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Toxic Math-masculinity: Changing Harmful Lay Theories of Mathematics to Improve Student Achievement

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Toxic Math-masculinity: Changing Harmful Lay Theories

of Mathematics to Improve Student Achievement

by

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CHAPTER ONE

Introduction

Overview

After training to become a mathematics teacher, I slowly began to perceive certain stereotypes that I choose to call Toxic Math-masculinity. Toxic Math-sculinity describes the cultural perceptions around mathematics that determine how people, especially students, view mathematics. The term Toxic Math-masculinity is inspired by the concept of Toxic Masculinity where men and women are socialized to perceive their gender performance as something essential and normative. This can be connected to many psychological effects (among other effects) that are harmful for both groups. Toxic Math-masculinity is the harmful belief that there are Math-People and non-Math-People and that to be a "Math Person" is to be smart and capable of effortlessly solving problems, while being a "Non-Math-Person" is to be less intelligent and to be incapable of learning mathematics. The resulting belief structure harms both high-achieving and low-achieving students.

My anecdotal experiences led me toward considerations of how this Toxic Math-masculinity affects students in the math classroom. This chapter describes the development of my interest in the research question: *how can lessons focused on students' mathematical disposition change students' lay theories of mathematics and guide them toward pursuing learning goals?* I have discussed my coinage of the term Toxic Math-masculinity to describe the harmful views our society holds around mathematics with several friends and colleagues and they will always respond with immediate understanding of what I mean. Everyone knows that our culture has a strained relationship with mathematics which leads to two further questions: *Why?* And *How do we change it?*

Personal Context

I work as a middle school math teacher in Minneapolis. There are many ways that I could describe my school but I feel that many of them, even those that are federally defined, can act as labels that prejudice my view or others' views of my students and school. I think it's more illuminating to say that I am a rather imperfect mirror for many of my students. By using 'mirror' I am referring to the concept of students having access to adult interactions that reflect their culture and background.

I am white. Cisgender. Straight. I speak only one language. I love math. I grew up in a middle-class suburb outside of Chicago. Growing up, I lived in the same single family home with a two-car garage and a basketball hoop on the driveway. My parents still live in that house. Both of my parents have attained at least a Master's Degree. All of my siblings and cousins have attended college. I am tall. I have a beard. My favorite sports are rugby union and hockey. My favorite musician is Bob Dylan.

Some of these differences are obviously minor: they amount to differences of personality and age. Some of these differences are more meaningful. It means that simply showing up to the first day of class students are assuming certain things about me and the subject that I teach. It means that I have to do more work in order to understand and engage with the students that I teach because my memories and experiences with education do not necessarily match their own. Except, perhaps, in one respect. I hate talking about math.

I have either been taking classes to become a math teacher or teaching math in the classroom for the last six years, yet I still hate being asked to talk about math. I empathize with the student who is asked to share out for the group and has to be prodded or enticed to speak up. At social functions when I meet new people I rehearse in my head what I am going to say, hoping my name is not called when the question is “What do you do for work?” Because immediately after sharing that I am a math teacher, I hear one of several responses: “I don’t understand the homework my daughter brings home”; or “I hated math in middle school”; or, “I liked math up until calculus”; or the most common, “I’m not good at math. I’m not a math person."

This last comment is one I’ve heard from students, fellow educators, parents, friends, waiters, people sitting at my table at weddings, people seeing me grade papers in a coffee shop, and so on. I’ve had parents during conferences make sweeping statements that their entire family is not good at math and they firmly believe that it is a genetic trait like freckles or a cleft chin. The first time I heard that sentiment from a parent all I could think of was how harmful that attitude must have been for their own math education. Then I began to consider how they developed that self-understanding of themselves with respect to math. Obviously, it stems from their personal experience with mathematics but that experience is mediated by the larger culture.

Cultural Depictions of Mathematics

Broadly speaking, popular culture is not a fan of mathematics. There are two main archetypes for depicting math in our culture. The first is representing dread or anxiety about mathematics, emphasizing its incomprehensibility or how it rewards only “correct” answers rather than effort. This archetype can be found throughout young adult media.

Popular book series, such as *Diary of a Wimpy Kid*, almost always depict the protagonist as disliking math class or trying to escape from math homework and quizzes. Television shows have their characters react in horror to a pop-quiz or come home defeated after a math test. The received message is that math is a struggle; it presupposes failure. Math, the cultural depictions intimate, is not for the everyman protagonist.

The other archetype of math depiction in culture is the “genius”, often a singular individual in the same math class as the protagonist. This person, like Minkus in *Boy Meets World*, excels at math. They’re often depicted as performing mathematics at a substantially higher level with little to no effort (and yet still in the same classroom setting). Other cultural examples are legion. *Good Will Hunting* focuses on a man with an innate, miraculous gift for mathematics even without formal training. *A Beautiful Mind* is about a mathematical genius whose intelligence makes him an outsider until his genius is finally useful to regular people. This archetype is so common that it has become a trope for someone on an investigation show to reel off a few vaguely mathematical sounding things (Picker, 2007). The received message is that math is the domain only of the preternaturally gifted student. Again, it is unintelligible to most anyone else.

Effects of Toxic Math-sculinity

When people are exposed to these mathematical stereotypes, they internalize them and self-select their identities. For those who identify with the dread and anxiety archetype, this identity can express itself as learned helplessness. People who see themselves as “good at math” and closer to the genius archetype can also experience negative consequences from their identification when they reach a topic that is more difficult for them. Both groups come to equate effort with failure. Having to work at a problem means that they are not smart enough for the class or activity. This is very threatening to their self-identity and self-esteem. Students and adults will often reflexively protect themselves and their self-esteem by not trying. You cannot be judged smart or un-smart if you do not try, their thinking goes.

A lot of research has been done investigating how to address this problem of self-identification as it appears in the math classroom. Math education more generally has moved from valuing getting the One-Right-Answer to valuing the process. The cultural archetypes are analogs of incorrect and correct, an either/or that is sometimes mirrored in how students are graded, assessed, or tracked. But despite the cultural representations, math ability exists on a continuum and a student's place within that continuum is not fixed. A lot of my work in the classroom attempts to teach this fact, either directly or indirectly.

The Findall et al. (2001) identified five strands of mathematical proficiency: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Productive disposition is described as "[the] habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy" (p. 116). Productive disposition is intrinsically connected with a student's self-identity. Insofar as popular culture's representations of mathematics are damaging, they damage a student's productive disposition most of all. Many of the tools I use in the classroom to make mathematics fun and accessible are tools that I use to break down the received messages that students have internalized.

Dispositional Methods

In my classroom, I wear a pink half-apron with pockets. I wear the apron because it keeps my pens and other materials organized. It is pink because that is my favorite color. I did not think about anything else when I picked it out. Yet a colleague once thanked me for wearing it because they felt I was helping to break down stereotypes they considered part of "toxic masculinity." On Fridays, I wear a math-magician robe or cape with numbers and equations pinned to them. I correct students who call me a math-wizard, telling them "I am only a Math-magician. Becoming a Math Wizard requires a PhD." The best joke that I know is to take a student who is feeling cold to the corner of a room and say, "Stand here, you'll feel better. It's ninety-degrees." I also have an oblique angle in my wall and I warn them to stay away from it: "Careful, that's one hundred and forty degrees, you might burn yourself."

I dress up and joke about math because it takes some of the edge off of the anxiety of mathematics for students. My research question is focused on what effects exploratory lessons have on changing students' own self-conception and their conception of what mathematics can mean for them and their context.

Summary

My personal experiences with discussing math with other people as well as working in a math classroom have led me to describe the culture surrounding mathematics as a Toxic Math-masculinity. This is a construct that creates mathematical haves and have-nots and deeply affects both of these groups, both outside and inside the math classroom. This led me to the research question: *How can lessons focused on students' mathematical disposition change students' lay theories of mathematics and guide them toward pursuing learning goals?*

In the next chapter, I will review the literature relevant to the research question. I will focus on how lay theories of mathematics are constructed and the effects they have on students' mindset, motivation, and goals. I will make an argument that there is a need for lessons that are specifically focused on students' lay theories of mathematics and their goal orientations. In later chapters I will describe the design of the project and reflect on the process as a whole.

CHAPTER TWO

Literature Review

Introduction

Mathematics is unique as a subject for many reasons. Furinghetti (1993) pointed out that “the image of mathematics is conditioned (unfortunately, usually in a negative direction) by the school experience of the individual in a more radical way than happens with other subjects” (p. 37). Beginning a new course or unit in math is more likely to present a student with tasks that they are, as yet, unable to perform fluently (Dweck, 1986) compared to other subjects.

The skills required to read and comprehend two different texts in a language arts classroom are functionally the same; the epistemological method of a science classroom does not fundamentally change from sixth to eighth grade. Students in a middle school math classroom, on the other hand, may be presented with several units in a year that share only a small overlap of skills. A unit on prime factorization shares skills with a unit on rational numbers only in the applications of greatest common factor and lowest common denominator in generating equivalent fractions. The bulk of the conceptual understanding of rational numbers is a new skill. Thus a student’s mindset and motivation is a key determinant of their behavior when experiencing the almost inevitable sense of confusion or failure (Licht & Dweck, 1984).

Mathematics is also unique in cultural perception (Furinghetti, 1993). For many, mathematical achievement is the primary marker of intelligence with the corresponding view that mathematical achievement should come easily and without effort. This can mean that students with high achievement in mathematics still lack the proper mindset to help them select good strategies for dealing with failure and confusion.

Student motivation is one of the most salient features of the mathematics learning environment. Motivation in the mathematics classroom is derived from a student's implicit theory of mathematics which influences and is influenced by their implicit theory of mathematical ability (mindset). Both of these help determine a student's goal orientation.

There is a deficit in the literature when it comes to prescriptive interventions for mathematical mindset. Most research has been descriptive in nature, establishing a correlation between certain implicit theories and mindsets and increased achievement or growth in mathematics. The research question *How can lessons focused on students' mathematical disposition change students' lay theories of mathematics and guide them toward pursuing learning goals?* is meant to investigate this gap.

Lay Theories of Mathematics

Lay theories are implicit theories that influence a student's perception of their own intelligence, their motivation, mindset, sense of control, feelings, and behavior (Haslam, 2017). Dweck divided lay theories into "incremental" and "entity" lay theories (Dweck, 2006). "Incremental" lay theories are those that emphasize the changeable nature of certain characteristics such as intelligence. "Entity" theories are essentialist in that they view characteristics such as intelligence as innate and immutable (Haslam, 2017). These ideas have been popularized as growth or fixed mindsets (Dweck 2006).

While mindsets describe the operative implicit theories that students use while in the classroom, they often fail to describe the wider cultural and personal environment that influences the development of these mindsets. A lay theory is an implicit theory that subsumes the specific concept of a mindset which is focused more narrowly on belief and ability in a particular domain (Haslam 2017). A student's mathematical lay theory can include their feelings about the utility of mathematics as well as how enjoyable they find mathematical tasks, both of which have important implications for the student's mindset and behaviors in the classroom. A mathematical lay theory arises from a combination of experience and the implicit and explicit messages that the culture communicates. Students approach mathematical tasks through the lens of the environment created for them by these mathematical lay theories (Schoenfeld, 1985).

Research has been done about the correlation between parent attitudes and student attitudes to mathematics, showing a link between the two (Haimovitz & Dweck, 2016). While mathematical pedagogy has undergone a generational shift in emphasis and methods (Schoenfeld, 2016a), a student's implicit theories are molded not only by their experience in the math classroom but those of the adults in their lives. Students who are taught by a teacher who has an entity theory of their ability will often receive implicit and explicit messages that discourage effort and teach them an entity theory of mathematical ability (Rattan et al., 2012).

Cultural messages often connect intelligence with mathematics, with important implications for students' goal orientation (Dubiel, 2007). Math is thought to be difficult for the average person, so that anyone who does not experience that difficulty is smart. Mtetwa and Garofalo (1989) describe these attitudes as having their genesis in students' experiences in the classroom and being reinforced by society. When the Scarecrow in the Wizard of Oz is given a brain, he recites the Pythagorean theorem. Mattel produced a Barbie doll that spoke the phrase "Math is hard" (Dubiel, 2007). These all represent cultural idioms (Chinn, 2012) that inform lay theories of mathematics.

The literature on mathematical lay theories is underdeveloped, especially in the middle grades (Schoenfeld 1992). More research has been done on lay theories and general achievement as well as mindset and goal orientation in general academics rather than in a mathematical context (Claro et al., 2016) . Research done that is specific to the mathematics classroom tends to focus on gender with an emphasis on course selection, achievement, and attitudes (Murayama et al., 2013). The final level of mathematical achievement has been studied in connection to attitudes (Brown et al., 2008) with less emphasis on the intermediate experiences of students in the middle grades. Still, Brown et al. found that a student's perceptions of mathematics as difficult were shaped by their teachers and peers.

Stereotypes

Conceiving of lay theories as implicit theories allows us to consider cultural influences. Stereotype threat is a situation where a member of a group who believes in or is presented with a stereotype of low achievement performs worse on mathematical or other assessments, an implicit meeting of the standard set for their group (Spencer, et al., 2016; Spenceret al., 1999). Spencer et al. (2016) suggested that the mechanism for low performance is related to anxiety over confirming the perceived stereotype through low performance. Smeding et al. (2013) identified interference with executive resources as the mechanism. The incidence of the stereotype threat among women and students of color is well documented (Smeding et al., 2013).

Aronson et al. (1999) also show that this stereotype effect can also be induced in groups, such as white males, who generally are not subject to the same negative stereotypes. This effect seems to be heightened when the student is more invested in their math performance. Students who perceive themselves as high achievers perform worse when presented with a stereotype threat. This result points to the importance of both the cultural environment in which a student performs mathematics as well as the motivations and mindset of the individual student.

Mathematics, in its role as the stereotypical measure of intelligence, is subject to more stereotypical thinking than other subjects. Joseph, Hailu, and Matthews (2019) identify the role of the concept of “smartness” in mathematics, where effortlessness is connected to ability and intelligence. Dweck addresses the concept that “dumb” and “smart” are also stereotypes that moderate students’ performance (Licht & Dweck 1984). Anti-stereotype instruction has been shown to reduce the effect of stereotype threat, but this instruction is generally direct instruction to students and does not entail a change in the culture of the classroom or school. Its action is on the level of the individual and similar interventions have been used for students’ mindset.

Stereotypes of mathematics. Mathematics as a discipline is the subject of stereotypes as well. While not well studied, the stereotype that mathematics is difficult or arcane also subjects students to a stereotype threat (Furinghetti, 1998). Any confusion will tend to increase a student’s anxiety at not understanding and will reduce the student’s executive resources for the task.

The Findall et al. (2001) identifies *productive disposition* as the tendency to view mathematics as sensible and useful. As one of the strands of mathematical proficiency, this illustrates the central importance of a student’s beliefs in mathematical achievement. Students who perceive or are taught, either explicitly or implicitly, that mathematics is an incomprehensible set of rules will approach mathematics as if that were true. Students whose lay theory of mathematics emphasizes its incomprehensibility will be more likely to have an entity theory of mathematical ability.

Summary. There is a gap in the literature when it comes to instruction focused on changing lay theories of mathematics. The research that exists on mindsets will be discussed in the section on mindset. These studies generally investigate the correlation between implicit theories and achievement or growth (Claro, Paunesku, & Dweck 2016). Little consideration has been made for how lay theories are developed and how they can be changed. Instead, the focus of much research has been the impact of implicit theories for student achievement (Leder, 1985). These studies focus on the correlation of implicit theories and achievement or growth (Blackwell & Trzesniewski, 2007; Dweck, 2000). By conceiving of lay theories as a cultural characteristic, it is possible to think of change at the level of school or classroom, whereas the bulk of the literature looks at change at the level of the individual (Dweck & Yeager, 2019).

This research conceives of several interrelated implicit theories that students hold. First, students have an implicit theory of mathematics. This can be referred to as a lay theory of mathematics: what a student perceives to be the purpose, utility, and process of mathematics. Students' lay theories of mathematics generally focus on outcomes, imagining the work as simply finding a right or wrong answer. This incorrect theory leads them to develop implicit theories of mathematical ability which can be regarded as their mindset. Students whose mathematical lay theory includes the entity theory that there are "math people" and "non-math people" are more likely to hold an entity mindset of mathematical ability which in turn influences their achievement and growth.

Implicit Theories of Mathematical Ability (Mindset)

Because mathematical ability is closely aligned with intelligence in most lay theories of mathematics, general implicit theories of intelligence and ability may be more applicable to mathematics than other subjects. Individuals readily express the subjective view that mathematical ability is an innate ability that you are born with (Brown, Brown, & Bibby 2008). Both high achieving and low achieving students can have this essentialist theory of mathematical ability. While they exist on a continuum, students' mindsets around mathematics can be roughly grouped into mindsets that view mathematical ability more as an innate quality of an individual and those that view mathematical ability as something that can be improved (Leder, 1985). A student's response to different challenges is moderated to a large extent by their mindset (Dweck, 1986).

It should be said that there is ample evidence available to all students that mathematical ability is subject to change and improvement. All students begin by counting objects and progress well beyond that in all cases. Their mindset is determined by their subjective experience in mathematics. What is difficult for one student may be perceived as challenging for another student. This understanding appears to be mediated by their own experience of struggle in mathematics. High achieving students may interpret effort as a reflection of their lack of intelligence or ability whereas a low achieving student may have greater familiarity with confusion and effort and consider it a normal part of learning (Dweck, 1986).

There is an array of tools designed for measuring a student's mindset (Murayama, Pekrun, Lichtenfeld, & Vom Hofe, 2013). Because mindset determines learning goals, these tools can provide valuable information about how students view and expend effort. Student mindsets can be roughly grouped into those aligned with an entity theory or incremental theory of ability (Dweck, 2000). This research utilizes the terms entity theory and incremental theory instead of what Dweck and Yeager referred to as the "more user-friendly terms of fixed and growth mindsets" (2019, p. 483) because naming them as theories aligns them with the conception of lay theories used in this research. Growth and fixed mindsets have also been widely disseminated as terms and their meanings have often been diluted.

Since its development, entity and incremental theory has had few dissenting views (Dweck & Yeager, 2019). Instead, much research has focused on expanding and applying these theories to explain meaning systems that students utilize to make sense of their learning and effort (Dweck, 2000). Meaning systems can be used to encompass student beliefs around ability, effort, and motivation.

Entity Theory of mathematical ability. Students who express an entity theory of mathematical ability fundamentally feel that mathematical ability is a fixed quality of a person. An Entity Theory of intelligence associates effort with a lack of ability (Dweck, 1986), which is a theory that is already connected to mathematical ability through the general lay theory of mathematics. Students who have an Entity Theory of ability are more likely to attribute failure to things outside of their control, such as innate ability (Dweck & Yeager, 2019). As a result, they are less likely to modify things within their control such as effort or strategy, in order to reach higher achievement levels.

A student who adheres to an Entity Theory of mathematical ability is more likely to produce certain behaviors when faced with difficult tasks. They are more likely to fail to persist in their tasks. If they do succeed, they're more likely to see this result as due to their innate ability rather than their effort. This perception matches the common lay theory of mathematical ability associated with effortlessness (Joseph, Hailu, & Matthews, 2019). Because of this dual perception, even high achieving students who express an Entity Theory of mathematical ability can exhibit withdrawal of effort during challenging tasks.

Chinn (2017) has shown that high ability students fail to attempt difficult tasks at a higher rate than their lower ability peers. This withdrawal of effort is a protective measure; if mathematical ability is seen as intelligence and intelligence is innate, then mathematical failure is a threat to the student's self-conception as intelligent. Again, the connection between effortlessness and ability increases anxiety around perceiving effort and confusion, which can lead students to fail to try in order to reduce their anxiety. As with any anxiety avoidance strategies, this can become a self-reinforcing strategy.

Lower ability students with an Entity Theory of mathematics may withdraw effort for different reasons. Because the Lay Theory of mathematics connects effortlessness with correctness, students may give up on tasks that feel difficult because they perceive themselves as incapable of doing the work. In some ways, this is similar to the stereotype threat discussed above. Students who believe they have low ability will often perform in ways that conform to that stereotype. While this is different from the protective withdrawal of effort, these students may also be withdrawing effort in order to protect their sense of self and to calm anxiety.

Dweck and Yeager (2019) have shown that Entity Theories of intelligence can be changed through intervention. This generally involves direct teaching of an Incremental Theory of intelligence rather than a modification of the curriculum to change the perceived learning goals or the general lay theory of mathematics. Murayama, Pekrun, Lichtenfeld, and Vom Hofe (2013) studied intrinsic motivation and sense of control in the middle grades and showed that they were strong predictors of both growth and achievement. Students who adhere to an Entity Theory of mathematical ability are more likely to lack intrinsic motivation and feel that their ability to learn is outside of their control (Dweck, 1986). This suggests that many types of intervention could be beneficial to these students, particularly during the transitional period of the middle grades (Blackwell & Trzesniewski, 2007; Romero, Master, Paunesku, Dweck, & Gross, 2014).

Incremental Theory of Mathematical Ability. Students who express an Incremental Theory of mathematical ability believe that mathematical ability is a skill that can be developed. They are more likely to attribute success or failure to factors within their control such as effort and strategy selection (Dweck, 1986). These students are more likely to have a productive disposition in that they view mathematics as sensible and will persist in sense-making even after experiencing confusion (Ma, 1999). This means that they persist more often when faced with a novel task or confusion. Students with an Incremental Theory are more likely to select challenging tasks which result in greater learning and skill mastery (Dweck 1986). These factors and others contribute to increased growth throughout the middle grades for students who have an Incremental Theory (Murayama, Pekrun, Lichtenfeld, & Vom Hofe, 2013) as opposed to an Entity Theory of mathematical ability.

Though the phrase “growth mindset” suggests that those with an Incremental Theory are positively focused on growth, students who adhere to an Incremental Theory are distinguished by their reaction to failure (Dweck, 1986). Studies done with teachers who have an Entity Mindset of their students’ abilities show that they modify their teaching to comfort students or shelter them from difficult tasks (Rattan, Good, & Dweck, 2012), which prevents them from engaging with mathematics and confirms their entity theory of mathematical ability. Experiencing and reacting positively to failure seems to be correlated with an Incremental Theory. A parent's Entity or Incremental disposition is less predictive of their child's own Entity or Incremental Theory than the parent's view of failure (Haimovitz & Dweck 2016). Productive reaction to failure, especially in instruction that emphasizes discovery and conceptual understanding (Schettino, 2016; Schoenfeld, 1988, 2004, 2016b), is thus a key component of student success in mathematics.

Summary. Student motivation is a complex phenomenon that involves their implicit theories about the subject and themselves. A student's mindset is a strong predictor of their goal orientation and responses to challenges. Mindset is not the only predictor but is perhaps the most salient to both teachers and students themselves. This is important because interventions around mindset are well studied and the effects on student growth are well known.

Goal Orientation

Motivation is a complex psychological phenomenon (Dweck, 1986) and varies greatly between those who have an Entity Theory or an Incremental Theory of mathematical ability. While goal orientation is not the only effect of motivation, it is one that can be used to understand students' behavior in the classroom. Parents, teachers, schools, and individual tasks can periodically or temporarily change the goal orientation of a student (Miller & Speirs Neumeister, 2017).

In this research, I follow the general trend to consider goals as divided into three groups: performance-approach, performance-avoidance, and mastery goals (Elliot & Muryama 2008; Linnenbrink-Garcia et al., 2012). Dweck (1986) uses a dual model of performance and learning, but that fails to distinguish between those who are seeking to do well and those who are seeking to avoid failure. While both types of performance goals can result in similar behaviors such as cheating or dependent help-seeking (Linnenbrink-Garcia et al., 2012), there are meaningful ways in which a student's attributions and motivation differs. For example, s student with a performance approach goal is less likely to be truant from a math class than a student with a performance avoidance goal orientation.

Performance approach goals. Dweck (1986) characterized performance goals as a student seeking to gain a positive judgment of their ability either from themselves or from others. Performance approach goals are task-goals that focus on demonstrating competence in a skill (Linnenbrink-Garcia et al., 2012). This can be a positive motivation for students if they currently have a positive view of their ability, motivating them to seek out challenging tasks in order to demonstrate their skills. For a student with low self-perceived ability, this goal orientation can result in avoiding challenging tasks or seeking other ways to improve performance, such as cheating or seeking extra credit that does not require additional skill practice. Grades are a very common performance goal for many students, teachers, and parents.

Students' lay theories of mathematics may induce them to choose performance approach goals more often than in other subjects. Compared to a task in another subject, such as an essay, student work is more objectively and directly comparable to one another. Coupled with students' implicit belief that mathematical achievement determines intelligence, this can result in a group competitive environment where students are oriented toward the goal of doing better than other students (Licht & Dweck, 1984). This may be motivating for some students who choose appropriately challenging tasks in order to differentiate themselves, but harmful for other students who are driven to choose less challenging work in order to maintain their perceived ranking within the classroom.

Performance approach goals are often associated with an Entity Theory of mathematical ability (Dweck, 1986). A student's outcome on a task or grades are used by the student to confirm their belief, if a high achieving student, that they are intelligent or a "math person." Low achieving students who do not achieve at the level that they wish may interpret the outcome to confirm their lack of ability. These students will not focus on errors that they can correct or on the growth that they have made but rather on the performance itself. This may be reinforced by a student's lay theory of mathematics that emphasizes the correctness of the answer rather than the correctness of the process.

Performance avoidance goals. Performance avoidance goals are similar enough to performance approach goals that students may have difficulty distinguishing a difference in goal structure for a task (Linnenbrink-Garcia et al., 2012). Rather than seeking a positive judgment of their ability, a student who has a performance avoidance goal orientation is seeking to avoid negative assessments of their ability (Dweck 1986). In mathematics, this often results in self-protective withdrawals of effort in order to avoid appearing "dumb." Because lay theories of mathematics equate effort with lack of ability, students oriented towards performance avoidance goals may exhibit behavior such as cheating and disruption instead of persistence on mathematical tasks they find challenging. Performance avoidance goals may also have a positive effect on student achievement if the anxiety around avoiding negative judgments motivates a student to persist in their work. Avoiding a negative grade can, in some circumstances, provide students with motivation to increase their effort in response to failure.

Students with an entity theory of mathematical ability may be more likely to choose performance avoidance goals for themselves (Dweck, 1986). The anxiety around the stereotype of being perceived as “dumb” may motivate dependent help seeking, especially because adult support often comes with praise and obvious achievement. Students with this goal orientation may also participate in class less due to fear of giving a wrong answer or explanation and exposing themselves to negative judgments of their ability. These students are then less connected to the learning environment and less likely to engage with their own failures and misconceptions. Mathematical lay theories reinforce this goal orientation when students perceive mathematics as valuing the result or answer rather than the process of mathematical thinking.

Learning goals. Learning goals are frameworks where a student is driven to achieve mastery of a skill or concept (Dweck, 1986; Licht & Dweck, 1984). Because the goal is focused on the skill itself, students with a learning goal orientation are more likely to persist in challenging tasks as well as selecting tasks that are likely to increase their mastery of skills or concepts rather than simply confirming a previous judgment of their competence. Students oriented towards a learning goal are more likely to increase their effort and examine their work for errors when presented with a negative judgment of their ability such as a bad grade. Students who have an Incremental Theory of mathematical ability are more likely to select learning goals for themselves (Dweck, 1986). This means that students who have an Incremental Theory of mathematical ability are more likely to have a positive affect towards mathematics (Tocci & Engelhard, 1991).

Synthesis. Learning goals and performance goals are not mutually exclusive orientations. Students will possess a mixture of both orientations. A student may have a learning goal orientation that is subordinate to a larger performance approach goal because of the expectations of their parents or teachers (Miller & Speirs Neumeister, 2007; Tocci & Engelhard, 1991). In this case, they may be motivated to persist in learning in order to receive rewards or positive judgments for their achievement. Similar structures can be implemented in the classroom where a performance goal that provides access to a reward can still be beneficial for student persistence in the event of confusion and failure.

The focus in the literature on performance goals is often on the negative factors such as lack of growth or maladaptive behavior in students with these orientations (Murayama, Pekrun, Lichtenfeld, & Vom Hofe, 2017), but these goal orientations can be the source of productive motivation for students. It is more correct to say that performance goals may be harmful and that learning goals are more productive for students, especially when measured over the course of their school careers (Claro, Paunesku, & Dweck, 2016).

Students' mathematical lay theories have a large effect on their goal orientations. Students who have the implicit theory that mathematics is more about product than process and that mathematical ability is a fixed characteristic, are more likely to orient themselves towards goals that focus on outcomes. Because of this focus on outcomes, they are more likely to attribute their outcome to things beyond their control. Students whose mathematical lay theory values the process of mathematical thinking are more likely to orient themselves towards learning goals which help them understand the process.

A teacher has the ability to select learning goals for students. A mathematics task may be performed as a test or with instructions that make it able to be played as a game. While students may take cues from the context of a mathematics task or the larger context of the classroom's goal orientation, an individual student may still orient themselves towards a performance goal when most are oriented towards a learning goal. Students who orient themselves towards performance goals may also be influenced to pursue learning goals when given the proper context.

Summary

Student motivation is influenced by an interrelated set of factors such as their implicit theories of mathematics, implicit theories of mathematical ability, and goal orientation. Among these, student mindset (implicit theory of ability) is the most well studied. Individual interventions have proven to be effective in changing student mindset. An incremental theory has been correlated with higher student growth and achievement.

Because a student's mindset is interdependent with their lay theory of mathematics and their goal orientation, interventions that address one must necessarily address all three. Most of the research has been done on correlating one of these factors with growth or achievement with less emphasis on describing what makes an effective intervention.

Mathematics is a unique field because students across cultures and time experience fundamentally the same mathematics. While teaching methods and emphasis have changed, the general implicit theory of mathematics has not shifted as much. Students' lay theories of mathematics are more likely to be detrimental to their motivation than in other subjects because the prevailing lay theory often includes an entity theory of mathematical ability.

Most studies on implicit theories in the mathematics classroom have focused on measuring the effects of different implicit theories. Less research has been conducted on how these theories can be effectively changed. There is an opportunity to develop a curriculum that addresses the central question: *How can lessons focused on students' mathematical disposition change students' lay theories of mathematics and guide them toward pursuing learning goals?*

The next chapter will outline a ten lesson curriculum delivered over ten weeks meant to change students' lay theories of mathematics as a subject, their lay theories of mathematical ability, and their goal orientation.

CHAPTER THREE

Project Description

Overview

Many students come into the math classroom with an entity model of mathematical ability that interferes with their persistence in inquiry based mathematical tasks (Dweck, 1986). Students with an entity model are less likely to persist in mathematical tasks where they are actively constructing their understanding of a mathematical concept. These students often self-select performance goals and choose tasks that offer a safe alternative to failure (Dweck, 1986). These behaviors can range from dependent help-seeking to constant off-task behavior and even to disruptive behavior (Linnenbrink-Garcia et al., 2012) whose implicit goal, perhaps not understood by the student, is to be removed from the instructional environment. Over the course of a student's elementary career these behaviors can leave students with a significant skills gap. This can lead to something of a feedback loop where the student's view of mathematical ability as innate is reinforced by their struggles with new tasks where they lack some of the prerequisite knowledge. The student often relies on the behavioral skills they do have in order to avoid poor performance on a mathematical task.

The transition from elementary level mathematics to secondary mathematics changes the emphasis from fact fluency and numeracy towards understanding more abstract concepts and problem solving (Scimathmn.org). Students are also experiencing a change in focus, becoming more aware of peers and seeking to avoid being seen in a negative light. Combined with the implicit lay theory of mathematics that prioritises quick, correct calculation, this can lead to failures of effort and failures to participate, further reinforcing a student's negative self-conception of their mathematical ability as they do not receive positive feedback about efforts that approach but do not demonstrate skill mastery and attribute that failure to their ability (Dweck, 1986). The goal of this project is to move students from an entity model of mathematical ability toward an incremental view of mathematical ability while changing their lay theory of mathematics as a whole. An ancillary goal is to help students understand their goal orientation and understand learning or mastery goals. The project focuses on ten dispositional lessons that are meant to help a student construct a new lay theory of mathematics and a new mathematical identity.

In this chapter I will describe a ten week long series of lessons that are focused primarily on students' productive disposition with an intended audience of early secondary students in a diverse urban classroom. I will describe the theory of change for the students as well as the intended outcomes for all learners. The lessons are aligned with the research described in the previous chapters about the effects of students' lay theories on academic achievement and meant to address the question: *How can lessons focused on students' mathematical disposition change students' lay theories of mathematics and guide them toward pursuing learning goals?*

Description of the Project

The beginning of the school year is when students begin to establish relationships with their teacher, classroom, and subject materials. It is a time when a student's attitude and past associations with school are at their most malleable and the classroom norms set during this time have effects that can last the entire school year (Everston and Emmer, 1982). This project is a whole class intervention meant for the beginning of the year when students are making new associations and connections. The plan extends for ten weeks and is intentionally designed to rely on no content standards so as to be as accessible as possible to students regardless of their skill level. The lessons are designed to help produce a classroom-wide vocabulary for talking about the process of mathematics as it occurs in the classroom. This vocabulary and ideas are intended to be used throughout the year to complement the core math instruction.

There are ten lessons in the project. Each lesson is designed to take one class period lasting roughly forty-five minutes. Lessons are flexible and could include routines such as number talks and other accessible mathematical tasks. The lessons are designed to be delivered once a week allowing students to consolidate their understanding of the lessons throughout the intervening week while working on core math content. The vocabulary and attitude developed in each lesson is meant to be interleaved with core math instruction. The lesson plans as written are generalized but many of the individual lessons would be strengthened by drawing on the context of the skills and tasks students are working on in the classroom at the current time.

The unit begins with considering mathematics as an act or a process, rather than simply an innate ability. Students engage with their lay theories of mathematics that are assumed to be centered around numeracy and calculation by working on non-numerical tasks and making connections to mathematical thinking as a general category. Class conversations move students towards understanding that a mathematician is a person who engages in a mathematical task, rather than someone who simply has fact or procedural fluency. By focusing on another lay theory of mathematics, students' old associations and self-judgments can be deconstructed and new, more positive ones, created. The focus of this section is on students' lay theories of mathematics.

The middle section of the unit focuses on lay theories of mathematical ability, shifting students from an entity theory of mathematical ability towards an incremental theory of ability. For ease of communication with students and alignment with messages they may receive in other classes, lay theories of ability are referred to as mindsets, a widely popularized term. These lessons are timely in the sense that a lot of the social emotional learning for secondary students is focused on similar themes of self-image. These middle lessons are written as if they were a student's first introduction to the concept but could be easily adapted to align with school-wide messaging around growth mindset and self-talk if such a program is in place. The main connection to mathematics in the lessons is the idea of mistakes as being part of the process. The lessons are targeted at students whose lay theories of mathematics involve quick, accurate calculation as the determining factor in one's math ability. The objective of this section is to give students the skills to help themselves recover from the inevitable mistakes and frustration that will occur.

The third section of the lessons focuses on goals and grades which are a newly important focus for early secondary students. Each lesson helps students view goals and grades through the lens of growth and learning. Students work towards an understanding of grades as a measure of progress rather than a measure of worth. The lessons assume that the classroom grading is a mixture of participation or completion and skill assessment, as opposed to grading systems that tally points for correct answers only. The objective of this set of lessons is to help students understand the value of effort and persistence. The goal is to help students to understand grades as encouraging learning and mastery goals rather than simply performance approach or performance avoidance goals.

The end of the series of lessons is meant to foster conversations between students and the adults in their lives to help students solidify their understanding of what they've learned previously about mathematics as a process. The final lesson is meant to begin conversations with the students' caregivers about mathematics and allows them the opportunity to communicate their new understanding of mathematics to their caregivers. After the conclusion of the final lesson, students should be able to share out the differences that they noticed between their view of mathematics and their caregivers' (or received) view of mathematics. The focus of these lessons returns to the focus of the first set of lessons, directing students to consider their own lay theories of mathematics.

Framework for Lessons

Initially, the Understanding by Design (UbD) lesson planning framework was utilized for each of the 10 lessons. While the UbD templates provided by McTighe and Wiggins (2005) are comprehensive and enable substantial reflection on the teaching process, it was felt that a more generalized backward design would be more helpful for teachers hoping to implement the project. I chose to develop a unique, pared down lesson plan utilizing similar principles of backwards design as UbD (McTighee & Wiggins, 1998). The project was designed with a learning outcome in mind from the beginning: students will be able to explicate a new lay theory of mathematics focused on mathematics as a process that one utilizes to make sense of different situations. This outcome is roughly correlated to the productive disposition strand of mathematical proficiency (Findell et al., 2001). As well as being my preferred planning style, backward design was a natural fit because the literature motivated the learning outcomes and activities were designed to match those outcomes.

While Understanding by Design was not utilized, the motivations behind that design helped shape the final generalized lesson plan. McTighe and Wiggins (2013) explain that essential questions can help students understand that inquiry is the goal of the lessons, as well as encouraging metacognition. The goals of the unit include metacognition in that students are asked to think about their thought processes as they pertain to mathematics. Another essential goal of the project is student inquiry into the processes of mathematics. Learning objectives and essential questions are provided for all lesson plans. The general structure of each lesson follows a Launch, Explore, Summarize format. The launch is meant to give context to the students for the day's lesson as well as activating their prior knowledge. It often takes the form of a class discussion. The explore portion of the lessons are meant to be student-centered activities that allow students to explore the essential question. The summarize portion of the lessons are intended to help students consolidate and express their understanding of the day's activities.

Intended Audience

The primary audience of the project is meant to be students in early secondary, especially sixth and seventh graders, in an urban education setting. While all secondary students could benefit from the lessons in the project, 6th and 7th graders were the primary focus for several reasons. First, middle school is the first time for many students when they have a teacher whose sole role is mathematics teacher and whose primary training is in teaching mathematics and thus an important time to demonstrate that mathematics doesn't necessarily have to look like their experiences in elementary classrooms. Students at this age have also begun to form their own lay theories of mathematics. The project also addresses the anxieties and the focus on establishing an identity as a person and as a learner that early secondary students may have.

Students in an urban learning environment are more likely to be heterogeneous in regards to a whole host of characteristics. These include socio-economic background, race, home language, among many others; these characteristics are often not shared by their teachers. Scores on mathematics standardized tests in urban school districts tend to be below the national or state average. There is not a causal link between student background and achievement but it does help illustrate why these students would benefit from the project. Students with low achievement who do not see themselves represented in their teachers are susceptible to forming a harmful lay theory of mathematics that something in their identity precludes them from “being a math person."

This lay theory may also be shaped by their parents’ experience in education. Students who come from immigrant families may have less formal mathematics education and thus are able to provide less academic support at home leading to internalized frustration from a student who is working on classwork or homework outside of the classroom. Families whose caregivers last worked with math several decades ago may have also internalized some messages from less progressive mathematics instruction where grades and value were based more on a right and wrong binary. Often families put too much worth into grades in mathematics and mathematical achievement, seeing mathematics as a measure of intelligence and thus future possibilities for their students.

The reasons that students may form a harmful lay theory of mathematics are legion, and not limited to students in an urban setting. I am most familiar with the concerns and feelings of students in an urban setting so the learning goals of the project are tailored to assume very little about the students. This may seem counterintuitive to identifying the target demographic as students in an urban setting but students in a more homogenous environment might have more of a shared context that could be used to ground some of the lessons in the project.

Lessons, especially the examples, were created with the student population of my current site in mind. Students who identify as Black or African-American account for 49% of all students, with the majority of these students having a home language other than English including Somali and Oromo. Many of these students' families, and sometimes the students themselves, have lived in refugee camps or have otherwise experienced trauma and hardship as a result of the Somali Civil war and the resulting "failed state." Students who identify as White make up 38% of students at the school. Latino/Hispanic self-identified students are 5% of students. Native students and Asian-American students are less than 5% of the student body. The Minnesota Department of Education considers the school to have a "high number of students of color" (Minnesota Department of Education, 2019).

Students receiving some form of English Language Learner services comprise 25% of all students. Students who receive special education services provided in a Federal level 1 or level 2 setting are 7% of the population. While 55% of students qualify for free and reduced price lunch, this means the school is designated "neither a high- or low- poverty school", as defined by the State of Minnesota (Minnesota Department of Education 2019).

Summary

In Chapter Three, an overview for the motivation of the lesson plans was provided. It was focused on students who choose to pursue performance goals due to a lay theory of mathematics that privileges fast and accurate calculation as the measure of mathematical skill. A framework for the lessons was described based on the general principle of backward design, designing lessons by focusing on student learning outcomes first and then working on the specific activities afterwards. The target demographics as well as the demographics of the school who inspired the lessons were described. A general overview of the several parts of the lesson plan was provided along with their purpose and motivation. The next chapter will provide a reflection on the process of creating the project as well as limitations and possible future extensions of the work.

CHAPTER FOUR

Conclusion

Overview

The guiding question of this project was: *How can lessons focused on students' mathematical disposition change students' lay theories of mathematics and guide them toward pursuing learning goals?* The project focused on metacognition and reflection on the students' part and was guided by a deep literature review that helped illuminate the complexities that exist beyond the popularized, generalized dichotomy of "growth" and "fixed" mindset. This chapter will begin by discussing the process of the literature review and the Eureka (borrowed from the Ancient Greek for "I have found it") moment that put the goals of this project into sharp focus. The chapter will then address how I was affected by the process of completing the project as well as how their learning will be used going forward. The chapter will close with a discussion of the implications of the project as well as the limitations and possibility for continuing the work in a similar vein going forward.

Literature Review Reflection

This project began first with a title, "Toxic Math-masculinity", which seems like an apt description of how mathematics is perceived by most laypeople. Similar to the concept of toxic masculinity, toxic math-sculinity appears to prescribe a certain set of behaviors and attitudes for one group of people ("math person"s) and privileges that group in a way that is harmful to both the privileged group and the out-group. I saw the effects in my classroom and colleagues noticed it as well but much of the mathematical literature I reviewed focused on pedagogy for particular units or raising student achievement generally without describing what I felt was one of the root problems. I struggled to find purchase on the problem I wanted to address, especially with regards to finding a way to view the problem other than as a definition. Then I read Carol Dweck's 1986 paper titled "Motivation Processes Affecting Learning."

The field of education as it exists in primary and secondary schools has a general understanding of growth and fixed mindsets (Dweck, 2000). Students are encouraged to have growth mindsets and many teachers can list the positive characteristics of growth mindsets but it is only a surface level understanding. I feel that in many settings the dichotomy of growth versus fixed mindset is a bowdlerized version of a more complex understanding of students motivation, goal-orientation, and task selection. Reading Dweck's article felt akin to perceiving a third dimension after living in Flatland.

In many ways the growth versus fixed discourse, at least as it is practiced in schools, seems to reflect an entity theory of students' motivation. In my experience, students are assumed to have a growth or fixed mindset and little is done to effect a change in that. There may be time made for discussing growth mindsets in class but the curriculum moves on quickly to other content. Students are often left with whatever mindset they came into the classroom with. At least in my own experience, the mindset framework was not even used to understand student behavior and motivation in the classroom. Understanding student motivation and goals, especially performance-approach and performance-avoidance (Dweck 1986), was illuminating. It allowed for a two-part theory of change, a positive feedback loop of helping students understand an incremental theory of intelligence as well as selecting and pursuing learning goals.

A student's mindset is interdependent with their lay theory of mathematics and their goal orientation. Yet as I continued to review the literature, most of the research isolated one of these factors. In many cases, the studies were investigating correlations between one of these factors and student achievement. I was convinced that the correlations were strong but that there was a gap in the literature in regards to how to change students' mindset, lay theories, and goal orientation. There are studies in the literature that address all of these factors, but they generally address them separately, often focusing solely on changing students' mindset.

While much research around mindset and goal orientation has been done across fields, I felt that there was a gap in addressing what appears to be a unique perception of mathematics for both students and adults. Mathematics, at least in lay theories, is a monolith. Students express dislike of writing or a particular book in English class but even into adulthood Math with a rhetorical capital 'M' is something many people have an opinion and emotions about. The dearth of discussion on this in the literature reviewed helped focus the project on changing students harmful lay theories of mathematics.

Major Learnings

I engaged with this project in several simultaneous roles: researcher, writer, and practicing teacher. The research that went into this project differed in scope and scale from any previous research I've conducted. The writing, too, was different in both scope and scale from any previous writing. This was expected at the outset of the project, but I had not anticipated the large effect that the project would have on my own teaching practice. I will discuss the effects of completing this project on myself as a researcher and writer before turning to a discussion on the effect that completing the project had on myself as a teacher.

Educational research, including educational research involving mathematics, is different from mathematical research. The history of mathematics can be told more or less neatly in series. Problems in motion lead to the development of calculus which lead to higher order calculus and mathematics progresses. At the start of my research I was biased towards this mathematical mode of fact accumulation and landmark results. There is still some of this in educational research but I began to appreciate more how progress was made overlapping investigations and ways of perceiving a problem. While Carol Dweck's work was very influential in my own research and the papers that I read, the role of her work isn't comparable to someone like Georg Cantor (in mathematics) in scale of influence. Instead, I came to appreciate the incremental nature of educational research compared to what might be considered the entity theory of mathematical progress: these facts are true and will remain so. Looking back, I was obviously naive to assume that educational research that involves so many variables would be as neat as mathematical investigation.

As a writer, I also approached the project with some naïvete. My background is in creative writing and it was difficult at first to adapt to the rigorous requirements of a Capstone project. It has taken a great deal of effort to tamp down my writing idiosyncrasies to fit into the structure of academic writing. On the other hand, I have come to appreciate those same conventions for the way they enable mutual intelligibility across domains and time. I talk to my math students about needing to have conventions such as numerals and order of operations to help facilitate communication and now I have a greater appreciation of the general academic writing style as serving the same purpose.

Still, a careful reader may note places where I strayed from a more straightforward and laconic style.

Undertaking this project had the largest effect on my own practice as a teacher. Previously in this chapter I described reading Dweck's 1986 paper as something akin to an Eureka moment. It helped me understand students' motivations much better and to separate student behavior from the student themselves. Obviously, in any classroom student behavior of all kinds seeks to meet a need. Before this project I had thought that the needs were largely for social interaction or attention but I did not appreciate how those would interact with performance avoidance goals. I often feel that a student's goal comes first, and they then decide on a behavior that will help them meet that goal even if that is an unconscious thought process. I've modified many of routines and activities to present students with a more palatable performance-approach goal. An example of this would be ways for them to earn badges in digital activities.

Goal-orientation was also a helpful lens for understanding students who were persistently seeking extra credit or asking if a task would be graded. I've worked with those students to understand that the goal of the class is the learning. I've modified my grading practices to reflect a student's learning progress rather than simply completion or correctness. Anecdotally, I've found that students who have a performance-approach goal orientation will often self-select learning goals once they feel they have secured their desired performance level. As an example, before undertaking the project I often assigned grades to tasks in order to encourage students to engage with them. Predictably, at least after having read more of the literature around goal-orientation, this led to more maladaptive behavior such as cheating, copying, or dependent help seeking. By including more activities such as number talks where the primary purpose is learning and discussion I’ve seen an increase in students pursuing learning goals regardless of their more general goal-orientation. Selecting tasks that are more engaging has had a similar effect.

Limitations

Time may be the greatest factor limiting the applicability of the project. The mathematics curriculum is often set in a classroom in such a way as to have very few days that are not already assigned to core content instruction. Any such days not already taken up with core content are often filled with beneficial review activities, extension activities, or other school-wide activities such as standardized testing or assemblies. The project requires at least ten days of instructional time spread out over as many weeks. Even with these caveats, the benefits for both the students and classroom are expected to allow better learning throughout the rest of the year.

Another limitation of the project is how much understanding of the goals and underlying concepts is required from the teacher. The teacher’s role in many of these lessons is primarily as a facilitator and much like the role as a facilitator for students’ understanding of specific math skills a solid understanding of the concepts is necessary. Many teacher preparation programs focus on content and mathematics pedagogy and the psychological aspect of learning such as goal-orientation may be new to a teacher implementing this project. It is hoped that the literature review in this project will be a helpful guide for those implementing the lessons and a guide for further readings if teachers are searching for a deeper understanding.

Future Work

During the development of this project, I have delivered variants of several of the lessons and activities that are included. I plan to implement the lessons as they are described here at the beginning of the next school year. While there are benefits for students who engage in any of the activities I believe that delivering them as a cohesive unit at the start of the year will provide a much greater benefit than delivering the lessons one at a time throughout the year. Another possible use for the project would be use as the foundation of a professional development opportunity for teachers. Growth and fixed mindset are ideas in circulation in many schools but the theory underpinning them, specifically lay theories and goal orientation, are less well known and discussed.

This project focused on students in the early secondary grades and the activities were chosen to match their social and emotional developmental stage as well as taking into account their prior knowledge and skills. Students in high school, especially juniors and seniors, are obviously in a different social and emotional developmental stage and pursuing different types of goals in a mathematics classroom. While the research reviewed for this project included some high school settings, it is expected that more exploration of the literature would be beneficial for extending the project to be relevant to students in high school. Of particular interest would be a students' post-secondary plans and how they interact with their goal orientation. Students in high school may be more prone to considering math class as a means to an end such as graduation or future job prospects and thus may be more likely to have a performance-approach goal orientation when compared with a sixth or seventh grader.

Summary

This chapter began with a reflection on the literature review and the effect that completing the project had on my own skills as a researcher, writer, and teacher. It discussed limitations of the project and proposed future work including an implementation of the lesson plan and possible extension to include upper secondary students.

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