and then say 'do I want to change it.' (Meeting 2.1, lines 1259-1267)

Perhaps these educators had assumed that students would naturally want to change their way of thinking about their mathematical abilities, particularly if it meant they would progress in their learning and feel successful. Then, after attempting to implement growth mindset and experiencing some students' resistance, the educators realized that what they had assumed was not necessarily the case. By thinking about asking students if they wanted to change, these educators seem to be suggesting that mindset is a choice, and that placing the choice on the student leaves room for some students to decide not to buy into the growth mindset culture.

Half way through the second year, the PLC were again discussing how some students continued to be non-receptive to growth mindset. One of the Grade 8 educators commented on how there are always students who resist their teachers' instruction, even outside of mindset instruction. The Grade 9 Applied teacher's reaction to the comment reiterated the perception that the Grade 9 Applied course may include students with negative ability beliefs.

> Grade 8 Teacher 1: Well there are nay-sayers in every group in every subject. And I don't know why you let it, they can't be the dominant voice in the classroom. And eventually they just die out. Like if you just keep plugging along, they just die out, you know. [others laugh]
>
> Vice Principal: They get tired. [laughs]
>
> Grade 9 Applied Teacher 1: You know the time that it doesn't die out is when you end up with all those nay-sayers and they're suddenly put together in one class. [others agree] You know, like 9 Applied . . . So suddenly we've got all those kids who're saying 'I can't do math' and that's all you hear sometimes. (Meeting 2.4, lines 678-685)

By the end of her participation in the project, Grade 9 Teacher 1 expressed that she was not sure how well growth mindset approaches worked with Grade 9 Applied mathematics students, possibly due to her experience with these persistent "naysayers." During her interview she had the following conversation with the research assistant.

> Grade 9 Applied Teacher 1: The kids in Grade 9 Applied, I'm still, I still wonder whether it's too late? Well I guess it's never too late, but where is it that we really need to take a look at it, you know?
>
> Research Assistant: You mean in terms of, too late for what?
>
> Grade 9 Applied Teacher 1: In Grade 9 they're already discouraged. Right?
>
> Research Assistant: Right.
>
> Grade 9 Applied Teacher 1: Discouraged with math, but you know, especially the group that I saw. And their skill level was somewhat low, but it doesn't mean that they don't understand certain things, but they have such a negative attitude towards so much that it's tough. (Grade 9 Applied Teacher 1 Interview, lines 94-102)

The suggestion that it might be "too late" for Grade 9 students to change their mindsets revealed this educator's experience with the pervasive, unchanging nature of many of the students' mindsets and suggests she felt that work on mindset would need to occur in earlier grades. This view was also expressed by the Vice Principal, as shown in earlier quotations.

I also noticed that ingrained fixed mindsets did not seem to be specific to students. One conversation revealed the challenge some educators had in maintaining a growth mindset themselves and that the tendency to slip back into a fixed mindset when teaching becomes difficult or students are not progressing is strong. This excerpt is from one of the last meetings.

> Board Mathematics Lead: I think as teachers, too, like I remember back when I was in the classroom, and I felt like I had a better mindset at the start of the year, and as the year.
>
> Grade 8 Teacher 2: Oh yeah. [others agree too]
>
> Research Assistant: Because challenges pile on.
>
> Board Mathematics Lead: Like it's bad, it is. And I, when I go back [to classroom teaching], I will be, I think, maybe taking some time to like check it when it gets bad. Because I think as a teacher a mindset, for me, is the belief that your kids can do it.
>
> Grade 9 Applied Teacher 1: Right.
>
> Board Mathematics Lead: And as the year goes on that gets harder.
>
> Grade 8 Teacher 1: Well it's not to wear their frustration on your sleeve.
>
> Board Mathematics Lead: That's right. (Meeting 2.5, lines 453-464)

Many of the excerpts I drew attention to in this section, where the PLC considered the challenge of ingrained mindsets both in their students and themselves, revealed to me that fostering a growth mindset culture entails honest reflection and a conscious decision to change mindsets. The members of this PLC seemed to engage in this sort of honest reflection about their mindsets through this project. They seemed to also realize that this change cannot be forced on students.

View of mathematics. According to these educators, a view of mathematics as a subject comprised of correct and incorrect responses also seemed to stand in the way of cultivating a growth mindset in students. During the project they talked several times about students' fear of being wrong as an issue that is amplified in a growth mindset culture where students are encouraged to learn from mistakes. The PLC members seemed to feel that the students equated

being wrong with being incapable of doing mathematics. The challenge with mathematics being seen as a right-or-wrong subject, where fear of making mistakes holds students back, was discussed in relation to students in both the Applied and Academic mathematics courses. For instance, in the first meeting of the second year, the Vice Principal expressed her opinion on this type of student anxiety as a general problem in mathematics teaching.

> Like there's stress, there's anxiety and that kind of thing. So it's not like only the Applied level students are the students who struggle, who, the mindset holds them back. It's that fear of mistakes . . . they get scared that if you're asking them to explain their thinking they've made a mistake. And so at some point, and I don't know why it's math in particular, there's a real fear about math and that making mistakes is going to be seen as something that is horrible (Meeting 2.1, lines 162-170)

I saw this view expressed by several other PLC members over the course of the project. For instance, the Differentiated Instruction Coach suggested the exactness in the way mathematics is traditionally presented caused student anxiety, particularly when teaching practices coinciding with growth mindset were introduced. She articulated,

> Often we spend a lot of time saying, this is what success looks like. This is the kind of answer I am looking for, we spend a lot of time modelling, so they are often used to seeing that, rather than having that open, explore, where they won't know what their answers should look like. Because our rubrics, really do give them, this is what I'm looking for. We spend a lot of time trying to be very specific. So when we take that away, it makes sense, I would feel anxious. (Meeting 1.1, lines 149-155)

Her perspective on the challenge that this approach to teaching mathematics poses to growth mindset was echoed by other educators over the two years. For example, mid-way through the second year, the PLC members were reflecting on teaching with open problems as a way to expose students to a range of problem solving strategies. It was suggested that some of the students' anxiety may have stemmed from mathematics being so often taught as a closed subject, where students are instructed to follow specific algorithms to get the right answer. They wondered if some students were less able to approach the open problems due to a fear of choosing the wrong strategy. This conversation continued with various PLC members offering ways in which students could gain confidence trying multiple strategies. However, one participant suggested that teaching practices meant to help the students enter a problem, like flow charts, may actually deter students' efforts. He said,

> I think part of the problem was they get that and they think they have to follow this particular pathway, and that's the only answer. And I think sometimes we'll try to help them, like give them some of those crutches, perhaps we do a bit of a disservice and again teach them 'you have to do it this way, you have to do it this way, you have to do it that way.' (Mathematics Department Head, Meeting 2.4, lines 202-206)

Teachers rescuing students from struggle was brought up in relation to the first research question as a potential reason that students enter Grade 9 with fixed mindsets. I also analyzed this idea as it pertained to an obstacle to moving toward a growth mindset. In a conversation early in the second year, it was proposed that students' dependence on the teacher, exhibited in behaviours such as raising a hand immediately when presented with a mathematical problem, resulted from teachers' repeated rescue moves. For example, the Board Mathematics Lead

observed, “As teachers, we’re instinctively trying to save kids a lot, and we’re very uncomfortable with the struggle . . . Teachers have the best intentions, but it’s, it’s a hard thing to . . . like just the idea of not rescuing them, right away” (Meeting 2.2, 1463-1474). It seems as if these educators realized that their efforts to ease struggle could also result in students being unwilling to try, a behaviour that stood at odds with their perception of growth mindset.

Thus, the view of mathematics as a narrow subject characterized by right or wrong answers and the various ways students might attempt to get the right answers emerged as an obstacle for these educators as they pursued the growth mindset goal.

Assessment culture. In the observations for the first two research questions, I described the PLC’s shift in assessment strategies from achievement-based to more progress-oriented as coinciding with their assumption that mindset involved a redefining of success and failure. Continuing with that perception, as the team attempted to assess individual students’ progress and emphasized the success of small improvements, they also seemed to recognize that the culture of assessment in mathematics can stand at odds with a growth mindset culture. This assessment culture is focused on evaluating students’ content understanding against a course’s curricular goals using marks, grades, or levels. Even when the shift was made to assess students in mindset-friendly ways, these educators recognized that marking schemes remained a mandatory part of their education system’s requirements. The culture of assessing with marks or grades could neither be removed from their own responsibilities nor was it easy to reduce their students’ attention to grades. Early in the second year of the project, the PLC discussed how the students remained focused on the mark they received for an assignment or test, with little regard for other forms of feedback. Grade 10 Applied Teacher 1 explained it this way:

> Their first thing is going to be, 'What can I do to improve my mark?' and again it's all about the number, as to where to focus. It's not, 'What can I do to improve my understanding' or 'improve my math' or 'improve my processes,' none of that. It's all about the mark, and unfortunately that's the culture that's been built up over years and years and years. (Meeting 2.1, lines 326-332)

In that same meeting, the culture of assessing with marks or grades continued to emerge as an obstacle to growth mindset for the PLC members, as they were discussing various assessment strategies and seemed to be wrestling with how to fit their newly tried approaches with the school-based report cards. The Board Mathematics Lead seemed to have some past experience with helping educators integrate mindset-oriented assessment and shared her view with the PLC. The conversation proceeded as follows.

> Board Mathematics Lead: You make a good point, [Grade 8 Teacher 1], like we're still responsible for a report card, right? That has marks! That has numbers. So that's never going to go away, and that's always going to be a part of it. So I think, just, if you're, this is what I tried before. If you're really committed and you believe in mindset, it's just trying to infuse different language, infuse different types of assessment, different, just not being so reliant on traditional forms. Um, it doesn't mean they disappear.
>
> Grade 8 Teacher 1: Yeah.
>
> Board Mathematics Lead: Because there is that. We still have this report card that good or bad it's there and its part of our life.
>
> Grade 8 Teacher 1: and they do need practice at being successful in those environments no matter what level you're at, because whether you go to college,

> or university, or you're doing a trade, there's times where you have to perform well on an examination.
>
> Board Mathematics Lead: Mm-hm.
>
> Grade 8 Teacher 1: And you have to know how to do that.
>
> Board Mathematics Lead: Absolutely.
>
> Grade 8 Teacher 1: And that's a skill that needs to be still mastered, right? But I agree it's not the only thing and there's steps along the way that you can teach them, but it can't become so fluffy that they have no ideas where it [the marks] comes [from]. (Meeting 2.1, lines 360-376)

This excerpt demonstrates how these educators' past experience with relying on performance-based report cards or tests as measures of success was difficult to let go of in the name of progress-based assessment strategies, particularly as they see grading practices prevail in postsecondary situations. Later in the second year, the same Grade 8 teacher appeared to continue to struggle with focusing on students' progress while still using a marks-based reporting system. She recounted a moment of conflict in her practice between the progress assessment and performance assessment for a particular student:

> He got a 50, but from where he started, my god, he came leaps and bounds. Like that 50, if I put a mark for effort on that 50, it's a level 4. But he's not going to see that, he's going to see it as 50. So I keep, I haven't given the test back because I'm struggling with that. Like how do I show him that I recognize the progress that he's made with that 50? (Grade 8 Teacher 1, Meeting 2.5, lines 725-728)

It is evident to me through these comments that these educators had to navigate how to redefine success as progress within a mark-centered system, and they wondered if the two could be

compatible. Although the previous excerpts did not explicitly link growth mindset to this challenge, one of the educators in the final team meeting found a connection to growth mindset in another educator's expression of how he was redefining success. In this example, Grade 10 Applied Teacher 2 described his perspective of passing and failing for a student who had large gaps in her mathematics understanding.

> Grade 10 Applied Teacher 2: And it's like, you know [I had] a student that came in and she said, 'I missed all of Grade 8. I missed a lot of stuff.' That's fine, we'll work with you, where you are now, and as long as you keep working, you'll be ok. You may not be at the end, but you'll be further ahead. And she was just mindful, and thoughtful enough to ask me, and say this is where I am, and it's like fine. We can work with that. If you work, we can catch you up a little bit. We'll find out where your holes are.
>
> Grade 8 Special Education Teacher: Which is mindset. [Others agreeing] . . .
>
> Grade 10 Applied Teacher 2: They're still going to fail. But
>
> Vice Principal: They've learned something.
>
> Grade 10 Applied Teacher 2: Exactly. And it's not the failing that's most important. It's the idea of what have you gained and are you better prepared next year to continue. (Meeting 2.7, lines 509-532)

For this Grade 10 Applied teacher, fostering growth mindset meant reworking his perspective on students with gaps in their understanding who would likely fail the course. He was able to shift the negative perception of failure to incorporate the notion of progress. However, the challenge for many of these educators seemed to be the contrast between progress which is central to growth mindset and a culture that is used to viewing success as graded, specific content

achievement. Many of the PLC members seemed to feel that assigning marks for student competence with the curriculum alongside giving progress feedback did not work as well as they hoped. They perceived that students disregarded the progress feedback in their preoccupation with marks. Despite this obstacle, these educators continued to find ways to change their assessment practices in pursuit of a growth mindset culture.

Applied mathematics context. The mathematics course pathway that a student chooses upon entering Grade 9 also seemed to emerge as an obstacle for the PLC members. As noted earlier, Ontario students are required to choose a pathway for Grade 9 mathematics, either Academic, Applied, or Locally Developed (called Essentials by these educators), based on their future aspirations and ways of learning, not their perceived mathematical competencies (OME, 2005). Although these educators acknowledged at times that the students had the right to choose whichever course route they want ("we can't forbid them from taking an Applied course" (Special Education Teacher, Meeting 1.3, line 26)), there were many instances where they talked about choice of course in relation to students' level of mathematical skill and understanding. I also found that the language used by these educators to describe the three pathways was often more reflective of an ability-based placement structure. Therefore, I present this obstacle in two parts. First, I highlight the situations in which these educators directly acknowledged the Applied label of the course impacting students' beliefs in their mathematics ability, and then I draw attention to the moments where the Applied course was discussed somewhat more indirectly but in ways that suggest a fixed mindset.

Direct acknowledgement of Applied course impact. Attempting to establish a growth mindset culture within the constraints of a pathway structure emerged toward the end of the project as a challenge for these educators. The PLC seemed to recognize the Applied course had

a negative stigma attached to it and in March of the second year, the Vice Principal brought up the issue of "streaming" as it related to mindset for the first time in this data set. The PLC had been discussing the mindset interviews done with students in the first year of the project and the negative perceptions the students had of being in the Applied class. The conversation continued,

> Vice Principal: But there's something between Grade 8 and Grade 9, where in Grade 8 they seem to all be [good] or for the most part they accept their differences, whatever. And then there's something about the streaming where all of a sudden the students go, 'I'm the stupid ones.' I don't know if you get that, [Grade 10 Applied Teacher 2], or you get that, [Grade 9 Applied Teacher 2].
>
> Grade 9 Applied Teacher 2: I agree.
>
> Grade 10 Applied Teacher 2: I think they see that.
>
> Vice Principal: They don't see Applied as something positive. (Meeting 2.6, lines 105-111)

These educators agreed that students in the Grade 9 and 10 Applied courses view themselves as "lesser than" because they are not in the Academic pathway. During the final meeting, as the PLC members attempted to describe what they had learned about mindset the issue came up again, as follows.

> Mathematics Department Head: But we still get, that's Academic, or that's Applied, or you should drop to Applied. I mean I still . . .
>
> Vice Principal: But we do notice, we do notice that the kids are pretty bummed out about being in Applied.
>
> Mathematics Department Head: Ya, they still –
>
> Vice Principal: They're bummed out about it.

> Mathematics Department Head: They still see Applied as lower. (Meeting 2.7, lines 162-173)

Even with the efforts they made to change their language around the Applied and Academic courses mentioned earlier, it appeared that the Applied course being seen as "lower" than Academic was perceived to affect students' views of their mathematics ability. The Vice Principal also expressed this view in her interview. Referencing her administrative experience, she suggested the negative perception of the Applied pathway is a worse problem for mathematics than other subjects. She said,

> One of the biggest issues I think we see once the streaming hits in Grade 9, is that the students in Applied classes feel like they're not as smart. Especially in math. Like they seem to be better with the other classes, but they say, 'I can't do math.' That comes up a lot. (Vice Principal Interview, lines 39-42)

She continued in the interview to talk about her perception of the greatest challenge in Applied mathematics as "just getting them to try something" (line 154) and observed, "the sad thing is those same kids [hits table for emphasis] were trying in Grade 8 . . . So there's something that happens with the streaming" (lines 166-171). Based on these observations, "streaming" students into mathematical pathways seems to result in many students in the Applied course saying "I can't" and not trying, both actions that relate to fixed mindset beliefs.

The view that students may not be willing to try in mathematics class, or embrace a growth mindset, because of their enrollment in a "lower level" course, also arose when the Grade 8 teachers talked to their students about choosing their Grade 9 mathematics course. For instance, they spoke about giving the Grade 8 students "recommendations" for which course they felt was best suited to each student. One Grade 8 teacher described her experience with

conveying the course recommendations to her students in a way that connected the practice to the mindsets of the students. The conversation went as follows.

> Grade 8 Teacher 1: Wait until you give the recommendations. 'Cause when I taught the core class, um, when we talk about mindset. After the recommendations came out, and you give recommendations for Applied, they wouldn't make eye contact for about 2 or 3 weeks, they were so devastated.
>
> Research Assistant: Wow.
>
> Grade 8 Teacher 1: And whether we realize it or not. They might say it doesn't mean anything to them, but it means something to them.
>
> Grade 8 Teacher 2: Oh I'm sure, no doubt. But
>
> Grade 8 Teacher 1: It's like you're confirming that they can't make the cut. You're confirming everything they thought about themselves. (Meeting 2.5, lines 181-190)

Clearly this Grade 8 teacher recognized the detrimental effect the placement recommendations had on her students, and associated the recommendation practice with reinforcing fixed mindset beliefs. This awareness ties to the theme that emerged with the first research question, where student mindsets are reinforced through past experiences with mathematics. "Confirming they can't make the cut" by recommending students to the Applied mathematics course pathway may be one reason that many students enter the course discouraged. This realization came toward the end of the project, however, and there were many instances before and after this conversation where these educators seemed unaware that their language evoked fixed mindset connotations. These instances will be discussed next.

Indications of fixed mindset beliefs. Although I saw evidence of a growing recognition of changing their perceptions of, and language around, the Applied course and students taking that course, there were also many occurrences in the data where the educators spoke in ways that seemed to reflect a fixed mindset. As these came up in the data, I created a separate code titled "subtle mindset" to refer to instances where participants seemed express a permanency to students' mathematical abilities or when it seemed as if the students' mathematical content exposure was restricted based on a finite ability to understand the concepts. Several of these instances occurred when the PLC discussed the course recommendations made by the Grade 8 teachers, a process introduced above. The notion of a recommendation implied that students were seen as "fitting" into a particular course and it seemed as if the school had developed "benchmarks" for achievement as the basis for their recommendations for students to enter the Academic, Applied or Essentials pathway. For example, Grade 8 Teacher 1 stated, "Our benchmark for what's Applied is that they need to be working at a Grade 6 level in math" (Meeting 1.3, line 147), meaning if they were below the Grade 6 benchmark they would be recommended for the Essentials course in Grade 9. In addition to making their course recommendations based on these kinds of curricular benchmarks, student attendance and work ethic were also taken into consideration. The following conversation that took place at the Summer Institute with the Vice Principal and Grade 9 Applied Teacher 1 illustrates this point.

> Vice Principal: And then there's the attendance, the attendance problem too, right? At least they have a sense of the trajectory of where things are going. And some of those kids are pretty strong in math. They're in the Applied stream because they don't do homework and they don't come to school.
>
> Grade 9 Teacher 1: Yeah.

> Vice Principal: I'm not saying that's the best place for them. (Summer Institute Meeting, lines 458-462)

This interchange indicates that some PLC members consider attendance as well as prior academic achievement and that all pathways are not seen as appropriate for all students. This view seems to be at odds with growth mindset.

Along the same lines as projecting a specific course suitability for students, it seemed as if these educators had lower expectations of the mathematical knowledge students were able to grasp in the Applied course. I located many comments throughout the data as the PLC were sharing strategies for teaching content that could be interpreted as simplifying the mathematics to fit the students' presumed learning capacity rather than supporting the learner to achieve the concept. The following excerpt took place during a discussion on teaching pattern rules.

> Grade 9 Applied Teacher 1: And maybe for the Applied kids, that messes them up. I know, oh and I wasn't using x and y with my Applied class, I was using input and output.
>
> Grade 8 Teacher 2: I was going to say that would confuse them (Meeting 1.3, lines 361-363)

Another example occurred in the second year, again during an algebra-related discussion.

> Research Assistant: Even building like a variable number line is very cool, when you're looking at relationships.
>
> Grade 9 Applied Teacher 1: I would not do that with 9 Applied. [laughs] (Meeting 2.3, lines 667-669)

In both of these excerpts there was a generalized reference to "Applied students" along with a sense of the teacher's lack of confidence in their capacity to handle complex mathematics. This

seems to contradict growth mindset. This view of students in the Applied course also seems at odds with the value these educators expressed about growth mindset as a way to increase individual students' efforts and achievement.

In addition to the dialogue around pathway recommendations and doubts regarding mathematical competence, I also found many subtle examples of students being described in terms of their perceived static intelligence. For example, a number of times various PLC members used the terms "smartest" or "brighter" in reference to which students would be able to tackle mathematical tasks or exhibit positive learning behaviours. Others talked about students who "would never get" a mathematical concept. For instance, one participant stated, "some of them didn't get it and they won't get it next year, sorry, [name of Grade 9 Applied Teacher 1]" (Grade 8 Teacher 2, Meeting 2.4, line 1129). For me, these comments exemplify the persistence of fixed mindset practices and language that sometimes crept into these educators' conversations despite their ongoing focus on growth mindset learning.

However, I also noticed that these educators were increasingly recognizing their fixed mindset inclinations. As one example, the PLC had been discussing grouping students for collaborative tasks and Grade 9 Applied Teacher 1 commented, "If I was a fixed mindset, I would say that there are some kids in there that don't belong . . . but from a growth mindset there's kids there that aren't at the skill level that they need to be at" (Meeting 2.1, lines 1502-1505). Although this was said amid laughter from the group, it did show that the PLC members were becoming more aware of their past perceptions. Similarly, during Grade 9 Applied Teacher 1's interview, she commented that considering how different students may solve a particular problem was helpful to her practice, but challenging, in that,

> As someone who can do math, you sometimes don't have that . . . depth of weird ways of doing things that don't make any sense to you . . . sometimes, I can't think of the bizarre ways that some of them approach it. Right? Like bizarre and incorrect ways, 'cause I don't work – my brain doesn't work that way. (Grade 9 Applied Teacher 1 Interview, lines 139-148)

It is unclear to me whether she is expressing a fixed mindset view of learning mathematics or, based on many of her previous comments endorsing growth mindset, simply acknowledging the difficulty of enacting growth mindset approaches that require understanding how students perceive mathematics. Regardless, I feel these observations suggest that the work of this teacher and of the PLC with respect to growth mindset was not done. I think these educators were just beginning the slow process of connecting growth mindset to mathematics and discovering that the journey is filled with numerous obstacles that might stall their efforts.

Summary of Observations and Insights about the Research Questions

In this section I briefly summarize my understandings of the patterns that emerged from the data and some of the insights I gained about the research questions from my analysis. For Question 1, How do these educators understand mindset as it relates to mathematics teaching and learning?, I organized the educators' understandings of mindset into five categories. They seemed to conceptualize mindset as (1) a slow, changeable process of developing optimism toward tasks and "unlearning" negative thinking in moments of struggle; (2) the redefining of success as progress, "incremental improvement," and a willingness to try rather than by performance; (3) rooted in experience, both past (as students enter a course with perceptions of their mathematics ability) and present (growth mindset may be transferred from other experiences into a mathematical context); (4) having both a knowledge entity and an action

entity where students should be able to identify growth mindset and exhibit growth mindset behaviours in mathematics classes; and (5) measurable in terms of students' beliefs about their mindsets as well as observations of students' behaviours such as a willingness to try or having a positive attitude. These understandings of mindset seemed to connect with the ways these educators implemented growth mindset in their mathematics classrooms, which was my second research question.

For Question 2, What strategies or approaches are used by these educators in their desire to foster a growth mindset?, I grouped the strategies these educators used to foster growth mindsets into two approaches. I included in the *explicit approach* the strategies used with an entire class to directly teach growth mindset, and in the *embedded approach* the strategies that wove mindset beliefs into mathematical teaching practices and with individual students. Explicit strategies implemented by the PLC included: data collection strategies such as surveys and self-reflection journaling; bulletin boards to visually represent a change in language; and mindset videos or activities that allowed the students to experience mindset in concrete ways from either outside a mathematical contexts or within mathematical activities. Strategies that the PLC members developed and used that were more embedded included: shifting language around learning and the Applied course to reflect that all students are capable of learning mathematics; implementing teaching practices that include collaborative, open problem solving tasks that promote engagement; and using assessment practices to integrate conversation, observation, and feedback as well as value small gains in progress. Notably, it was the PLC members themselves who began to recognize connections between these embedded approaches and fostering growth mindset.

For Question 3a, What are these educators' perceptions of the value of using growth mindset approaches in the context of the Grade 9 Applied mathematics course?, I found both general and specific ways these educators seemed to express value. In a general sense this approach appeared to increase the teachers' mindfulness of students' progress and gave them an avenue to address the prevalent negativity and fixed mindsets of many students in the Grade 9 Applied course. But what seemed to be more valuable to these educators was their observations of individual students' risk-taking and perseverance, referring to several positive outcomes with students who had previously seemed apathetic or oppositional. At the same time, the value of the approach was often eclipsed in the data by these educators' accounts of many students' resistance to accepting growth mindset beliefs. This resistance was sometimes explained as a "disconnect" between the students' inward knowledge of growth mindset and their outward learning behaviour when facing a mathematics struggle.

For Question 3b, What are these educators' perceptions of the obstacles associated with using growth mindset approaches in the context of the Grade 9 Applied mathematics course?, I identified and categorized the obstacles the PLC discussed as: (1) ingrained mindset beliefs that have formed learning habits which are difficult to unlearn; (2) the view of mathematics as a right/wrong or correct/incorrect subject which leads to anxieties about making mistakes; (3) an assessment culture that is focused on mark-based grading; and (4) a course structure that perpetuates a streaming myth that says less-capable students should be enrolled in a lower-level course. Having a better sense of these obstacles was also helpful in more fully understanding the disconnect the PLC had identified.

Chapter 5: Discussion, Limitations, and Final Thoughts

The purpose of this study was to describe educators' experiences in using growth mindset approaches with underachieving Grade 9 students in an Applied mathematics course. I begin this chapter with some insights from this study that might be helpful to mathematics teachers who have decided to work on the concept of growth mindset. As considerable research has been done in the Grade 9 Applied course in Ontario, I then offer some observations about the PLC's perceptions of the Applied mathematics course as it connects to some of that research. I then discuss of the feasibility of implementing growth mindset approaches with underachieving students given certain features of the education system. I end this chapter by considering the limitations of the study and offering some final thoughts.

Insights for Mathematics Teachers and Secondary Mathematics Departments

This study provides insights for educators who are using or considering using growth mindset approaches in their mathematics classrooms. Those who endeavor to implement the approach will likely need to include a combination of explicit mindset teaching activities and embedded strategies that are integrated into instructional practices and student-teacher interactions. Numerous resources, such as the ones from Boaler's Youcubed website, are available to assist teachers as they determine how to implement the approach. Particular attention will likely need to be given to support students in transferring mindset perspectives used in contexts outside mathematics or in mindset building tasks to their mathematics learning context. One crucial understanding that emerged from this study is that shifting to a growth mindset, for students and for teachers, is a process that takes time and quite possibly will be met with some resistance. As the participants from this case observed, working to foster growth mindset across the grades or with the entire school may be a valuable approach. These insights are helpful for

educators who have decided to use growth mindset approaches. However, for those teachers or mathematics leaders who are considering the feasibility of the approach in their situations, the discussion after the next section will be beneficial.

Perceptions of Applied Mathematics: Connections to Research

I feel it is also valuable to discuss the case study participants' perceptions of the Applied mathematics course and of the students who take the course in light of the research done by Hamlin and Cameron (2015) and Macaulay (2015) on the Applied pathway in Ontario. First, several remarks made by the PLC members indicated a belief that the Applied course was for students who struggled with mathematics. For example,

> Grade 9 Applied Teacher 1: So [elementary school name] does really well on [the Grade 6] EQAO, which means that all of those kids are
>
> Special Education Teacher: At an advantage.
>
> Grade 9 Applied Teacher 1: have an ad – but do all those kids follow through with the 7 and 8 here?
>
> Differentiated Instruction Coach: Yeah. It doesn't translate.
>
> Board Mathematics Lead: Well, I don't know if it does translate, because if they did translate, then
>
> Grade 9 Applied Teacher 1: We wouldn't have any Applied kids.
>
> Board Mathematics Lead: Well, not necessarily, because, um, well yeah. You would have very low Applied numbers typically. (Meeting 1.4, lines 263-270)

This excerpt highlights these educators' understanding that students' placement in a pathway reflected their academic competency (in this case, achievement on the EQAO in Grade 6). In the second semester of the first year, Grade 9 Applied Teacher 1 commented that she had 26

students in her Grade 9 Applied class and "half of them are identified" (Meeting 1.6, line 279), meaning they had individualized education plans that might include modifications to the curricular expectations due to recognized learning difficulties. This observation, along with the previous assumption, aligns with Hamlin and Cameron's (2015) claim that students in the Applied course are not there because of their future aspirations, but because they had a history of underachievement and gaps in their mathematical understanding.

Also connecting with Hamlin and Cameron's findings was the underperformance on the Grade 9 Applied mathematics EQAO assessment observed by PLC members. For instance, during her interview, Grade 8 Teacher 1 commented, "I don't see why all these kids are failing the Applied [EQAO assessment]. It's my take on it . . . When we first came here, we did look at the Applied math scores, we kind of dug in the data a bit, I was shocked. I had no idea the Applied scores were that low" (Grade 8 Teacher 1 Interview, lines 36-42). While her comment does not imply a belief that the students are incapable of higher marks, it does speak to the achievement gap between the students in the Applied course and those in the Academic course, where the students in the Applied course have a much lower passing rate on a test created for their specific course (Hamlin & Cameron, 2015).

The participants also made frequent references to the negative behaviours and attitudes of students in the Applied course. They seemed to view students' negativity as worse in mathematics, and worse in Applied mathematics, than in other courses. For example, in the first meeting of the project, the Vice Principal shared her perspective as an administrator as it related to negative student behaviour and different subjects. She admitted to Grade 9 Applied Teacher 1,

> Because you and I have talked about behaviour a lot, and it's a real barrier to math learning, and any learning, but in particular kids act up in English class and

> kids act up in math class. Like if I did data on this, I could tell you that those are the two classes where kids get kicked out in the class . . . But it seems more intense in math. (Meeting 1.1, lines 1659-1728)

At the end of the first year of the project, Grade 9 Applied Teacher 1 confessed that while she did see growth mindset behaviours developing in some of her students, others showed resistance and apathy. She explained,

> There are some kids in there that are great Grade 9 Applied students. They're making an effort, they're trying stuff, they're making some mistakes, but these other kids that have become very vocal, just basically 'I don't want to do this,' you know. 'I'm not interested in trying,' 'what's the point in all of this,' 'I'm never going to do math in my life.' Like that's what comes out of them. (Meeting 1.6, lines 80-83)

This conversation continued as a few of the educators proposed reasons for the students' indifference. One of the Grade 10 Applied teachers added, "I've got 4 students like that in the 2P class [Grade 10 Applied], who could easily be in Academic, but they told me they don't want to do that work, so they know they can come to Applied and just kind of make no effort" (Mathematics Department Head, Meeting 1.6, lines 106-108). After discussing the use of anchor charts to improve students' engagement, another PLC member and the Research Assistant asked Grade 9 Applied Teacher 1 about her students' interactions with each other. In the following excerpt, generalizations about student behaviour in the Applied course, seemingly acquired from the educators' past experiences, are evident.

> Research Assistant: How are they with each other? Are they quite comfortable with each other?

Grade 9 Applied Teacher 1: Socially? Fine. Math wise? [laugh]

Differentiated Instruction Coach: Socially fine but are they all polite with each other, I find sometimes in Applied class –

Research Assistant: They'll shut each other down.

Differentiated Instruction Coach: You get some very abrasive interactions.

Grade 9 Applied Teacher 1: No, I don't see that.

Differentiated Instruction Coach: That's good.

Grade 9 Applied Teacher 1: I see more off task stuff. (Meeting 1.6, 180-187)

These educators' views point to a stigma attached to "Applied student" behaviours, whether belligerence or apathy, that aligns with the low interest and motivation of students in the Applied course pointed out in Macaulay's (2015) research.

Feasibility of Growth Mindset for Enhancing Grade 9 Students' Achievement

The observations from this case study suggest that for these educators, using growth mindset approaches enhanced and challenged their practice. Returning to my original inclination to believe that growth mindset may propel underachieving mathematics students toward mathematical success, I now reflect on the responses to my research questions in a broader sense, asking if growth mindset is a feasible intervention strategy for low achieving Grade 9 mathematics students. I first consider this question in light of the Applied course context, and then in its potential within an educational system that has time constraints on learning. I end this discussion with an attempt to reconcile the participants' perception of the mindset disconnect by considering my original conceptual framework. Implications for research and practice are embedded within each section.

Applied course context. Recent research confirms the use of growth mindset with academically at-risk students (Yeager et al., 2019). However, my analysis in this study suggests that when students are enrolled in a course that has been recommended for them based on former difficulties they've had in mathematics or prior achievement, the course 'level' seems to become their mathematical identity, "confirming that they can't make the cut [and] . . . confirming everything they thought about themselves" (Grade 8 Teacher 1, Meeting 2.5, lines 189-190). Given these observations, I question to what extent growth mindset approaches are viable with underachieving students situated within an Applied course context or in another lower stream course. Historically, streaming structures involved sorting students into levels according to their perceived ability or intelligence (Biafora & Ansalone, 2008) and some research suggests that streaming increases the achievement gap between high and low-level streams and perpetuates social class divisions (Boaler & Staples, 2008). These structures directly oppose growth mindset views that intelligence is an emergent, dynamic entity. Although Ontario has a pathways of choice model to organize their secondary courses by postsecondary intentions and ways of learning (OME, 2005), the insights from this research suggest that the pathways effectively embody a streaming archetype. That is, the participants in this study seemed to view the Applied mathematics course as an appropriate 'choice' for those students who struggle with mathematics academically, not for those whose future aspirations require a less theoretical mathematics background or for those who might learn best through hands-on approaches. This view appears to reaffirm research on Applied courses across Ontario discussed earlier (Hamlin & Cameron, 2015).

There is also a perception from the educators in this PLC that the Applied course should benefit the underachieving students by targeting their mathematical needs, however past research

(Hamlin & Cameron, 2015; Macaulay, 2015) as well as the EQAO scores for this case study school highlight the disproportionately high number of students who fail to meet the provincial standard on the Grade 9 Applied EQAO assessment, an assessment which purports to align with the curriculum for the Applied course. If a growth mindset view is taken, the pervasive underachievement in Applied mathematics cannot be excused as mathematical deficiency, and other reasons for the low achievement on this standardized assessment must be considered. One possible explanation emerging from my analysis is that low achievement may be connected to students' mindsets, through their limited motivation to engage and persevere. Some participants mentioned they observed a notable transition from Grade 8 to Grade 9 for those students who struggled with mathematics; those who had exhibited effort in Grade 8 and ended up (by teacher recommendation or by their choice) in the Applied course became "bummed", "devastated", exhibited less independent learning behaviours, and repeatedly claimed, "I can't do math."

Dweck (2006) explains this sort of lack of motivation as stemming from a place of self-preservation. She observed that "students with fixed mindsets who were facing the hard transition saw it as a threat. It threatened to unmask their flaws and turn them from winners to losers … It's no wonder adolescents mobilize their resources, not for learning, but to protect their egos. And one of the main ways they do this … is by not trying" (p. 58). Paradoxically, it was this lack of motivation observed in students taking the Applied course that initially led the PLC to want to integrate growth mindset. They aimed to develop growth mindset in the students and then anticipated an increase in engagement, perseverance, and mathematics grades would follow (Suurtamm et al., 2017). What occurred over the two years of the project, however, was a growing recognition among these educators of the weight of what it means to be a student at the Applied 'level' and how that context influences the implementation and effectiveness of their

approaches to fostering growth mindset. This issue seemed to become more and more clear over the two years of the project, and by the time of the final interviews, the Vice Principal explicitly stated "there's something that happens with the streaming" (Vice Principal Interview, line 171). Her observation seems to align with Boaler's (2016) view that "We can give no stronger fixed mindset message to students than we do by putting them into groups determined by their current achievement and teaching them accordingly" (p. 112). Ultimately, the issue that the educators in this case study had to wrestle with was how to promote a growth mindset culture in a fixed mindset context, and whether the effort was worthwhile.

I analyzed the PLC's efforts to implement growth mindset ideas in both explicit and embedded ways, such as how they attempted to counteract the students' negativity with positive ability statements in the bulletin board activity, by embracing formative assessment practices, and by pointing out moments of mathematical progress to students. I found that many of these strategies coincide with Boaler's (2016) norms for establishing a growth mindset classroom, as noted in Chapter 1. In particular, some participants' attempts to view all students as capable learners of mathematics links to the norm that there is no such thing as a math person; their desire to integrate collaborative, rich problem solving tasks links to the norms that speak about mathematics as a creative, connected subject; and their discussion around assessing learning rather than performance, particularly learning through mistakes, links to the norms that relate struggle and progress to notions of success. While several participants did offer a few general comments during individual interviews about students being more willing to try after the mindset approaches, the greatest impacts of the mindset approach were described by these PLC members for only a few individual students even though the approaches they used seem to align well with Boaler's recommendations.

Another effort of these educators was to remove the negative stigma around the Applied course by reclaiming the original intent of the OME pathway definition for the course. That is, toward the end of the project these educators discussed trying to shift the perception of the Applied course to reflect its practicality for particular post-secondary majors, as well as removing the "dropped down" language when talking about students switching from Academic to Applied courses. Interestingly, the idea of supporting all students in a single, homogeneous mathematics course did not emerge in any of the transcripts from this PLC. In past research, de-streaming secondary mathematics courses has been shown to increase the achievement and engagement of the previously low-streamed students (Boaler & Staples, 2008; Burris, Wiley, Welner & Murphy, 2008; Horn, 2008), possibly because the mathematical expectations for all students are felt to be equal (Boaler, 2016).

In studying the journey of these educators' efforts to foster growth mindset, I saw the context of the Applied course surface in meeting after meeting as a barrier to students' embracing a growth mindset; there was a sense that, despite their efforts, most students remained negative about their mathematics ability and the course itself. Therefore, students may not be able to fully embrace a growth mindset in streamed course structures, even those disguised as a 'pathways of choice' model, because students sense their abilities in mathematics have been confirmed. My analysis suggests that the very students that research indicates should benefit most from growth mindset – those who are underachieving and academically at-risk – may be unable to move past their ingrained fixed mindsets when they find themselves "streamed" into a course designated for students deemed to be mathematically inferior.

But perhaps the question should not be *if* growth mindset is a feasible intervention strategy in an Applied mathematics context, but *how* growth mindset can be used as an

intervention strategy in a streamed course. My analysis of this data does suggest that the efforts of the PLC were not futile; I think the reason these educators continued to pursue their goal of growth mindset over the two years, and invited more educators to join their PLC, was that they did deem it a worthwhile endeavor, even if the gains were small. As one participant commented, "with this project, we definitely, you can see the change in the kids' ideas around math" (Grade 8 Special Education Teacher Interview, line 46). Similarly, the Vice Principal reflected on the mindset approach, stating the "biggest success is that students wouldn't leave their pages blank [anymore]. And that's not really about math. It's more about mindset and whether they're willing to try something" (Vice Principal Interview, lines 160-162).

These observations are valuable for schools and provinces looking to increase the engagement and achievement of their underachieving mathematics students using growth mindset approaches, particularly those who use or are considering the use of levels or paths for mathematics. Manitoba, for example, begins mathematical course pathways in Grade 10, but I have heard conversations among educators advocating for splitting the Grade 9 course into two courses (Applied and Pre-Calculus) as they feel doing so will better serve the needs of students who have gaps in their learning without holding back the high achieving students. My analysis suggests that the underachieving students in the Applied course do not necessarily embrace growth mindset with ease, in part due to their Applied pathway designation. Secondary schools keen to adopt a growth mindset culture should be aware of the fixed mindset nature of streamed course structures, as well as the way they may be masked as pathways of choice but continue to perpetuate inequalities. Limiting students' mathematical potential based on past low achievement and then attempting to foster growth mindsets in those underachieving students may prove to be a difficult undertaking, as these PLC members experienced. Moreover, the hoped-for collective

increase in achievement may not occur. Further research on growth mindset with underachieving mathematics students in streamed contexts would be helpful to more fully understand the nuances involved. In addition, longitudinal studies that examine the impact of establishing a growth mindset culture in mathematics course contexts over many years, perhaps beginning in the elementary grades, would be very informative.

Time constraints on learning. I also began to question the feasibility of using growth mindset in an educational system that puts time parameters on content learning. This was particularly evident to me as I reflected on my own teaching experience while analyzing the data. Like the school in this case, most secondary educational schools I am familiar with across Canada and in the United States operate on specific schedules, meaning courses are contained within a term, semester, or school year. Courses also have specific learning goals, outcomes or standards set by the educational system that the students are expected to achieve over the designated time period for the course. In my experience, elementary or middle school students are often allowed to move ahead in grade level with their same-aged peers regardless of achieving the particular outcomes of the year. However, once they reach high school, students must earn course credits toward graduation, and attaining the standard for a course's curricular outcomes becomes mandatory. For the underachieving Grade 9 students I work with, this change in expectation seems to increase their anxiety and/or decrease their effort, particularly if the gap between what they know and what they are required to know feels like an insurmountable chasm.

Mindset theory claims that students are capable of growing their brains, but according to the participants in this case study, the growth does not necessarily occur at the same speed or with the same amount of effort for each student. Dweck (2006) concedes this idea and explains how the mindset perspective responds to the appearance of "gifted" individuals: "Just because

some people can do something with little or no training, it doesn't mean that others can't do it (and sometimes do it even better) with training" (p. 70). Some of the dialogue in the data I analyzed was not explicitly about mindset, but did refer to the concept of students' learning development, with phrases emphasizing that it takes "time to process," and that it's unfair to expect students to exhibit understanding and skill after a topic has been taught for just a few weeks. One Grade 8 teacher explained,

> If they don't get it in Grade 8 and they only have four months to get it in Grade 9 . . . the amount of time that we can actually focus on that, you know, it becomes tricky to keep going back and revisiting it and make sure that you've covered everything that they have to do in Grade 8. So you feel bad for the kids that are still doing something like that and then you know when they get to Grade 9 it's like, oh my lord, how are we going to fix this, you know? (Grade 8 Teacher 1, Meeting 2.3, lines 579-584)

Similar to this teacher, I have found that a common dilemma for many secondary mathematics teachers I work with in Manitoba is how to give students the time to process their understanding while attempting to cover the curricular expectations for the course in the span of one semester. According to the comment above, Ontario's learning goals must also prove challenging for teachers to cover in the time allowed. This case study suggests that when mindset beliefs are introduced into a classroom, there must be a shift in how students embrace the learning process, a focus on celebrating the little successes, and an emphasis on moving forward in their learning from wherever they are in their understanding. In their implementation of growth mindset, the PLC members also integrated formative assessment strategies such as allowing students to resubmit assignments and tests, giving specific feedback to help students

bridge learning gaps, and connecting students' learning behaviours to their content learning. And yet, my analysis of this data suggests that these strategies alongside the redefining of success and shifts in assessment practices do not eliminate or reduce the expectations on students to achieve the course outcomes within a specific timeframe.

As I understand it, the growth mindset says 'there is no limit to your ability to learn' yet in a typical education system there will always be a limit placed on the learning, specifically in high school where the end of a semester marks the end of the time allotted for the students to grasp the concepts, unless they repeat the course. For students who are in the process of developing a growth mindset, failing a course may reconfirm their perceived inability. As Dweck (2006) says, "The idea of trying and still failing…is the worst fear within the fixed mindset" (p. 42). In Ontario and Manitoba, earning a high school mathematics credit is determined by meeting the standards of the required learning goals; it is not based on an individual making considerable progress in their learning. This approach seems contrary to the underlying message of growth mindset. None of the literature I located about mindset and mathematics education addressed this aspect of educational systems. Boaler (2016) does offer "advice for grading" for situations in which assigning marks is mandatory, and says that ideally teachers should focus on formative assessment and be required to "provide grades only at the end of the course" (p. 167) but the constraints that a term or semester might have on mindset is not discussed.

Similar to the discussion of streaming, I wonder if the question should not be *if* growth mindset is feasible in the context of an educational system where there are time limits for achieving the content requirements, but *how* can growth mindset be implemented in this context? It may be that the value of growth mindset for students with large gaps in their understanding who will likely not be able to demonstrate the course requirements within a single semester may

be to encourage perseverance as they attempt the course again, after they have failed. As the Grade 10 Applied Teacher 2 in the PLC stated,

> We always work in the dates of the semester. How do I get my students from here to here, and we worry about the pass and the fail, and now [after using mindset approaches] it's like, you know what, you may not pass this course, but you know, you move this far ahead and you can do it this way. And you'll get it next term, or you'll continue learning, as opposed to, you know, you're always focused on the here and now. (Meeting 2.7, lines 504-508)

The implications of this observation for educational practice may pertain to secondary educators who, like myself and those in this case study, value the message of growth mindset but are required to work within the boundaries of courses that have set curricular outcomes and set instructional time. I also wonder if this discussion on mindset's use with underachieving students can be applied to subjects beyond mathematics, particularly since there was much to observe in the way these educators contended with the obstacle of an assessment culture largely focused on grades. They worked to switch their perceptions of success and their assessment practices to align with growth mindset views, while acknowledging the reality of marks-based grading and the lack of time they had to cover their curricular learning goals, much less bridge the gaps in content that many of their students had upon entering Grade 9. These observations may be valuable for the teachers, counsellors, and administrators working with underachieving students who are enrolled in courses that are beyond their current understandings. Establishing a growth mindset culture should involve the mindful ways in which educators discuss assessment scores from tests, exams, and final grades as well as how we communicate with students about their relative progress in a course. Using course modules to allow students to progress at their own

pace, or granting students more opportunities and support to acquire the knowledge and skills they have missed might also be effective. For example, some schools are currently offering a Grade 9 mathematics bridging-course for students who may need to improve their mathematical understanding before they attempt the Grade 9 course learning outcomes. I think research into the use of growth mindset in these courses would be beneficial.

Reconsidering the conceptual framework. To create the conceptual framework for this study, I looked to studies that had connected mindset to student achievement and noted that several of them included a pathway model linking mindset to achievement through various mediating variables. Since mindset is a psychological term stemming from the concepts of self-efficacy or views of intelligence and ability (Yeager & Dweck, 2012), I considered that it may be difficult for educators to identify those beliefs in students and that outward expressions of the belief, such as students' attitudes, actions, and achievement of content material, might be easier to identify. I decided to analyze my research with the help of a simplified linear pathway that connected mindset to achievement through the variables of goal orientation and learning strategies (see Figure 1, replicated below); I anticipated these mediating variables would be helpful in informing my interpretations of the PLC's perspectives on and approaches to fostering growth mindset.

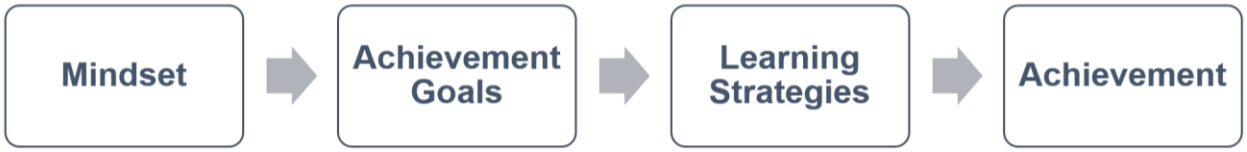


Figure 1. Pathway model representing the connection between mindset and achievement.

While analyzing the data and writing the observations for Chapter 4, I reflected on the conceptual model and began to realize I might need to adapt it according to the understandings

that emerged in the study. I found ways that these educators' experiences seemed to connect with the model, but more often realized that the model was limited in its ability to describe the observations that emerged from the data. In this section, I first draw connections from the data to the model, then address the model's limitations, and end with suggesting an alternative view of this study's observations in the form of an analogy.

Connections to the model. I was able to see connections between the participants' understandings of mindset and some components of the conceptual model; for example, *achievement goals* I see as connecting to participants' understanding that success needs to be redefined as progress not performance, and *learning strategies* connects with their understanding that mindset has an action counterpart. There also seemed to be a general sense that students' mindsets are the root of their action or inaction in mathematics class, suggesting to me that in some ways there was a linear understanding of mindset's influence on student behaviour. For instance, the PLC stated as their initial inquiry goal that as students developed growth mindsets there would be an increase in risk-taking, perseverance, engagement, ability to self-assess, and achievement on the Grade 9 Applied EQAO assessment (Suurtamm et al., 2017). This expectation of mindset influencing behaviour lines up with the claims of numerous mindset intervention studies described in Chapter 2 as well as Dweck's (2006) statement that explicit mindset teaching experiences made "our research participants into growth-minded thinkers, at least for the moment – and they act like growth-minded thinkers, too" (p. 47). The notion of mindset having 'thinking' and 'action' aspects emerged throughout the project, with many conversations alluding to the view that knowing leads to doing. For example, some PLC members viewed the implementation of mindset as an evolving approach, moving from explicit strategies where students gain knowledge about mindset to embedded strategies where views of

success and learning behaviours were challenged by shifting teaching practices. This approach seems to align with the linear view of mindset and behaviour illustrated in the conceptual model.

Limitations of the model. I also saw many ways that the data does not align with a linear pathway that places mindset as the root of students' views of success and learning behaviours. For instance, some of the participants disagreed with the idea that thinking leads to doing; one educator explained, "I think I approached [mindset] through doing. I didn't really talk about the thinking. Because I thought through the doing, they would get to the thinking after" (Grade 8 Teacher 1, Meeting 2.5, lines 72-74). Similarly, several of the PLC members emphasized a belief that the explicit approach did not necessarily precede the embedded, and that the two approaches should be consistently "interspersed" into the Applied course to support a growth mindset culture. These perspectives indicate to me that the relationship between student mindsets and actions may be more reciprocal than linear.

My initial conceptual model also did not have the capacity to describe these educators' perceptions of the disconnect they identified between students' knowledge about mindset and how that knowledge was lived out in a mathematics setting. The smooth transition from teaching mindset to gains in achievement portrayed in most of the intervention studies discussed in Chapter 2 was not the experience of these educators as they began implementing a mindset approach. In fact, close to the end of the project there was a realization among some of the educators that students may know they have a fixed mindset toward mathematics and *choose* not to change their mindset. I did not find this perspective on mindset "choice" in the empirical studies I explored, although Dweck (2006) indicates that "growth mindset is a starting point for change, but people need to decide for themselves where their efforts toward change would be most valuable" (p. 51). Given these observations, I feel that what my original conceptual model

fails to adequately explain is the idea that this disconnect (or perhaps choice not to change) might be attributed to obstacles to implementing growth mindset approaches which the PLC perceived such as: ingrained fixed mindsets stemming from past experiences, the view of mathematics as a right-or-wrong subject, a marks-based assessment culture, and the streamed nature of the Applied course. With these observations in mind, I believe these contextual or environmental factors need to be more evident in the conceptual model.

The interaction between mindset and various contexts or environmental factors is included in both my literature review and theoretical framework. For instance, in Chapter 2 I discussed several non-intervention strategies that were shown to influence growth mindset in the classroom and the PLC's experiences seem to align with the research that found greater gains in growth mindset in classrooms that used mastery-oriented messages (Park et al., 2016; Sun, 2015), reformed instructional approaches (Cobb, Gresalfi, & Hodge, 2009), and were part of non-streamed mathematics course structures (Boaler & Staples, 2008). I also highlighted some recent studies that administered mindset interventions while considering the influence of context. For example, Yeager et al. (2019) used the image of a seed within soil to explain how mindset interventions can fail or flourish depending on the context. Additionally, I indicated in my theoretical framework that the concept of mindset stems from Bandura's social cognitive theory of motivation, which takes into account the influence of environment on cognitive thought and behaviour (1999). Since I observed the participants in this study emphasizing the weight of these environmental factors on the ability of the students in the Applied course to embrace growth mindsets, I feel this aspect should be more fully addressed in the conceptual framework.

For that reason, I began to attempt various adaptations to the framework: making the components cyclical, adding in an environmental component, and trying a spiral-like model. I

could not see how I could portray the interweaving, multifaceted aspects of mindset that surfaced from these educators over the two years of the project by altering the model. What I could see, however, was the representation of these educators' experiences as an analogy.

The analogy. To illustrate the observations from this case study, I offer an analogy of a fuel tank (see Figure 3).

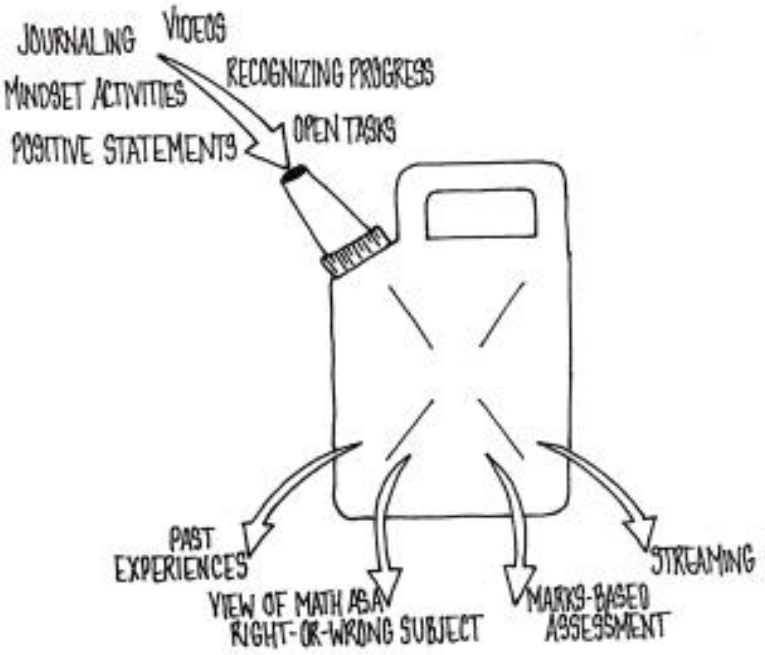


Figure 3. Growth mindset analogy illustration.

The following points describe how I see features of a fuel tank helping to understand the PLC's experiences with growth mindset.

1. The fullness of the tank represents growth mindset. Just as the tank can have various levels of fuel, students and teachers can have various levels of mindset. This aspect of the analogy aligns with the PLC's observation that mindset seems to develop slowly and possibly on a continuum.

2. The fuel being poured into the tank represents the explicit and embedded strategies these educators used to build growth mindset. For example, they "poured in" mindset-related experiences, visuals, encouraging language, engaging, open-tasks, and celebrations of small gains in skills or understanding.

3. The tank symbolizes the context or environment in which growth mindset approaches are implemented. In this case, the context is the Grade 9 Applied mathematics course.

4. Holes, or leaks, in the tank represent the circumstances that seem to undermine the adoption of growth mindset. For example, there could be a hole for marks-based assessment, streamed courses, fixed mindset habits from past experiences, and a closed view of mathematics. The size of the holes could also represent how influential each obstacle may be.

I feel that a fuel tank analogy corresponds to the experiences of these educators in several ways. In one way, it allows the connection between the influences on and by growth mindset to be muddled rather than having various factors correspond to each other in particular ways, as the original model suggested. I found this study did not de-mystify the interworking components around mindset; more often the PLC members seemed challenged by the somewhat "nebulous" determinants of students' responses to the growth mindset as well as how they saw mathematics content attainment tied to mindset. I see the fuel (strategies) being poured into the tank (context or environment) and mixing in complex ways to affect students differently. This aspect of the analogy may illustrate why these educators saw a greater impact with some students than others.

In a similar way, the analogy allows the contextual piece of mindset to be evident and play a role in the ebb and flow of growth mindset in students. If the fuel tank is the context in which growth mindset is introduced, then we could imagine that students may have different

tanks for various situations. Just as some tanks may have more holes than others, some contexts or environments may have more obstacles than others, and be less inclined to "hold onto" growth mindset. Even if a student would take a full growth mindset tank from one situation and use it to fill up their Applied mathematics-context tank (what the PLC discussed as *transferring* growth mindset from one context to another), the holes in the tank would not allow the level of growth mindset to remain full. Additionally, some tanks may have tightly closed caps that do not allow fuel in to begin with. This idea would parallel the observation that students in the Applied course seemed to sometimes choose not to have a growth mindset, despite understanding what it is.

Moreover, the analogy offers an explanation for the perceived disconnect between mindset and action. Just as pouring fuel into a leaky tank can initially cause the illusion of a filling tank, teaching growth mindset to students within a fixed mindset context may initially cause the illusion of students grasping growth mindset. When asked to put the fuel to use, however, the leaky tank will quickly run dry. This aspect of the analogy corresponds to the PLC's observation that many students seemed to apply growth mindset in mindset-related activities, but when faced with difficult mathematics tasks they were "stuck" and reverted back to fixed mindset behaviours. Perhaps those students' mindset tanks were too full of holes and therefore they were less willing to take risks or persevere. Their tanks were dry.

I feel that a fuel tank analogy provides a way for educators, educational leaders, and researchers to look at the potential implications for using growth mindset in similar contexts to this case study. As I suggested earlier, changing the question from *if* growth mindset is feasible in a streamed course context with time constraints on learning to *how* growth mindset could be used in such contexts is key. Looking at the observations that emerged from this study, it seems that students' reception to growth mindset had less to do with the wide range of strategies that

these educators used and more to do with the obstacles they perceived. I see this understanding paralleling the idea that in order to keep a leaky fuel tank full, you could either provide a constant supply of fuel, or – what seems to be the better solution – plug the holes. In other words, removing the obstacles that hinder students from adopting growth mindset seems to be the more valuable and sustainable approach for successfully implementing growth mindset. And yet, as an educator, I cannot control the students' past experiences with mathematics, the course structure of mathematics, or how the school or province requires reporting on student achievement. Nonetheless, like the educators in this case study, I see the value of imparting the message of growth mindset in mathematics with underachieving students, even if it will require steady reinforcement and support.

Limitations of Secondary Analysis and Generalizations from Case Study Research

In this section, I begin with outlining the limitations of this research. The principal limitation relates to the secondary analysis of data. I also discuss a way that generalizations can be made more appropriately from case study approaches based on the ideas of Eisenhart (2009).

Secondary analysis limitations. I feel that not being a part of the original research team for the OAME Project produces the greatest limitations for this thesis. As I was not present at the data gathering sessions, did not transcribe the audio recordings and could not communicate with any of the participants, my interpretations were constructed principally from written transcripts. Any dialogue I read from the transcripts was devoid of body language, facial expressions, and vocal inflections, which can, at times, indicate alternative connotations to words or phrases. I was unable to ask for clarification on participants' views or for more detail to gain additional insight into my research questions. Although the discussions I had with the principal researcher

and with my thesis supervisor helped reduce these difficulties and increased the trustworthiness of my study, I feel that these limitations could not be completely overcome.

In some ways I also found that the open-ended inquiry of the OAME Project limited my ability to specifically target the aspects of mindset that I was exploring, as compared with a study designed explicitly to gather insights about mindset. At the same time, I acknowledge that the open-ended nature of the OAME Project also gave me the opportunity to witness the authentic, non-researcher-driven journey of 11 educators as they attempted to implement growth mindset approaches. Overall, I feel this was a benefit that greatly outweighed the limitations.

As with any multiple-participant case-study, I also realize that group dynamics and power structures may have impacted what was said during the PLC meetings. For example, the Vice Principal and Board Mathematics Lead were present during most meetings and had some influence over the participants. These relationships may not necessarily be evident in a transcript of a conversation and yet that may have impacted how individuals behaved. In addition, since the growth mindset phenomenon has been touted in many educational circles, some group members may have been inclined to portray their beliefs in what they think of as the current mainstream, socially accepted manner. Again, although I was able to validate my insights with the researchers involved in the project, I realize the limitations of analyzing data as an outsider listening in.

Generalizations from case study research. Case study findings are inherently context-based and the interpretations are discussed with the goal "not to generalize to predict and control but rather to describe what people say and do in local contexts" (Freeman, deMarrais, Preissle, Roulston, & St. Pierre, 2007, p. 29). However, Eisenhart (2009) argues that generalizations across similar sites is possible if a researcher provides "sufficient detail about the researched context for a person with intimate knowledge of a second context to judge the likelihood of

transferability" (p. 56). She recommends choosing sites whose contexts are typical, familiar, and can be described in detail, and I believe the case I chose for this thesis aligns with her recommendations. The case involved a group of educators at a mid-sized Grades 7-12 school in rural Ontario who attempted to use growth mindset approaches with particular cohorts of students in the Grade 9 Applied mathematics course over two years. The themes that emerged from this PLC may have implications for educators working in similar settings with underachieving students as they enter high school, particularly where secondary mathematics courses are set up in pathways or streamed course structures.

Final Thoughts

This thesis provides observations for secondary educators, educational leaders, policy makers, and researchers who are exploring potential motivational interventions for low achieving mathematics students. Growth mindset approaches in mathematics appear to be growing in influence, particularly for the interventions that have been promoted as a high gain for low cost initiative for raising the mathematical achievement of academically at-risk students (Boaler et al., 2018; Yeager et al., 2019). According to the experiences of the educators in this case study, the benefits of the approach with the underachieving students were not as easy to come by as the mindset literature may suggest. I chose to explore the implementation of growth mindset within an Applied mathematics course where Grade 9 students, and perhaps their teachers, viewed the course as "lower" in academic rigour and expectation than its Academic mathematics counterpart. Many of the students in the Applied course had histories of underachievement in mathematics and entered the course with negativity toward mathematics and their ability to learn mathematics. What this research tended to show was that if the students in the Applied course chose to shift from a fixed mindset to a growth mindset, the process was slow and often impeded

by ingrained fixed mindset behaviours, the view that mathematics is a right or wrong subject, marks-based assessment practices, and the streamed nature of the Applied mathematics course. I observed these educators maintain their inquiry with mindset over the two years of the project, shifting in the ways they approached teaching and integrating mindset theory into the classroom. They celebrated individual students who were perceived to make large gains in their progress as well as the more subtle success of many students being more willing to try a mathematical task. In the end, one participant deemed mindset "a huge component to learning math." I believe this thesis demonstrates that when educators decide to pursue growth mindset with mathematics students, the decision necessitates a permeation of the beliefs into every aspect of their practice, effectively calling for change in many ongoing secondary mathematics norms.

References

Allexsaht-Snider, M. & Hart, L. E. (2001). "Mathematics for all": How do we get there? *Theory into Practice, 40*(2), 93-101.

Anderson, R. K., Boaler, J., & Dieckmann, J. A. (2018). Achieving elusive teacher change through challenging myths about learning: A blended approach. *Educational Science, 8*(3): 98.

Aronson, J., Fried, C. B., & Good, C. (2001). Reducing the effects of stereotype threat on African American college students by shaping theories of intelligence. *Journal of Experimental Psychology, 38,* 113-125.

Bandura, A. (1999). A social cognitive theory of personality. In L. Pervin & O. John (Ed.), *Handbook of personality* (2nd ed., pp. 154-196). New York, NY: Guilford Publications.

Bandura, A. (2006). Toward a psychology of human agency. *Perspectives on Psychological Science, 1,* 164-180.

Berry, R. (2018, September 20, 3:14pm). Are tracked math classes helping or hurting students? *The show.* [Radio broadcast]. Tempe, AZ: KJZZ 91.5 FM.

Biafora, F. & Ansalone, G. (2008). Perceptions and attitudes of school principals toward school tracking: Structural considerations of personal beliefs. *Education, 128*(2), 588-602.

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development, 78*, 246-263.

Boaler, J. (1998). Open and closed mathematics: Student experiences and understandings. *Journal for Research in Mathematics Education, 29*(1), 41-62.

Boaler, J. (2008). *What's math got to do with it? How teachers and parents can transform mathematics learning and inspire success.* New York, NY: Penguin Group.

Boaler, J. (2016). *Mathematical mindsets.* San Francisco, CA: Jossey-Bass.

Boaler, J., Dieckmann, J. A., Pérez-Núñez, G., Sun, K. L., & Williams, C. (2018). Changing students minds and achievement in mathematics: The impact of a free online student course. *Frontiers in Education, 3*(26). Retrieved from https://www.frontiersin.org/articles/10.3389/feduc.2018.00026/full

Boaler, J. & Selling, S. K. (2017). Psychological imprisonment of intellectual freedom? A longitudinal study of contrasting school mathematics approaches and their impact on adults' lives. *Journal for Research in Mathematics Education, 48*(1), 78-105.

Boaler, J., & Staples, M. (2008). Creating mathematical futures through an equitable teaching approach: The case of Railside School. *Teachers College Record, 110*(3), 608-645.

Burris, C. C., Wiley, E., Welner, K., & Murphy, J. (2008). Accountability, rigor, and detracking: Achievement effects of embracing a challenging curriculum as a universal good for all students. *Teachers College Record, 110*(3), 571-607.

Charles, A. S. (2018). Rivers and fireworks: Social constructivism in education. In V. Kapur & S. Ghose (Eds.), *Dynamic Learning Spaces in Education* (pp. 285-300). Singapore: Springer.

Claro, S., Paunesku, D., & Dweck, C. S. (2016). Growth mindset tempers the effects of poverty on academic achievement. *PNAS, 113*(31). Retrieved from http://www.pnas.org/content/113/31/8664.full

Cobb, P., Gresalfi, M., & Hodge, L. L. (2009). An interpretive scheme for analyzing the identities that students develop in mathematics classrooms. *Journal for Research in Mathematics Education, 40*(1), 40-68.

Creswell, J., & Miller, D. (2000). Determining validity in qualitative inquiry. *Theory into Practice, 39*, 124-130.

Daley, B. J. (2004). Using concept maps in qualitative research. In A. J. Cañas, J. D. Novak & F. M. González (Eds.), *Concept maps: Theory, methodology, technology: Proceedings of the First International Conference on Concept Mapping* (pp. 191-197). Pamplona, Spain: Universidad Pública de Navarra.

Denworth, L. (2019, August 12). Debate arises over teaching "growth mindsets" to motivate students. *Scientific American*. Retrieved from https://www.scientificamerican.com/article/debate-arises-over-teaching-growth-mindsets-to-motivate-students/

Dweck, C. S. (2006). *Mindset: The new psychology of success*. New York, NY: Ballantine Books.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*, 256-273.

Eisenhart, M. (2009). Generalization from qualitative inquiry. In K. Ercikan & W. M. Roth (Eds.), *Generalizing from educational research: Beyond qualitative and quantitative polarization* (pp. 51-66). New York, NY: Routledge.

Foster, C. (2018). Developing mathematical fluency: Comparing exercises and rich tasks. *Educational Studies in Mathematics, 97*(2), 121-141.

Freeman, M., deMarrais, K., Preissle, J., Roulston, K., & St. Pierre, E. A. (2007). Standards of evidence in qualitative research: An incitement to discourse. *Educational Researcher, 36*(1), 25-31.

Grant, H. & Dweck, C. S. (2003). Clarifying achievement goals and their impact. *Journal of Personality and Social Psychology, 85*(3), 541-553.

Greene, B. A., Miller, R. B., Crowson, H. M., Duke, B. L., & Akey, K. L. (2004). Predicting high school students' cognitive engagement and achievement: Contributions of classroom perceptions and motivation. *Contemporary Educational Psychology, 29*, 462-482.

Gross-Loh, C. (2016, December 16). How praise became a consolation prize: Helping children confront challenge requires a more nuanced understanding of the growth mindset. *The Atlantic*. Retrieved from https://www.theatlantic.com/education/archive/2016/12/how-praise-became-a-consolation-prize/510845

Haimovitz, K., & Dweck, C. S. (2016). What predicts children's fixed and growth intelligence mindsets? Not their parents' views of intelligence but their parents' views of failure. *Psychological Science, 27*, 859-869.

Hamlin, D. & Cameron, D. (2015). *Applied or academic: High impact decisions for Ontario students*. Retrieved from http://www.peopleforeducation.ca/wp-content/uploads/2015/04/People-for-Education-Applied-or-Academic-Report-2015.pdf

Hardre, P. L., & Sullivan, D. W. (2008). Student differences and environmental perceptions: How they contribute to student motivation in rural high schools. *Learning and Individual Differences, 18*, 471-485.

Horn, I. S. (2008). Turnaround students in high school mathematics: constructing identities of competence through mathematical worlds. *Mathematical Thinking and Learning, 10*, 201-239.

Leslie, S., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science, 347*(6291), 262-265.

Li, Y., & Bates, T. C. (2019). You can't change your basic ability, but you work at things, and that's how we get hard things done: Testing the role of growth mindset on response to setbacks, educational attainment, and cognitive ability. *Journal of Experimental Psychology, 148*(9), 1640-1655.

Liem, A. D., Lau, S., & Nie, Y. (2008). The role of self-efficacy, task value, and achievement goals in predicting learning strategies, task disengagement, peer relationship, and achievement outcome. *Contemporary Educational Psychology*, *33*, 486-512.

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*. New York, NY: Springer.

Macaulay, A.V. (2015). *Effective practices in Grade 9 Applied Mathematics.* (Doctoral dissertation). University of Toronto. Retrieved from https://tspace.library.utoronto.ca/bitstream/1807/71461/1/Macaulay_Alison_201511_EdD_thesis.pdf

Mangels, J. A., Butterfield, B., Lamb, J., Good, C. & Dweck, C. S. (2006). Why do beliefs about intelligence influence learning success? A social cognitive neuroscience model. *Social Cognitive and Affective Neuroscience, 1,* 75-86.

Merriam, S. & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation* (4th ed.). San Francisco, CA: Jossey-Bass.

Miller, R. B., Greene, B. A., Montalvo, G. P., Ravindran, B., & Nichols, J. D. (1996). Engagement in academic work: The role of learning goals, future consequences, pleasing others, and perceived ability. *Contemporary Educational Psychology*, *21*, 388-422.

Moser, J. S., Schroder, H. S., Heeter, C., Moran, T. P, Lee, Y. (2011). Mind your errors: evidence for a neural mechanism linking growth mind-set to adaptive posterror adjustments. *Psychological Science, 22*(2), 1484-1489.

Murphy, M. C., & Dweck, C. S. (2010). A culture of genius: How an organization's lay theory shapes people's cognition, affect, and behavior. *Personality and Social Psychology Bulletin, 36*(3), 283-296.

National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all.* Reston, VA: Author.

Ontario Ministry of Education. (2005). *The Ontario curriculum grades 9 and 10: Mathematics*. Retrieved from www.edu.gov.on.ca/eng/curriculum/secondary/math910curr.pdf

Parekh, G. & Gaztambide-Fernandez, R. (2017). The more things change: Durable inequalities and new forms of segregation in Canadian public schools. In W. T. Pink & G. W. Noblit (Eds.), *Second International Handbook of Urban Education* (pp. 809-831). Switzerland: Springer International.

Parrish, S. D. (2010). *Number talks: Helping children build mental math and computations strategies*. Sausalito, CA: Math Solutions.

Park, D., Gunderson, E. A., Tsukayama, E., Levine, S. C., & Beilock, S. L. (2016). Young children's motivational frameworks and math achievement: Relation to teacher-reported

instructional practices, but not teacher theory of intelligence. *Journal of Educational Psychology, 108,* 300-313.

Paunesku, D., Walton, G. M., Romero, C., Smith, E. N., Yeager, D. S., & Dweck, C. S. (2015). Mind-set interventions are a scalable treatment for academic underachievement. *Psychological Science, 26,* 784-793.

Rattan, A., Good, C., & Dweck, C. S. (2012). "It's ok – not everyone can be good at math": Instructors with an entity theory comfort (and demotivate) students. *Journal of Experimental Social Psychology, 48,* 731-737.

Romero, C., Master, A., Paunesku, D., Dweck, C. S., & Gross, J. J. (2014). Academic and emotional functioning in middle school: The role of implicit theories. *Emotion, 14*, 227-234.

Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N. (2018). To what extent and under which circumstances are growth mind-sets important to academic achievement? Two meta-analyses. *Psychological Science, 29*(4), 549-571.

Schroder, H. S., Moran, T. P, Donnellan, M. B., & Moser, J. S. (2014). Mindset induction effects on cognitive control: A neurobehavioral investigation. *Biological Psychology, 103*, 27-37.

St. Amant, T. R. (2017). The effect of teacher mindset on low-tracked students. (Doctoral dissertation). University of Pittsburg. Retrieved from d-scholarship.pitt.edu/32084

Sun, K. L. (2015). *There's no limit: Mathematics teaching for a growth mindset*. (Doctoral dissertation). Stanford University. Retrieved from https://stacks.stanford.edu/file/druid:sf479cc2194/Sun-Dissertation-Upload-augmented.pdf

Suurtamm, C., Lazarus, J., Koch, M., McKie, K., Pai, J., Quigley, B., … Knowles, K. (2017, January). *Teaching grade 9 applied mathematics: A collaborative inquiry*. Unpublished report to the Ontario Association for Mathematics Education.

Suurtamm, C., Lazarus, J., & McKie, K. (2017, September). Teaching grade 9 applied mathematics: A collaborative inquiry. *Gazette – Ontario Association for Mathematics Education, 56*(1), 35-41.

Urdan, T., & Schoenfelder, E. (2006). Classroom effects on student motivation: Goal structures, social relationships, and competence beliefs. *Journal of School Psychology, 44*, 331-349.

Ward, H. (2015, December 4). Jo Boaler: We need a revolution in how we think about maths. Retrieved from https://www.tes.com/news/tes-magazine/tes-magazine/we-need-a-revolution-how-we-think-about-maths

Wood, R., & Bandura, A. (1989). Impact of conceptions of ability on self-regulatory mechanisms and complex decision making. *Journal of Personality and Social Psychology, 56*, 407-415.

Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist, 47*(4), 302-314.

Yeager, D. S., Hanselman, P., Walton, G. M., Murray, J. S., Crosnoe, R., Muller, C., … Dweck, C. S. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature.* Retrieved from https://www.nature.com/articles/s41586-019-1466-y.pdf

Yeager, D. S., Romero, C., Paunesku, D., Hulleman, C. S., Schneider, B., Hinojosa, C., … Dweck, C. S. (2016). Using design thinking to improve psychological interventions: The case of the growth mindset during the transition to high school. *Journal of Educational Psychology, 108*, 374-391.

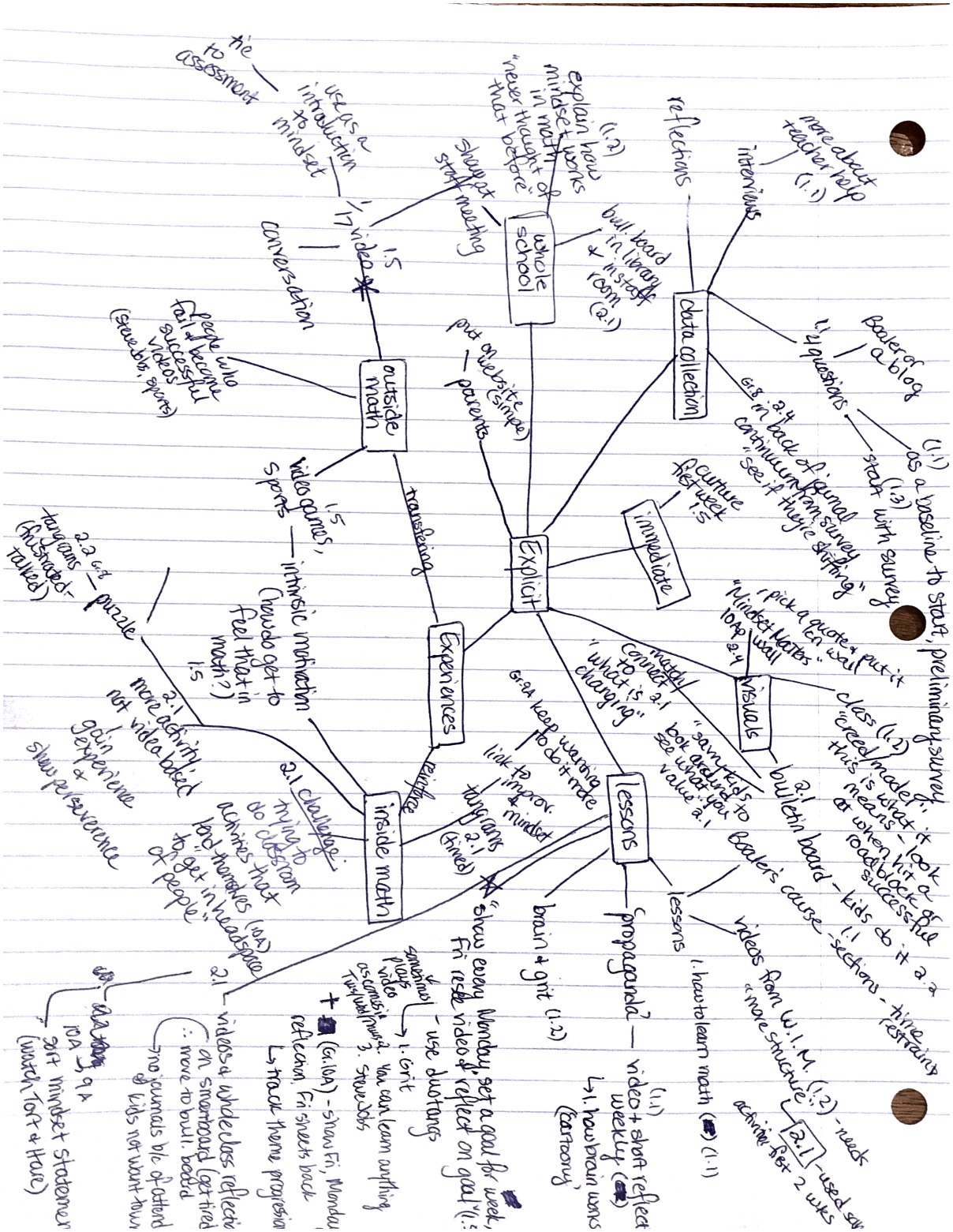
Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: SAGE Publications.

Yin, R. K. (2015). Case studies. In J. D. Wright (Ed.), *International encyclopedia of the social and behavioral sciences.* (pp. 194-201). New York, NY: Oxford University Press.

Zager, T. J. (2017). *Becoming the math teacher you wish you'd had: Ideas and strategies from vibrant classrooms*. Portland, ME: Stenhouse Publishers.

Appendix A

Concept Map Example



Appendix B

Student Mindset Survey

NAME:
DATE:

Mindset Progress – Self Reflection

Criteria	Growth Mindset	Reflection		
Challenges	I enthusiastically start a challenge.	Often	Sometimes	Rarely
Mistakes	I am open to learning from my mistakes.	Often	Sometimes	Rarely
Feedback/Criticism	When the teachers tells me how I am doing I want to keep trying.	Often	Sometimes	Rarely
Perseverance	I keep working until the task is complete.	Often	Sometimes	Rarely
Questions	I ask thoughtful questions.	Often	Sometimes	Rarely
Taking risks	I openly share my work and my learning.	Often	Sometimes	Rarely
Participation	I like to participate and offer my ideas.	Often	Sometimes	Rarely

Comments:

Adapted from: http://www.mindsetworks.com

Appendix C

Growth Mindset Bulletin Board

