Spring 2020

The Impact of Feedback on Learning and Mindset for Female Students in Mathematics Using Comments to Improve Mindset and Learning in Math: A Professional Development Workshop

Elizabeth Christenson

THE IMPACT OF FEEDBACK ON LEARNING AND MINDSET FOR FEMALE STUDENTS IN MATHEMATICS

by

Elizabeth Christenson

A capstone project submitted in partial fulfillment of the requirements for the degree of Master of Arts in Education.

Hamline University

Saint Paul. MN

December 2019

Capstone Project Facilitator: Laura Hilden

Content Expert: Jennifer Hanzak, Mary Lambrect, and Dawn White

Peer Reviewer: Carrie Reisdorfer

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CHAPTER ONE

Introduction

Overview

I love math. As a current fifth and sixth grade math teacher and former high school teacher I know the topics we study are the foundation for much of the mathematics that my students will do in high school. I have noticed this is a time when many students decide it is okay to be "bad at math" or that they are "not a math person." I need to know how to help my students not only learn but also develop a positive mindset about mathematics. For many years I did not consider myself a math person. Other girls also come to this belief through their interaction with teachers and other adults (Dweck, 2016; Eccles & Jacob, 1986, as reported in Boaler, 2016) or through the procedural mathematics they often encounter in school (Boaler, 2002b, as reported in Boaler, 2016). While many girls have high achievement on standardized tests when they are required to participate in math classes, girls often choose not to pursue higher level math when given the choice (Boaler, 2015; Boaler & Sengupta-Irving, 2006).

This capstone will focus on the question: *How does the feedback given by math teachers on formative assessments impact the learning and mindset of female students in math?*

In this chapter I will describe my journey from anxious test taker to math lover and my professional journey to understand math learning and assessment. In addition, I will share the focus of my current study and its professional significance. Finally, I will outline the rest of my project.

Personal Connection

I still remember my high-school conferences when one of my family members told my teacher how good my younger brother was at math. I also remember competing with my classmates and friends for the highest grade, not understanding most of my homework, and asking for help what felt like every day. When I had a test I worried about how I would do and was devastated when I received what felt to me like a failure, a B. I went to college to study biology, not even thinking about having to take another math class. I thought I was okay at math, I knew I was smart and a hard worker but I had to work at it. I thought my brother, who is now a librarian, was a math person because he did not have to study and it just seemed to come to him so easily. I was a science lover.

My mathematical life changed when I was enrolled in college calculus. My professor helped me love math for the patterns and challenge it contained. We were learning because it was fascinating; the problems you could solve with math became a

beautiful way to describe the world. That professor encouraged me to add a math major and I did because I enjoyed doing my calculus homework. I was now a math person.

After reading about math learning and brain science I now know that I was always a math person. We all are. Everyone can learn math (Boaler, 2015). Math is no longer a set of procedures for me but a problem and puzzle solving tool and a way to describe our world.

As a teacher I have had the challenge and desire to really understand the math that I am teaching my students. I believe strongly in conceptual understanding and found the stronger my understanding and excitement about a topic, the more effective I can be as a teacher. Boaler (2016) describes math as a "conceptual domain" (p. 36). Boaler (2016) also describes how our brains can take a large concept in mathematics that used to take up a large part of our brain and compress it. This happens once a person has really understood and learned it. However, compression does not work on procedures only on concepts and ideas. As a math lover I enjoy reading the "professional development" sections of my textbooks and seek out opportunities to learn about math teaching. I play math games on planes and with my family. I also feel saddened every time a hear a student say "I hate math" or a parent or teacher says "I'm just not a math person".

Professional Journey

As a math teacher I have never been quite satisfied with the results of my students' assessments. I started as a traditional high-school math teacher, modeling and explaining procedures to my students. Based on the data I received from my own tests and quizzes, and from standardized tests, the students were not learning, I began searching for ways to improve my instruction. As a school we participated in professional development around backwards planning which included formative assessments. I, however, missed that opportunity and focused on writing summative assessments and aligning my instruction to them. This helped a little but I was still unsatisfied. When I changed districts and began teaching middle school, other math teachers who were also new to the district and I were invited to lunch by a veteran math teacher. She is one of the people who suggested yocubed.org as a resource for teaching mathematics for conceptual understanding. After hearing about this website again and again in professional development and conversations with other math teachers I finally investigated it myself. There I found a new paradigm of math teaching and assessment based on brain science. It was also where I vividly remember being introduced to the idea of Assessment for Learning.

This experience coincided with my district's focus on "how do we know they are learning before the final test?" I have participated in professional development and collaborative learning about using assessments to guide instruction, reviewing student work, and developing formative assessments. At the same time, I have been listening to and reading the work of Jo Boaler and her colleagues at Stanford about mathematics teaching, mindset, and brain research through the website www.youcubed.org, podcasts featuring Jo Boaler, and the 2015 edition of her book *What's Math Got to Do with It?*

I was excited when a fifth-grade math curriculum was developed using the ideas collected by Jo Boaler and colleagues. *Mindset Mathematics: Visualizing and Investigating Big Ideas* was created by Jo Boaler, Jen Munson, and Cathy Williams. Using the grade five and grade four books I provided my students with open ended, visual tasks that focused on the big ideas of math. My students were more engaged and excited, but I still could not figure out if and what they were learning.

At this point in my career I was aware of and had begun using a few formative assessments. For two years I gave frequent, short assessments that I used to group students for math groups. This did not seem to be enough. How would my students know if they were learning? I knew how to give quality feedback on their behavior but how could I give my students quality feedback on their actual learning?

Last fall, my school focused on teacher language and feedback. We learned about and reflected on our use of feedback to help our students know where they were at, how they got there, and where to go next. Now I just needed to figure out how to provide timely and specific feedback in math for 100 students.

I took a short break from school this spring to be with my new baby. When I returned, my sixth graders seemed completely different people as they were struggling with the emotional and physical changes that happen to sixth graders every spring. Math anxiety and negative mindset were more prevalent than any other time during the year. Some students stopped participating completely or avoiding class claiming, “I can’t do math”; “I’m so dumb”; or “I don’t want to be here beacuse I know I can’t do it.” This seemed especially true for my female students.

Last fall I took a graduate course on teacher action research. I focused on formative assessment and tried some of the strategies throughout this year. However, they were not systematic or systemic, which has pushed me to continue my research and desire to create comprehensive change in my own classroom and if successful other math classes in my school.

Current Project

As we will see in Chapter Two, mindset has a large impact on math learning (Boaler, 2016). Sixth grade is when students are supposed to develop an understanding of multiplication and division of decimals, percents, rates, and ratios. These understandings and concepts are important for higher level mathematics and are used by people in many jobs that would not be considered math related. It is important for students to have a strong foundation (Boaler, 2015).

Mindset can help students learn or prevent them from learning (Dweck, 2016). In the U.S. is it socially acceptable to be "bad at math." Many students either come to sixth grade or leave sixth grade with a negative mindset about themselves as mathematicians. Growth mindset helps students persists when problems are challenging. Fixed mindset can cause students to avoid risks or make determinations about themselves as learners (Dweck, 2016).

Feedback from teachers to students is not only important for learning but it can also impact how students view themselves and their mindsets (Dweck, 2016). It is challenging to provide timely, specific, and constructive feedback to students when teachers have many students.

Formative assessment is one tool to provide feedback to students, give the teacher information about student learning to guide her instruction, and provide opportunities for students to reflect on their own learning. As my district focuses more on short-term planning and monitoring student progress and learning, the math teachers in my building need to know how to use formative assessments effectively. Formative assessments can come in many varieties, be graded or ungraded, and be given with varying frequency.

Thus, I will be developing a set of professional development sessions for teachers based on the available research around mindset, learning, and feedback on formative assessments. This will support my learning and provide a resource for other teachers of math in my school who would like to support the learning and mathematical mindsets of their students through formative assessments.

Professional Significance

If teachers can use formative assessment to know where students are at, then they can plan for future learning and share information with families. If students receive feedback about their learning and what they need to do next they should learn more. Assessments that focus on growth and give students suggestions for moving forward should also help alleviate math anxiety and promote growth mindset. Teachers, parents, and students can all benefit from effective formative assessment.

I teach all the sections of fifth and sixth grade math at my school which means I have a large impact on the students in my school. As a content specialist in a K-8 who works closely with the math specialist, self contained, generalist teachers sometimes come to me with questions or follow my lead when it comes to math teaching. Our district provides time for all sixth grade teachers to meet and collaborate throughout the year. Knowledge that I will gain about effective assessments in math throughout the capstone process will not only improve the learning of my students but may also support other teachers and their students.

Summary and Preview

My love of math, frustration with my current teaching, the lack of student learning, and the impact on my students' mindsets has led me to focus on my research question: *How does the feedback given by math teachers on formative assessments impact the learning and mindset of female students in math?* Answers to this question are important not only for me and my students but also for my fellow sixth grade math teachers and colleges who teach math in my school. In Chapter Two, the literature on formative assessment is reviewed, in Chapter Three my project is described, and Chapter Four demonstrates my new learnings and understandings from my research.

CHAPTER TWO: Literature Review

Overview

The purpose of this capstone is to explore the impact of using research-based best practices when giving feedback on formative assessments. Math class is a place where many students feel anxiety (Boaler, 2016) and some develop a dislike of mathematics. Boaler (2016) suggested that children love math before they start school but their mindset changes as they travel through the education system. The mindset of students and their motivation to learn can be impacted by the assessments they are given (Boaler, Dance, & Woodbury, 2018). Girls have a special relationship with mathematics. While they often excel at the subject during elementary and high school, few girls continue to study mathematics in college or pursue math-related careers (Boaler & Sengupta-Irving, 2006).

This chapter will review the research available in order to create a professional development workshop for teachers to support the learning and mindset of girls in mathematics through the use of effective feedback on formative assessments. I am investigating best practices for giving feedback on formative assessments because I want to find out how such feedback impacts the learning and mindset of sixth grade students. I have chosen this focus in order to help educators understand how feedback can be used to promote learning for female students in math.

In order to answer my specific research question i.e., *How does the feedback given by math teachers on formative assessments impact the learning and mindset of female students in math?*, I will first discuss the relationship between mindset, anxiety, and mathematics. Then I will review the misconceptions about girls and mathematics followed by the actual differences researchers have found. Next, I will explain the impact of assessments and summarize the research on best practices. Then I will highlight the needs and strengths of adult learners and effective professional development, and finally, I will provide a short description of my project.

Math Anxiety, Motivation, and Mindset

Children love math before they start school but their mindset changes as they travel through the education system (Boaler, 2016). Mindset, how a student views himself or herself as a learner and a mathematician, can affect motivation and performance (Boaler, 2016; Foley, Herts, Borgonovi, Guerriero, Levine, & Beilock, 2017; Stiggins, 1999). This section will explain the relationships between mindset, anxiety, and mathematics. The first subsection will describe possible causes and impacts of math anxiety. The next section will discuss the connection between learning, confidence, and motivation. In addition, it will also relate the impact that our testing

culture could have on motivation. Finally, growth mindset and fixed mindset will be compared and related to mathematics.

Math anxiety. The fear students feel before and during a timed test, a student freezing on a test when they knew the answer yesterday, avoiding sharing a solution or asking a question in math, and working hard just to get the right answer or cheating to get the right answer are all ways teachers may see math anxiety manifesting in students. Richardson and Suinn (1972) state that "mathematics anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 1). Math anxiety is a common phenomenon in middle schools but can begin with children as young as five years old (Boaler, 2016).

Possible causes of math anxiety. Many studies agree that math anxiety is likely increased by parents and teachers with negative mindset (Boaler 2015; Finlayson, 2014; Foley et. al., 2017). As a math teacher, other teachers share their uncertainty about their own math ability in their reaction to me sharing my content area. I often hear phrases like "good you for" or "you must be smart." I have also had parents express their concern about not being able to help their children because they "never really got math." Another common perspective is that math anxiety can be caused by testing (Boaler 2014c, as

reported in Boaler, 2016; Finlayson, 2014; Steele & Arth, 1998) or impacted by math performance (Boaler 2015; Finlayson, 2014; Foley et. al., 2017). Timed tests like math facts could be especially problematic (Boaler, 2016) since they combine the possibility of failure with testing and the added pressure of speed. The way mathematics is taught may also be a factor in developing math anxiety. Asking students to memorize (Steele & Arth, 1998, Finlayson, 2014) combined with teaching math procedurally for students who need a deep understanding could lead to math anxiety (Boaler, 2015). Tests and memorizing procedures are two experiences that could cause trauma for students. Boaler (2016) suggests that math trauma combined with a belief that only some people can do math well can help fuel math anxiety.

Possible impacts of math anxiety. In addition to the physical and emotion toll anxiety takes on a person, the performance and motivation of students can also be impacted. Some studies have found that students with math anxiety are still able to perform well on assessments (Dweck, 2016; Boaler, 2016), perhaps because of working hard to avoid failure. In contrast, Foley et al. (2017) counsels that math anxiety likely impacts math performance while Boaler's (2016) assertion that replacing anxiety with confidence leads to higher motivation suggests that anxiety also lowers motivation. I would argue that it may also lead to avoidance of interacting with math altogether based

on interactions with my sixth graders. I too have observed that when I talk to students after they have skipped or attempted to skip class, their anxiety around math appears to be the primary motivator. Teachers may be able to help students lower their anxiety, as Boaler (2016) found in her research and interactions with teachers, formative assessment paired with growth mindset messages reduces math anxiety and in turn increases self confidence, motivation, and achievement.

Motivation, confidence, and learning. Confidence is necessary for motivation (Boaler, 2016; Stiggins, 1999) and motivation is needed in order to learn (Stiggins, 1999). The curriculum and the feedback or praise that students receive from their teachers can increase their motivation. Students often find complex, challenging math problems that they are still able to solve, exciting. Boaler (2016) suggests that this excitement can increase motivation and also recommends using inquiry tasks in place of traditional process oriented tasks to increase motivation. In addition, "specific and timely" feedback can help students learn and increase their intrinsic motivation to learn (Jensen, 1998, p. 44). Students with intrinsic motivation are more focused on learning and more likely to persist (Black, Harrison, Lee, Marshall, & William, 2004; Stiggins, Arter, Chappuis, & Chappuis, 2007; Dance, Woodbury, & Boaler, 2018). The praise given to students can affect whether they have intrinsic or extrinsic motivation. In their 1998 study Mueller and

Dweck found that when students were given praise for their effort, it changed how they saw their intelligence. While students who were praised for their intelligence connected that to the idea that intelligence is fixed, students who were praised for effort did not, instead they connected to the idea that intelligence can be changed and depends on motivation and knowledge. Students can be motivated to learn by feedback that praises them for their hard work because following that praise they would likely choose problems that would allow them to continue learning instead of problems that would be easy for them do without mistakes (Mueller & Dweck, 1998). Conversely, Mueller and Dweck's 1998 study suggests that student confidence and enjoyment can be lowered by exposing them to praise focused on their intelligence followed by challenging problems that cause them to struggle or make mistakes.

Impact that our testing and grading culture could have on motivation. In addition to the possible impact of testing on anxiety discussed previously, the pervasive testing culture found in the United States combined with grades may also decrease student motivation (Boaler, 2016; Dance et al., 2018; Stiggins, et. al., 2007). Researchers suggest various reasons why students may have lower motivation when math anxiety is present. Students may not try to learn if they assume they are going to fail because they have received poor grades in the past and believe that is because they don't have the

ability (Black & Wiliam, 1998; Black, et. al., 2004). This is similar to Stiggins (1999) argument that testing culture causes students to give up and lose confidence. Black and William (1998) contend that this could also happen through students electing to work on easier tasks in order to get the right answer or from comparing themselves to other students. One way to counter the anxiety and decreased motivation present in our testing and grading culture is by developing mathematical and growth mindsets in students.

Mathematical mindset. Mindset, how a student views himself or herself as a learner and a mathematician, can affect motivation and performance (Boaler 2016; Foley et al., 2017; Stiggins, 1999). Boaler (2016) states that mathematical mindset is when students know that "math is a subject of growth and their role is to learn and think about new ideas" (p. 34) and try to make sense of them. Boaler (2016) contrasts a mathematical mindset with a fixed mindset focused on procedures and suggests that the common practice of teaching isolated mathematical procedures and having students repeat them brings about this fixed, procedural mindset. This is important because of the impact on learning, "Marsh and his colleagues (2005) demonstrated that prior math self-concept predicted later interest scores as well as school grades and standardized test scores in a longitudinal study of young German adolescents" (Costa, Rowley, Harris-Britt, & Woods, 2008, p. 405). Especially concerning is the fact that students can

have a growth mindset about everything else, but still have a fixed mindset about math (Boaler, 2016).

Growth mindset and mathematics. Various researchers have described the characteristics of students with a growth mindset. People and specifically students with a growth mindset accept mistakes and effort as part of learning (Dweck, 2009), have more motivation (Boaler, 2016), and learn and achieve more (Blackwell, 2007, as reported in Boaler, 2016; Dweck, 2009). Students with a fixed mindset, on the other hand lose confidence when challenged (Dweck, 2009) and learn and achieve less (Blackwell, 2007, as reported in Boaler, 2016; Dweck, 2009; PISA, 2012 as reported in Boaler, 2016). Students with fixed mindset assume that making mistakes or having to work hard that means you are dumb or not smart, leading them to avoid mistake and effort because of their assumption that learning should be easy (Dweck, 2009). This is concerning because effort and making mistakes are important parts of learning (Dweck, 2009). The ways teachers and parents praise students can determine if they will develop a fixed or growth mindset (Mueller & Dweck, 1998). Dweck (2009) recommends that teachers and parents give praise and criticism not on ability but on "effort, strategies, perseverance, and choices" (p. 57), in other words, the process the student used to undertake the task.

Summary. Discussion so far suggests that the mindset, confidence, motivation, and whether or not a student has anxiety can impact his/her learning. Teachers can help determine these factors for students. One way to do this is through feedback which will be discussed in the third section of this literature review. First, the research about girls and mathematics will be reviewed.

Girls and Mathematics

There is a belief in some countries including the United States that boys are better at math than girls. This is not supported by research (Boaler, 2016; Boaler & Sengupta-Irving, 2006). This section will first describe perceived differences between boys and girls and stereotypes about girls and math. Next it will relate the actual differences researchers have found between boys and girls. Finally, this section will outline the impact of teachers perceptions of and interactions with girls during math class.

Perceived differences between boys and girls. There is a belief in many countries that boys are better at math than girls but this is not supported by research (Boaler & Sengupta-Irving, 2006; Boaler, 2016). Nowicki and Lopata (2017) found in their study that fourth through sixth grade girls did not believe the stereotype that boys are better at math, reporting that girls were better at math through explicit and implicit measures. However, Costa, Rowley, Harris-Britt, and Woods (2008) uncovered a

mismatch between how competent at math girls view girls as a whole group and their individual levels of confidence. Girls perceive themselves as individuals as less competent than boys, but also believed that girls are more competent in general. Another concern was expressed by Boaler and Sengupta-Irving (2006) that in research girls have been compared to boys, with boys' achievement and attitudes being the standard against which girls are measured. Outside the common misbelief that boys are better at math, there is little consensus about actual differences related to girls and math.

Anxiety and self-perception. The Organization for Economic Co-operation and Development's Programme (PISA) for International Student Assessment (2015 & 2017) found that in most countries girls had more test anxiety and that it impacted their test scores (as reported in Boaler, Dance, & Woodbury, 2018). Boaler (2016) specified that anxiety related to timed tests is widespread for girls. Not all studies agree. Gierl and Bisanz (1999) found no difference in math anxiety between boys and girls in elementary school but suggested increases for girls may happen after elementary school based on previous studies. In addition to anxiety, some researchers have found that girls believe math is a boy's subject and girls are not as good at it (Boaler & Sengupta-Irving, 2006).

Achievement and participation. PISA (2017) reported that girls outscored boys when working on a collaborative assessment with a computer agent (as reported in

Boaler, Dance, & Woodbury, 2018). Boaler and Sengupta-Irving (2006) reported that girls have higher achievement (test scores) than boys especially in Japan, Sweden, and Iceland but lower participation in college math.

Other differences. Boys think mathematics is more useful than girls do (Gierl & Bisanz, 1995). While girls want to understand more deeply and many of them have fixed mindset (Boaler, 2016). Good, Rattan, and Dweck (2012) studied how a sense of belonging impacted future mathematics participation. They found that the inclination of a student to continue in mathematics can be predicted by how much they feel they belong in math. Sense of belonging also impacted corresponding areas like confidence and anxiety. This study seemed especially poignant for my students because as Good et al. (2012) asserted "it is precisely in the middle-school years that girls' confidence in and liking of mathematics begins to wane" (p. 714). Two common misconceptions that girls hear that may make them feel they don't belong in math are that math ability is innate and that boys are born better at math than girls (Good et al., 2012). Teachers have an impact over whether girls are exposed to these misconceptions in class since teachers create the learning environment. Teacher perceptions and interactions are part of that learning environment.

Student reactions to perceived teacher perceptions. Some teachers may have misconceptions about the ability of girls in mathematics. Their perceptions may in some cases affect the perceptions and achievement of girls. Picho and Schamder (2018) were studying stereotype threat and discovered that it was actually the researcher expectations that impacted performance more than students' beliefs regarding stereotype threat. In their study girls did worse when they thought the researchers expected girls to do worse and boys also followed the perceived expectations of the researcher. There is disagreement among researchers about the impact of adults views. Costa et al. (2008) found variation by age. Sixth grade "girls who believed that adults viewed boys as better than girls in mathematics and science tended to have poorer mathematics and science self-concepts" but eighth grade girls did not (p. 404). While Sarouphim and Chartouny (2016) reported that teacher's beliefs about mathematics as a boys' subject did not impact the perceptions of girls in Lebanon. The girls did not think negatively about mathematics. In addition, Updayaya and Eccles (2014) noticed that teachers thought boys had higher ability, however, the beliefs of the teachers did not predict the amount of interest boys had in mathematics. Nevertheless, for both girls and boys, a teacher's understanding of a particular students' effort and potential was a better predictor of math interest than the teacher's understanding of their ability.

Additional findings. One surprising finding by many researchers is the idea that teachers think that when girls do well, it is because of effort (Sarouphom & Chartouny, 2016; Espinoza, Areas de La Fontes, & Arms-Chavez, 2014) but when girls do poorly, it is an innate ability, whereas when boys do well, it is because of ability (Espinoza, Areas de La Fontes, & Arms-Chavez, 2014) and poorly because of components outside of the boys' control (M. Cohen, 1999, as reported in Boaler & Sengupta-Irving, 2006). Costa et al. (2008) proposed that the time period encompassing fourth grade to sixth grade may be a good time for adults to promote a positive belief in an individual student's math ability. Becker's (1981) study found teacher-student interactions in math were more positive towards boys (as reported in Boaler & Sengupta-Irving, 2006). This does not necessarily impact mindset and achievement; however, many agree that teachers and parents anxiety and negative view of mathematics can impact the achievement of girls in a negative way (Beilock, Gunderson, Ramirez, & Levine, 2009, as reported in Boaler, 2016; Eccles & Jacobs, 1986 as reported in Boaler, 2016).

Summary. This section has described the unsupported stereotype that boys are better at math than girls. While it is uncertain how much impact this has on the achievement of girls it does appear to impact the perceptions of their teachers and possibly the self image of girls. Importantly, even though girls can achieve at high levels

they choose not to pursue further studies in math. This may be due to the procedural nature of mathematics and the mindset created by the feedback given by adults. Feedback will be discussed more deeply in the next section.

Teacher Feedback on Assessments

Teachers can give feedback to students on their learning through formative assessments. This feedback can also give students messages about their ability and impact their self image (Boaler, 2016). This section will contrast comment-only marking with traditional letter grades and standards based grading. It will also describe the impact that feedback can have on student confidence and self perception. This section will conclude with a summary of best practices for giving feedback discovered by researchers.

The difference between formative and summative assessment. Grades are a type of summative assessment used to show parents and students what a student has learned (Boaler, Dance, & Woodbury, 2018). Grades also tell a student how she compares to others but do not give her specific information about what she has learned or what she needs to change in order to learn more moving forward (Boaler, Dance, & Woodbury, 2018). Cauley and McMillian (2010) contrast summative assessment as evidence that "only records current student achievement" (p. 1) and effective formative assessment as assessment used "during instruction to identify specific student

misunderstandings, provide feedback to students to help them correct their errors, and identify and implement instructional correctives" (p. 1). While Boaler (2016) defines each assessment types by focusing on its purpose. The purpose of summative assessment is to condense learning into a final report, while the purpose of formative assessment is to help teachers and students determine what a student has learned so far and where to go next while learning is still happening.

Concerns about summative assessment. Some teachers, especially in math, give frequent summative assessments to students. These could be in the form of weekly quizzes, unit tests, and standardized tests. Frequent tests and grades can cause students to focus on performing (getting the best grade) instead of learning (Black & Wiliam, 1998; Boaler, Dance, & Woodbury, 2018). Many schools require grades at the end of a term and some require or encourage teachers to post grades weekly or bi-weekly in order to inform parents about student progress. However, multiple studies found that grades can lead students to focus on the goal of not failing which is a performance avoidance goal (Black & Wiliam, 1998; Pulfrey, Buchs, & Butera 2011). One study suggested that the performance of students declined when they received grades (Butler, 1987). Math class should be a place of learning where students find joy in the beauty of mathematics and the challenge of solving problems. Grades and tests can undermine this goal and promote

the fixed mindset and anxiety discussed previously. The impact of feedback on motivation will be discussed in the next section.

Feedback, motivation, and mindset. As discussed above, mindset and motivation are both important for learning. Assessment is a part of teaching and learning, however, the ways students are assessed can affect the way they are motivated (Butler, 1987) and their mindset (Boaler, Dance, & Woodbury, 2018). Formative assessment, such as Assessment for Learning, which uses feedback that focuses on: effort, the strategy chosen, not giving up, and mistakes in their process instead of how smart they are promotes growth mindset (Boaler, 2016; Dweck, 2008) through the messages the feedback gives to students. Feedback is helpful for low achievers when it tells them what they did wrong and how to fix it without connecting their mistake to their ability **(**Black & Wiliam, 1998) and all students need to know that they can learn (Boaler, 2016). One way to promote growth mindset and increase motivation could be to promote mastery goals. A mastery goal "emphasizes learning, understanding, improving, mastering new skills, and taking on challenges" as opposed to a performance or ego involved goal which "emphasizes caparison of students' abilities" (Cauley & McMillian, 2010, p. 3). Cauley and McMillian (2010) describe ways to promote mastery goals that closely align with the qualities found in effective formative assessment. Conversely, when teachers focus on

performance outcomes such as letter grades or saying "you need to know this for seventh grade" students can develop a fixed mindset (Boaler, Dance, & Woodbury, 2018). To avoid increasing extrinsic motivation and encouraging performance goals, avoid normative feedback or comparison to others (Cauley & McMillian, 2010).

Grades, mindset, and motivation. While feedback given on formative assessments can improve mindset and motivation, grades can have the opposite effect (Butler, 1988, as reported in Boaler, 2016; Cauley & McMillian, 2010; Pulfrey, Buchs, and Butera, 2011). Boaler (2016) describes how students "move through middle schools getting more and more grades and feeling less and less motivated by the ideas they are learning" (p. 148). One possible reason for this may be that grades can lead students to perceive themselves in a certain way, such as an A student or as a failing student who is not capable of doing the work (Black & Wiliam, 1998; Boaler 2015; Boaler, Dance, & Woodbury, 2018). High achieving students often have a fixed mindset which may lead them to stop trying when met with failure (Dweck, 2016). Another possibility is that grades can make it hard for students to see the connection between their efforts and what they are learning (Cauley & McMillian, 2010). It is possible to empathize with a struggling student who is trying her best to understand fraction division, when she makes an error, and gets the wrong answer, and the whole question is marked wrong. A student

would likely find this very discouraging. Grades are not the only way to assess students and to give them feedback on their learning. Even if a teacher must give a letter grade at the end of the term he may use comment only marking to give feedback on learning during the term.

Comment only marking. When a student completes a math problem or task instead of giving feedback through a grade a teacher could write a comment such as, "I see you have a common denominator. Remember that when you change only part of the fraction you change it's value. How can you change the denominator and keep the value of the fraction the same?" Butler (1987) submits that students receiving comment feedback had higher interest in the task and performed better than those receiving grades or praise (Butler, 1987). This may be because comment marking focuses on the task, while praise and grades affect the ego and can lower intrinsic motivation (Butler, 1987). Teachers trying to incorporate comments into assessments that also include grades may want to use comments only because not only did grades lower motivation but grades with comments lowered motivation as well (Black, Harrison, Lee, Marshall & Wiliam, 2004; Butler, 1988, as reported in Boaler, 2016; Cauley & McMillian, 2010; Pulfrey, Buchs, & Butera, 2011). Replacing grades with comments may provide some challenges for teachers such as not meeting grading mandates placed on them by their school, time and

expertise to write effective comments, and pushback from parents and students. Many teachers are creative problem solvers and may find that they are willing to overcome these issues in order to provide opportunities for their students to improve their motivation, engagement, mindset, and learning. The next section will describe in detail best practices for giving feedback on formative assessments.

The purpose of feedback. Effective feedback should encourage students to think about their work and their learning and then take action to improve (Black, Harrison, Lee, Marshall & Wiliam, 2004; Brookhart, 2011). Similarly, many researchers have found that feedback should give students the information they need about their progress and how to continue moving forward (Black & Wiliam, 1998; Boaler 2015; Brookhart, 2011; Hattie & Timperley, 2007; Stiggins, et al., 2007). In addition, feedback should be related to the goal and help students meet success criteria (Brookhart, 2011; Hattie & Timperley, 2007). The overarching goal of feedback should be to narrow the gap between what students know and understand and what teachers would like them to know and understand (Boaler 2015; Hattie & Timperley, 2007). Researchers have uncovered ways to give feedback that support this goal.

Qualities of effective written feedback. Most researchers agree that feedback for learning should include the following three elements. However, the order varies among

researchers. Students need to know where they need to be or the goal they are trying to reach. Students also need to know where they are now or how they are doing so far which could include recognition of strengths and successes. Finally, and possibly the most important part for learning, is for teachers to provide a suggestion or support for how the student can reach the goal from where they are now. (Boaler, Dance, & Woodbury, 2018; Cauley & McMillian, 2010; Hattie & Timperley, 2007; Sadler 1989 as reported in Black & Wiliam, 1998; Stiggins et al, 2007). These three pieces have been summarized as the Assessment for Learning Cycle (Boaler, Dance, & Woodbury, 2018; Stiggins, et al., 2007) and as Feed Up, Feedback, and Feed Forward (Hattie & Timperley, 2007).

Before feedback, consider the goal. Having a clear goal can help the teacher focus her feedback. Many authors suggest that goals should include success criteria; a description of what mastery looks like (Cauley & McMillian, 2010; Hattie & Timperley, 2007; Stiggins, et. al., 2007). After reviewing many research studies related to feedback Hattie and Timperley (2007) also concluded that goals should be specific and have the right level of challenge for the specific student.

What to give feedback on. When giving feedback on meeting the goal so far Hattie and Timperley (2007) recommend focusing on the task or problem the student was given, the steps the student used to complete the task, or how the student managed his/her

behavior and effort. Another element to give feedback on is the self such as praise or judgement; unsurprisingly, Hattie and Timperley (2007) found this type of feedback less effective and therefore do not recommend it. Boaler, Dance, and Woodbury (2018) recommend using growth mindset messages which would be undermined by praise as detailed earlier in this paper. While Cauley and McMillian (2010) note that teachers should "attribute results to student efforts" (p. 4). Hattie and Timperley (2007) also caution that the most effective feedback about task correctness is not based on information that the student is missing but an incorrect understanding or interpretation. In addition to noticing what the student is able to do and do well, Boaler, Dance, and Woodbury (2018), Brookhart (2011), and Stiggins et al. (2007) also advocate for giving each student specific suggestions or ideas to attempt as a way to improve. Focusing on the student's effort and connecting effort to the outcome can help students understand that when they are not successful, the student has the power to make changes that could lead to success. (Cauley and McMillian, 2010).

When to give feedback. Boaler, Dance, and Woodbury (2018) advise that teachers don't give grades or give them at the end of the grading term. This contrasts with diagnostic feedback. Brookhart (2011) put forward the idea that feedback should be given while it is still useful to students which seems to align with the recommendation from

Stiggins et al. (2007) to give feedback during learning. This would allow students to learn from feedback on their mistakes and misconceptions while the class is still working on the topic. However, this would likely work best when teachers provide time for students to use and respond to comments **(**Black, Harrison, Lee, Marshall & Wiliam, 2004). It would appear that comment based feedback would take much more time than giving a letter grade or assigning points to a task. Boaler (2016) describes two possible remedies for this. First, to give clear diagnostic feedback occasionally instead of graded tests or quizzes. Second, that feedback may be given when a teacher thinks a student needs it, instead of giving it to every student all the time or on a schedule (Boaler, 2016). Brookhart (2011) gives suggestions for tailoring feedback to struggling and successful students suggesting that feedback should be differentiated and different types may benefit students in different ways.

Summary. In summary, the review presented in the previous pages suggests that when possible, teachers should avoid grades which may be harmful to mindset and motivation and use as a replacement diagnostic, comment only feedback. This type of feedback should be used when reviewing formative assessments given during learning instead of at the end of a unit or term. These comments should allow students to reflect on their learning and see a way to move forward by pointing out the goal, how the

students are partially meeting or working towards the goals, and possible action steps to meet the goal. Comment-based feedback does not have to be given on a weekly or daily timetable but may be given to different students as they need it. The next section will describe the learning needs of adults and qualities of effective professional development (PD), which will help frame the PD session to be developed as part of the current capstone.

Adult Learning Through Professional Development

Teachers are not born master teachers and more experience does not always equal better teaching. The knowledge, skills, attitudes, and beliefs of a master teacher can be learned (Demonte, 2013). One way for teachers to improve their instruction and student learning is through structured professional development. Effective professional development should not only change teacher thinking and action but also improve student learning (Darling-Hammond, Hyler, & Garnder, 2017; Desimone, 2011). This section will describe the needs and strengths of adult learners, qualities commonly found in successful professional development, and a framework for designing professional development.

Needs and strengths of adult learners. Adults come into a learning situation with beliefs and attitudes already formed and prior knowledge from their own learning

and experience. Knowles (1992) suggests that adult learners are not passive receivers of information, but that they can express what they want to learn and can share knowledge and expertise with fellow adult learners. In Trotter's 2006 review of studies and theories about adult learning she found a similar idea. Trotter contends that the past learning and experience of adults is important for and can assist with new learning. The learning should also fit the needs of the teacher and her classroom which can be accomplished by allowing the teacher to plan or make choices about what and how she learns. In addition to these strengths, adult learners need to connect with what they are learning (Knowles, 1992) and have opportunities for interaction, collaboration, and reflection (Desimone, 2011; Knowles, 1992; Trotter, 2006) in order to seek out new information. The strengths and needs of adult learners should be considered when designing professional development workshops.

Common qualities of effective professional development. Following extensive reviews of the current literature available on professional development, Darling-Hammond, Hyler, and Garnder (2017) and Desimone (2011) both described the following characteristics of effective professional development:

- Professional Development sessions should focus on how to teach a specific content area and how students learn a specific content area such as math
- Teachers should learn together and collaborate, through activities such as reviewing work or creating lesson plans together; this could include teams, grades, or a whole school working together on the same professional learning
- Teachers need to be active participants
- Professional development should take place over time so teachers can learn, use, reflect on their learning, and continue to learn

Demonte (2013) agreed that in order to see improvement in the classroom through changes in instruction a large amount of time is needed, at least 14 hours, ideally 20 hours. In terms of active participation, Darling-Hammond, Hyler, and Garnder (2017) suggest a good way to provide this is to have teachers practice what they will be doing or to experience what they want their students to be doing. Knowles (1992) states that presenters have three venues to provide interaction: the presentation, the audience, and the connection between the presentation and audience. He recommends four ways to increase engagement and inquiry: include visuals, have multiple presenters, include

audience ideas and reactions, and provide opportunities for audience members to talk to each other. Desimone (2011) discovered an additional quality: the professional development should be consistent with current goals, beliefs, and policies of the teacher's school or district (Desimone, 2011). A common complaint of my fellow teachers is that two different professional development workshops we attend may contradict each other.

Darling-Hammond, Hyler, and Garnder (2017) listed additional traits of effective professional development:

- Connects to the specific needs of the teacher and the students
- Helps teachers to see what good curriculum and teaching look like through models and modeling, examples, demonstrations, peer observations, student work, and/or curriculum samples
- Offers coaching and/or assistance from an expert
- Provides space and time for teachers to reflect on their thinking, practice, and learning
- Supplies opportunities for feedback on their learning and implementation
- Plans for suggestions to address barriers or concerns

Creating effective professional development takes time and careful planning if a facilitator is hoping to incorporate many of the aspects common in successful

professional development. Desimone (2011) provides facilitators and developers with a simple framework of professional development that can be used as a support.

Framework for professional development. Desimone's 2011 model includes four parts:

1. Teachers participate in PD
2. Teachers learn (skills, understanding or knowledge, ways of thinking or believing)
3. Teachers use what they have learned
4. Student learning improves

This model can be used to help develop adult learning and to determine whether it is effective. Commons ways of determining effectiveness include surveys, observations, or interviews but should be tailored to the goal of the professional learning (Desimone, 2011). However effectiveness is measured, teacher change and student learning should both be considered (Darling-Hammond, Hyler, & Garnder, 2017; Desimone, 2011).

Summary. This section has provided an overview of characterics and considerations that could be used to design professional learning. Many of these strategies will be used during this capstone to create a professional development workshop around how teachers can provide feedback to students on their formative

assessments, specifically feedback that will not only improve their learning but also their mindset. The next section will provide the rationale for my project based on gaps in the current literature.

The Gap Leading to My Project

As discussed above, there is significant research about mindset, feedback, and the impact on motivation and achievement. However, girls still choose to pursue careers unrelated to mathematics or opt out of math when no longer required to take math classes. As a middle school teacher, I have experienced first hand the impact of fixed mindset and anxiety in my students, particularly my girls. The gap appears to be not in the literature but in the practice of teachers. As a teacher in the middle of a student's educational career, their beliefs about themselves as mathematicians have already begun to develop based on the teaching and feedback given by their previous teachers.

Thus, I have chosen to investigate best practices for giving feedback on formative assessments because I want to find out how such feedback impacts the learning and mindset of sixth grade students in order to help educators understand how feedback can be used to promote learning for female students in math. Specifically, I want to answer the question: *How does the feedback given by math teachers on formative assessments impact the learning and mindset of female students in math?* for myself and other

educators. In order to do this, I will create a series of professional development sessions for teachers who are also interested in this question.

Summary

This chapter has reviewed the available literature related to mindset, girls and mathematics, teacher feedback, and adult learning. The review indicates that both mathematical and growth mindset are important for motivation and learning. Some girls leave mathematics even though they have the same capacity to participate in higher mathematics as boys. Diagnostic, comment-only feedback given to help students know what they have learned, where they need to go, and how to get there will help support girls in developing the mindsets they need to continue in mathematics. The next chapter will describe in detail the professional development series that I will create for teachers who want to use research-based practices when giving written feedback on formative assessments.

CHAPTER THREE

Project Description

Introduction

Based on my own experiences and the literature review provided in Chapter Two, it can be concluded that what is really needed is not more research on feedback or mindset but more hands-on learning by educators. Thus, the current project includes creation of a professional development workshop for elementary and middle school math teachers in an effort to address my research question: *How does the feedback given by math teachers on formative assessments impact the learning and mindset of female students in math?*

This first section of this chapter will provide a description of the outcomes and goals of the workshop, research-based features of the workshop, and describe how the content will be determined through a needs assessment. The next section will detail the school and teachers the professional learning workshop will be designed for. Then a discussion of the measurements used to determine effectiveness will be included. Finally, the timeline for creating the learning activities and presentation during the Fall of 2019 will be outlined.

Description of the Project

My capstone is a set of professional development sessions for teachers. The content of the sessions are based on findings from Chapter Two about the impact of feedback on mindset and learning. The structure of and activities in professional development sessions were created based on what I learned about adult learning during my literature review.

Goal of the Professional Development. The main goal of these sessions is to help teachers change their understandings and practices around feedback given to students on formative assessments. Specifically, the sessions focus on comment-only feedback as this has been shown to support positive student mindset and learning (Black & Wiliam, 1998; Boaler, 2015; Cauley and McMillian, 2010; Dweck, 2008). An example of comment-only feedback could be: “you color coded how the pattern was growing, what can you say to describe how it is growing?” or ”you labeled number three as a cone but it is a pyramid because of its triangular faces, look at the shape of the faces and the vertex when you are naming these solids.” These would be written on the students paper or on a note attached to their work. The written feedback would take the place of a letter grade, percentage, or fraction showing how correct the student was in completing the task. The feedback given to students should help them create a mathematical, growth

mindset and improve their learning. Teachers will be able to give comments as feedback to help students know where they are going, where they are now, and how to get there (Boaler, Dance, & Woodbury, 2018; Cauley & McMillian, 2010; Hattie & Timperley, 2007; Sadler 1989 as reported in Black & Wiliam, 1998; Stiggins et al., 2007). In order to help students improve their mindset and learning, teachers will first need to understand the difference between a fixed mindset and growth mindset and then understand the impact of growth mindset on learning and engagement (Dweck, 2016). As discussed previously in Chapter Two, grades and feedback can either support student learning and engagement or undermine it. Through excerpts from and summaries of research teachers will understand how grades and feedback affect mindset and learning, especially for girls.

Adult Learning. As discussed in Chapter Two, feedback and changes in practices are important aspects of effective professional learning. Therefore, teachers will reflect on the feedback they give to students through the lens of mindset and actions steps for learning. Teachers will also create a plan for using comment only feedback with at least three students.

The professional development workshop was designed to take place during a weekly PD cycle. The sessions will be designed to occur over 8 to 10 weeks with one 45 minute session each week. Teachers will be able to opt in if they are interested in learning

about comment feedback as a strategy. As summarized in Chapter Two, Knowles (1992) suggests that adult learners know what they want to learn and should be able to have control over their learning. During the workshop sessions, teachers will be invited to bring in their own student work in order to make the professional learning more closely aligned with the needs of their students and classrooms. The sessions are in the format of a small group with a facilitator. Teacher engagement is encouraged through participation in many activities as suggested by Desimone (2011), Knowles (1992), and Trotter (2006) including: reviewing exemplars, reviewing and discussing limited research, practicing with provided student work samples collected through partners in the fall and participant supplied student work, and reflecting on learning, challenges, and next steps.

The focus is on only one specific content area (Darling-Hammond, Hyler, & Garnder, 2017; Desimone, 2011), which in this case will be math. The workshop was designed for teachers from second grade through eighth grade who teach math for at least part of their day. Teachers in pre-kindergarten through first grade would also be welcome, however, their students may not benefit as much as they are still learning to read and feedback comments will be written. Special education resource teachers who teach or co-teach math would also be invited to participate.

In order to make the workshop as productive and effective as possible, several research-based strategies will be incorporated. As discussed previously, professional learning programs found to be effective have many characteristics in common (Darling-Hammond, Hyler, & Garnder, 2017). There are opportunities for teacher participants to interact, collaborate, and reflect in various ways in order to meet their needs as adult learners (Desimone, 2011; Knowles, 1992; Trotter, 2006). Opportunities to interact and collaborate are provided through reviewing student work together in order to determine where students are at and what steps they need to reach their goal. Another collaboration activity will also provide feedback. Teachers can work in partners or trios to review the comment feedback given by each participant to a student or a few students. Partners will notice strengths and areas for growth, followed by providing suggestions for change. Reflective discussions with partners or trios will also take place. When problems or barriers arise with implementation in the participants' classrooms, problem solving and planning for challenges can tackled as a group. As discussed in Chapter Two, Knowles (1992) and Trotter (2006) submit that adults can contribute to current learning through their past experience and prior learning. Learning focused on the teaching and learning of a specific content has been found to be successful, so we are focusing on math. If time permits, teachers may be asked to describe how they could use their learning in other

areas. It would be most effective to provide fourteen to twenty hours of professional learning, however, only eight to ten hours will be possible based on the professional learning cycle of the school. In order to make the most of a short amount of time, the learning will be as interactive as possible with opportunities to practice writing comments and reviewing and discussing models and/or exemplars of effective written feedback in addition to the work reviews and discussions already mentioned.

Meeting the Needs of Participants. Besides providing an active learning environment, an informal needs assessment should be performed at least 8 weeks before the professional development begins in order to determine the needs and experience of likely participants and target the professional learning to its audience. When possible, teachers are asked to answer questions face-to-face in small groups but will also be able to complete them individually on paper if they prefer. The following questions are included:

- Do you know the difference between growth and fixed mindset?
- Do you know how mindset impacts learning and engagement?
- Do you know the difference between formative and summative assessments?
- How often do you give formative assessments?
- How often do you write comments on formative assessments?

- Do you believe your written comments give your students the information they need to learn?
- Would you like to learn more about growth mindset and its relationship to learning?
- Would you like to learn more about using comment feedback to help students develop a mathematical mindset and improve their learning?
- Have you noticed girls avoiding or being less engaged during math time than during other parts of the day?

The content of the workshop will depend on the current knowledge and preferences of likely participants. It is designed so the facilitator can pick which parts to include, especially during the building background sessions. However, the overarching theme will be centered around answering my research question: *How does the feedback given by math teachers on formative assessments impact the learning and mindset of female students in math?* The content is grounded in the research presented in Chapter Two, in particular Dweck's (2016) work around growth mindset and Butler's (1987) work on comment marking.

Intended Audience

The intended audience of this professional learning workshop is elementary and middle school teachers who spend part or all of their day teaching math. The teachers the

workshop was created for are part of a pre-kindergarten through eighth grade urban school in a large metropolitan city in the upper midwest. The teaching experiences of these teachers range from two years to fifteen years with some teachers holding Master's degrees. Roughly half of the teachers speak fluent Spanish as the school houses a Developmental Dual Language Program for native Spanish speakers up to grade five. The school has two classrooms of students for each grade level. This school has a large majority of students qualifying for free and reduced lunch and educates a majority of students of color including Black, Latinx, East African immigrant students and a small Native and South Asian population. The district recently began a multi-tiered systems of support initiative which includes an emphasis on short term instructional planning and vertical alignment of teaching and learning objectives.

Measurements of Effectiveness

As stated in Chapter Two, the effectiveness of teacher learning and implementation and student learning both need to be assessed. Teacher implementation and learning can be measured in two ways. First, teachers will be asked to complete a self-reflection survey about their use of comment feedback at the end of the workshop, six weeks later, and six months later. This will help determine not only if learning occurred but if it was incorporated into teacher practice. Sample questions include:

- How often do you give comment feedback on assessments?
- Which students do you give comment feedback and why?
- How often do you include information in your comment feedback about the students' process?
- How often do you give suggestions for steps the student can take to work towards the goal?
- Do you even give praise such as good job or excellent that students may perceive as being measures their ability?
- What problems or barriers have your encountered when using comment feedback?
- What else would you like to say about your implementation of comment feedback?

In addition to the survey, teachers will be asked to voluntarily submit samples of comment feedback given on actual formative assessments. Fastbridge aMath screener results can used to measure student learning. This assessment is routinely given in the Fall, Winter, and Spring each school year to assess whether students are on grade level in math or at risk of falling behind.

Timeline for Project Completion

This professional learning workshop around comment feedback was developed during the Fall 2019 semester in order to be used during the Spring 2020 PLC cycle. In

August, literature around comment feedback, mindset, and learning was still being collected, reviewed, and summarized. Contact was made with instructional leaders in the school to seek out continued support and feedback. In September, a skeleton outline of learning activities and presentation was developed based on research from Chapter Two. The facilitator of this workshop should complete the needs assessment between eight and twelve weeks prior to the start of the sessions. The facilitator should also collect students work during the four to eight weeks before the sessions starts. In November, the final presentation was created and reviewed by an instructional leader in the school.

Summary

In order to help myself and my colleagues improve the mindset and learning of female math students, a professional development workshop was created. This workshop uses research-based strategies around adult learning. This chapter described the project and its intended audience. It also described how effectiveness will be measured and the timeline for completing the project. In the next chapter I will describe how this process went and what I learned during the development of the comment feedback professional learning workshop.

CHAPTER FOUR

Reflection

Introduction

Mathematics learning is very important to me. As I work with my new class of fifth graders this Fall I have some of the same concerns about mindset and mathematics that I have every Fall and found myself having after my return to school from maternity leave. These concerns led me to investigate the question: *How does the feedback given by math teachers on formative assessments impact the learning and mindset of female students in math?* This first section of this chapter will describe what I have learned about research, writing, and myself as a learner during the capstone process. This will lead into the next section focusing on which parts of the literature were most impactful for developing my professional development workshop and new connections I have made during my learning. Policy implications about grades and feedback will be included in the third section. The limitations of data collection and only working on one of the many teaching practices that must come together to increase mindset and learning will be detailed in the following section. This will lead into recommendations for future action research. Finally, I will outline how the results of the project will be used and shared, followed by a description of the potential benefits.

Learning from the Capstone Process

While investigating this question I have learned many things about research, professional writing, and myself as a learner. Through my district action research program and my previous classes at Hamline I have read research studies and other educational literature. However, this was the first time where I had to find many related pieces of literature on my own. Reading the abstract and discussion of studies allowed me to determine if they seemed applicable and if the whole piece was worth reading. I

learned how to use the reference section to find additional studies and articles that were quoted or paraphrased in literature I was reading. This helped me expand my literature collection and focus on original sources. I learned about the importance of finding original sources and that not all research is published or available to everyone. I struggled to find some original sources and learned to use "as reported in" which was new to me. My ability to paraphrases has increased but I still find it challenging and often did not have the same takeaways as other researchers who paraphrased the same piece of research. I have learned about different kinds of research which allowed me to understand and appreciate research that is presented at professional conferences and about the importance of the Institutional review board, getting permission for study or research subjects/participants, and anonymity. This summer while taking capstone practicum I was able to attend a professional conference where research was being shared about Cognitively Guided Instruction in math. During and after the conference I was able to make connections to what I was learning about qualitative and quantitative research. It also helped me understand the challenges of researchers and look for limitations or flaws in research design.

I have always thought myself an acceptable writer but never really studied writing. I credited my skills to all of the reading I had done, since I am an avid reader. Through the capstone practicum class I explicitly studied and practiced academic writing. I learned about consolidating ideas or findings from many authors in order to tie ideas together and to contrast opposing points. This helped me to synthesize the various articles and journals I reviewed. I learned more about the fine points of APA style and learned to

keep a resource handy for reference about specific formatting and citations. When paraphrasing findings or conclusions from research studies, I learned to use hedging words in order to show an amount of uncertainty. I also learned that I needed a system to organize what I was learning from reviewing my collected literature. Usually when I read something I can remember the gist and know which book or article to return to to refresh my memory. This is not possible when reading thirty or forty articles and studies.

Reflecting on myself as a learner, I realized I needed to manage my time wisely and break assignments down into smaller pieces. Now, I am amazed at the amount of literature I was able to read and understand. I had to slow down and reread often to understand what I was reading. Many times, I would feel overwhelmed when I first started but I was always able to manage and complete the work. The best part of the process was being forced to give myself time to read two books which I have wanted to read but never made time for: Jo Boaler's *Mathematical Mindsets* and Carol Dweck's *Mindset.* I was surprised by how challenging I found the literature review. Specifically, how many times I had to review very specific APA guidelines and how to navigate original sources. Many articles I read reviewed or discussed other literature. Therefore I tried to find the original source of the findings or ideas. While reading books I had to discern which ideas were from the author and which were paraphrasing from another piece of research. I read many articles by Jo Boaler and was impressed by her ability to succinctly summarize an entire research study. I believe this is a skill learned through much practice and from reading models in many articles.

While researching comment feedback and its connection to mindset and learning and the creation of a professional development workshop I have grown as a researcher, writer, and as a learner. This process also encouraged me to make time to fully read books by authors who have influenced my philosophy of learning. The next section will detail how these and other researchers have contributed to my understanding and the creation of my project.

Connections to the Literature Review

The work of Jo Boaler on math learning and mindset and the work of Carol Dweck on growth mindset had a large impact on my capstone. I was familiar with their work from other teachers, past professional development, podcasts about math learning, and from my previous reading of *What's math got to do with it?* (2015) by Jo Boaler. Dweck's work on mindset plays a large role in Boaler's books. This was the first time I read Dweck's *Mindset: The new psychology of success* (2016). My understanding of mindset was deepened and I wanted my workshop participants to learn some of the same ideas. I was able to find videos about the negative impact of praise on mindset and learning. Boaler was the author or co-author of four different books and studies that influenced my work. She cited many articles and studies that I also found useful in my research.

The first two sessions of the professional development workshop I created provide the rationale for using comment feedback in order to build buy in from teachers for making a change in how they handle assessments. An important idea was the

difference between summative and formative assessments. Various researchers discuss formative and summative assessment but Black and Wiliam (1998) and Boaler, Dance, and Woodbury (2018) were important sources for the development of that section of my literature review. Both suggest that grades can harm motivation and outline a way of using assessment for learning instead of after learning. During the workshop teachers will practice giving feedback using ideas from these researchers and others about telling students where they are at in relation to the learning goal, what the learning goal looks like, and how to meet the goal or work towards meeting the goal.

The main teacher practice that is developed during the workshop is comment only marking. Butler (1987) provided the foundational research that using comments only instead of grades or in combination with grades can increase motivation and performance. Boaler, Dance, and Woodbury (2018) provided many of the exemplars of comments teachers could give on feedback.

While creating the activities for the adult participants of my workshop I kept in mind the suggestions of Darling-Hammond, Hyler, and Garnder (2017) for teachers to be active participants, collaborate, learn over time, and to practice the skill or activity they plan to use with students. Teachers will develop a bank of comment together and participant in peer coaching. Knowles contention that adult learners can share their expertise with fellow participants and express what they want to learn helped me design the building background portion of my workshop. Teachers have opportunities to share

what they already know and to choose the format, video or written article, from which they would like to learn more.

This section has reviewed which researchers were most influential to this project and how their ideas contributed to the project's completion. The next section will suggest potential policy implications from findings in the literature review.

Policy Implications

My review of the literature suggests that grades can be harmful to the mindset and learning of math students. This could lead to changes in the way grades are decided and shared with families and students. My school recommends teachers use standards based grading, a one to four points scale including: exceeding the goal, meeting the goal, partially meeting the goal, and not meeting the goal yet. We are also expected to update grades often. However, this does not give students specific information about how to reach the goal. A policy could be that each student should receive specific feedback on their learning at least once every two or three weeks. Summative grades could be given only at the quarter, semester, or end of year. An even better policy would be to avoid a single summative grade. Grades could also be co-created through conferencing with students while they reflect on their work and learning. Formative assessment feedback is important for student learning. It could be required that formatives to be part of curriculum and lesson plan design either by teachers or district personnel. Teachers could be supported and expected to use them or incorporate them into their professional develop plan or professional learning community.

Changes to grades and feedback policies could be made to improve mindset and learning in mathematics. While this project has lead to these conclusions, it also has some limitations. Limitations and ideas for future research to address these limitations will be discussed in the next section.

Limitations and Recommendations for Future Research

This project was originally designed for my school, however, without gaining consent from the Hamline Institutional Review Board and likely participants I was unable to tailor the adult learning presentation to our specific school. So, the project has been designed to be adapted to an individual school or set of participants, however, it's hard to provide for individual needs when creating something generic. I was also unable to test the efficacy of the training to see if it would really take change teacher practice since I was not able to facilitate the professional development with actual teachers and therefore could not collect data on teacher learning. Teacher feedback and assessments are not the only criteria that impact student learning and mindset. Mathematical mindsets are affected by the language teachers use everyday and by the questions students are asked to solve; these topics are outside the scope of this project. The many other aspects of formative assessment such as self reflection, writing the actual assessments, and peer reflection are also outside the scope of this project.

Formative assessment also known as assessment for learning has more components than just comment feedback from teachers, including student self reflection. A next step research project could be about student self-reflection. The action research

could be focused on teaching students to help figure out where they are and where they need to be. This would work in tandem with the support from teachers giving them suggestions about how to get there. Another possible area of future study would be around summative assessments. A researcher could investigate the goals of summative assessments, how and when to use them, how to grade them, and how to share results in ways that increase student learning and still support positive mathematical mindsets.

This project is a beginning step for change in my classroom and potentially in my school. Reviewing the literature around mindset and math learning suggests that comment feedback is one small part of changing the way students are assessed. While this project was limited to creation and was not taken to the implementation level, the suggestions for changing teacher are still important and could be useful to me and other educators and education leaders. Examples of possible benefits and how they could be shared will be described in the next section.

Communication of Results and Benefits to the Profession

The results of my project will be shared with various colleagues in my school and I will also be using the results of my literature review in my own classroom. I will be sharing my professional development presentations and supporting materials with the instructional leaders at my school in the hopes that we will be able to use this project in a future PLC. I will be sharing my learning with teachers in my building through team meetings, PLC discussions, and informal conversations about math learning. For example, reminding colleagues that there is no such thing as a math person and sharing

examples of written feedback. With my own students I will be using what I learned about feedback and formative assessments when assessing students and during planning time with my co-teachers. Specifically, I will give feedback that tells my students where they are at, where they are going, or what steps to take toward meeting the learning goal. I will also be refraining from sharing summative grades with students until the end of the quarter and using comments for feedback instead.

This project could benefit teachers and instructional leaders. New teachers and teachers continuing their education can access this project and bring the ideas to their self directed PLC if they want to learn more about feedback and mindset in mathematics. I have used ideas in my classroom and looked at research cited in projects on Digital Commons after reading other students' work during the capstone process. Instructional leaders can access the project and provide professional development for math teachers. Overall, math PD that bring practices to classrooms that support a positive math mindset may encourage more students to study mathematics education and lead to more math teachers in the future.

Summary

This chapter had described my learnings and next steps from investigating the question: *How does the feedback given by math teachers on formative assessments impact the learning and mindset of female students in math?* I have grown as a researcher, a writer, and a learner. Dweck, Boaler, and other math and mindset researchers provided the foundation for the professional development I created. While there are limits to the project, they provide possible next steps and future research ideas.

This work can be shared with math and non math teachers and instructional leaders or use to support policy changes around grading.

The capstone process has taught me a lot about research, writing, grading, mindset, and mathematics learning. My district provides opportunities for teachers to complete action research in our classrooms. I look forward to using many of my learnings from this process in my next action research project.

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