Hamline University

DigitalCommons@Hamline

School of Education Student Capstone Theses and Dissertations

School of Education

Spring 2017

The Impact Of Math Talks On Student Achievement In Kindergarten

Emily Payan
Hamline University

Follow this and additional works at: https://digitalcommons.hamline.edu/hse_all

Part of the Education Commons

THE IMPACT OF MATH TALKS ON STUDENT ACHIEVEMENT IN

KINDERGARTEN

by

Emily A. Payán

A capstone submitted in partial fulfillment of the requirements for the degree of Master

of Arts in Teaching. Hamline University Saint Paul, Minnesota

May 2017

Primary Advisor: James Brickwedde, Ph.D.

Secondary Advisor: Margaret Williams

Peer Reviewer: Elisabeth Carlson Williams

To my family for your support and encouragement. I would not have been able to begin this journey without you.

"…real mathematics is a subject full of uncertainty; it is about explorations, conjectures, and interpretations, not definitive answers."

-Jo Boaler

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF FIGURES

CHAPTER ONE

Introduction

In this introductory chapter, I will discuss my mathematical background that has led me to the topic and question I will research. I will also provide a rationale as to why it is professionally and personally relevant to me. The question I will research is, *How do daily math talks impact student achievement in kindergarten?*

Personal History

I have always had an interest in helping people who have disadvantages. A few years ago, I decided to turn this drive into a career as a teacher in a high poverty elementary school. I began my first year of teaching in a second grade classroom in 2015. In the 2016-17 school year, I taught kindergarten.

While I did not always struggle with mathematics, the formulas and algorithms made no sense to me and I oftentimes did not have an understanding of what I was doing. This lack of understanding seems to be prevalent in schools across the United States and

has become an epidemic (Kamii & Dominick, 1998). I have never truly understood math and, through many conversations with both children and adults, I have found I am certainly not the only one.

I was not able to build a foundational knowledge of mathematics in elementary school. Classes advanced to more challenging material, but because I lacked a basic understanding, my teachers were throwing algorithms into the math black hole that I had become. In elementary school math, I remember having a lot of timed tests. I was given a few minutes to successfully answer a paper filled with equations. The goal was memorization, not understanding. Until age 25, the standard algorithm was the only strategy I knew to use for addition and subtraction. The only multiplication facts I would have been able to recite were the ones I was able to memorize for the tests in elementary school.

I recognized that I did not quite understand the procedures in long division and the lattice method for multiplication. I was taught algorithms and the focus was always on getting the answer, not developing an understanding of the process and number relationships. When I asked questions about the processes, the response I received from my teacher was her repeating the steps to me. When I confessed that I still didn't understand, she repeated the same response, with a different tone and volume. From similar experiences throughout my younger years in education, I received the same message from all of my teachers: 'Math is a set of rules and procedures. One does not need to understand why or how something works, the key to success is to remember how

to get the answer. Tips, tricks, and memorization are all components of the path to success.'

As a child, I used to go home crying, feeling like a failure. Although I usually received good grades and was even pulled for a gifted math program, I didn't understand why I was selected for the program. It became my secret that I didn't understand most anything in math and I began to hate it. Math was the subject that made me feel stupid. I began to believe that I just wasn't born with the 'math gene.'

My dad always seemed like a math genius. My sister and I could ask him any question we could think of and within seconds, he'd have the answer. He not only knew strategies to solve problems, he actually understood them. By the time I began asking for his help, it was too late. If I did not understand him the first time he explained it, I shut down and felt even more inferior. Yet, somehow I managed to get through the more advanced math classes in high school without my teachers realizing there was a problem.

My mom is the lead for the elementary math department in the same school district in which I am employed. She pursued her Master of Arts Degree in Mathematics Education in the 1990's because she saw everyone else around her looking into reading. She became driven to help students gain achievement in math and has since become passionate about making it attainable for all students. One would probably think that having someone like her would be wonderful for a student like me, but I rejected her help because it did not involve the same algorithms my teachers used. My mom tried to intervene and help me gain an insight into the processes I was supposed to learn, but I had already labeled myself as hopeless and defective. I did not want to face more failures

by still not understanding concepts from yet another person. Math had rejected me so I began to reject it and gave up all effort so I would not be exposed for the failure that I felt I was.

Because my mom did not solve problems the same way my teachers showed me in school, her strategies were somehow wrong in my eyes. This has taught me to never underestimate the power of a teacher. There has to be a different way to teach math, a way that supports understanding. With all of the interest in math talks in my school district, I hope to discover whether or not they could be a more effective key to student mathematical success. As teachers, we have a powerful role and duty to protect our students from falling into the trap of following procedures. We need to ensure that our students are learning for understanding, not for just to find the right answer.

In my math class at Hamline University, my professor introduced me to the research of Boaler, a Stanford professor and math researcher. Much of Boaler's research (2015) is based on that of Dweck (2006) and the growth mindset, looking at how students' mindsets affect their progress and success. A growth mindset is a mentality that one can develop skills by working hard and learning from mistakes. On the other hand, the fixed mindset is the mentality that people are inherently either "good or bad" at certain school subject or activities due to circumstances outside of their control.

My Hamline professor implemented math talks in every session of my math class, two years ago. It was through these math talks that I began to see how math really is beautiful. There are multiple ways to solve any given problem, while I previously believed there was only one that was correct. Through hearing the ideas of my

classmates, I began to understand the problems we were solving and why their strategies worked. In addition, by having to verbalize my own thinking, I was able to solidify my understanding and catch holes in my logic.

In the spring of 2015, I completed my student teaching in a kindergarten classroom in a high poverty school. Math was taught in a similar way I was taught as a child. The teacher stood in the front of the room and told the students how to successfully solve problems. There were not any conversations about student thinking or understanding. To be successful meant using the same procedures the teacher did and getting the correct answer. While some students did well on their assessments, many did not.

Misconceptions were never explored and addressed. I wonder whether these students would perform differently if they had been given regular opportunities to explore their thinking and that of their classmates. Would it help them gain a better understanding of the math they were doing if they had opportunities to talk about it with one another? I hope to find the answer in my research.

I am certainly not suggesting that American teachers are intentionally harming our students. I believe many teachers, like the ones I had throughout my years in the education system, simply do not know any better. They teach the way they were taught, which, unfortunately perpetuates the system that has failed many students like me. At some point, however, we need to take a hard look at how we are teaching and examine the correlation between what we do and students success rates, or lack thereof.

I do not want my students to fall short of success in mathematics and develop a fixed mindset like I did. Many students I have worked with seem to have a fixed mindset, believing one is either good at math or not. The idea that one can work to be successful in math used to seem impossible and out of reach. I became a teacher to change this misconception. My desire is to find a way to stop the cycle of low achievement in math and to guide students to success.

Professional Connection. While I cannot change my past experiences with math, I can make sure that my students do not have a mirrored experience. I believe my failures have helped me relate to students who are struggling and feel the same way that I once did. I am interested in discovering how implementing daily math talks will affect the learning of kindergarten students. If it turns out that math talks, implemented regularly, help students to reach higher achievement, I will have something solid to reference in conversations with my colleagues. We can change the way math is taught in classrooms throughout the district, thus providing students the mathematical foundation they will need throughout their lives. This could change the future of the country, by opening careers for children they would have never thought possible had they gone through the experiences that I did.

I have worked at the same Title I school for three years. The first two years, I worked as a supplemental paraprofessional; providing math and reading interventions for struggling students in grades K-5. I have taught for one year as a classroom teacher in second grade. While conducting my research, I will be in my second year of teaching in a kindergarten classroom. I am interested in discovering whether or not the mathematical

success I experienced as a graduate student through math talks will have the same effect on the 5-6 year olds in my kindergarten class.

I will initiate my research by using an assessment, Kindergarten Concepts of Math, created by the Math Recovery Intervention Specialists in the Anoka-Hennepin School District. This assessment will be used to provide baseline data to identify students who are similar in specific strands of math. The Kindergarten Concepts of Math Assessment address MN State Benchmarks related to number sense: rote counting forward and backward, numeral identification, one more/less, ordering numbers, rational counting, cardinal principal, addition, subtraction and composing/decomposing numbers up to 10. The assessment identifies progressive targets for each task, starting with the beginning of the year and at the end of each trimester.

Capstone Overview

As a second grade teacher, I noticed that my students' ability to compose and decompose numbers had a direct connection to their ability to utilize mental math strategies. During my research, I will conduct daily math talks with my class on a variety of math subtopics, such as addition and subtraction to help students develop mental math strategies. My control group will be the students in a colleague's class in the same school (Appendix B). At the end of a six week period, I will give the same Concepts of Math assessment to each child in both groups to track any progress and note any differences. In addition, I will conduct student interviews in both classes throughout the study and document observations on students in the experimental group at the end of each week.

There are many who have come before me, interested in finding a way to change the all too common math experience that children like me have encountered in their education. There is a lot of research happening presently on the effects of math talks and classroom environment on student achievement in mathematics. I will discuss what researchers are saying about this math talks and student mathematical achievement in Chapter Two.

Throughout this discourse, I will reference both math talks and number talks. They both represent the same concept and are based on the same logic. Both types of discussions explore student thinking and foster an environment in which students build upon student understanding to develop more sophisticated thinking (Parrish 2010). Number talks focus solely on math that involves number sense, such as composing and decomposing numbers and algebraic thinking, while math talks also include geometry and spatial reasoning.

In Chapter Three, I will review the methods used in conducting my research. Chapter Four will discuss the findings of the study. In Chapter Five, I will summarize the study and conclude my reflections. It can seem overwhelming to reinvent how we are teaching mathematics in the United States, though many teacher researchers have already began paving a way. This capstone is the result of my quest to find the answer to, *"How do daily math talks impact student achievement in kindergarten?"*

CHAPTER TWO

Literature Review

How do daily math talks impact student achievement in kindergarten? The first

section of this chapter discusses mathematical proficiency, number sense, and equity in

mathematics within American schools. The second section focuses on classroom

environment and math talks. The final section of this chapter discusses the role of the

classroom teacher and how to cultivate an equitable classroom community in which

students are successful in mathematics.

Mathematical Proficiency

Proficiency is important in all stages of learning, yet in mathematics, it is

conceptually expansive (National Research Council, 2001). The National Research

Council adds that, while proficiency should be present in every stage, it is dependent

upon the type of instruction students receive in the classroom. They go on to say that

teachers must ask how each lesson will help students develop and integrate the strands of proficiency. They also suggest that teachers answer two questions while planning, "How does the lesson relate to previous learning and lay foundation for future learning? What materials and activities will help achieve these goals?" (National Research Council, 2001. p. 25).

Strands of Proficiency. According to the National Research Council (2001), there are five strands of mathematical proficiency with which our students are measured. The first is understanding, defined as comprehending concepts, operations, and relations. The second is computing, or being able to carry out procedures flexibly, accurately, efficiently, and appropriately. The third is applying, the ability to devise strategies. The fourth is reasoning, explaining and justifying logically. The fifth and final strand is engaging, the understanding that math is sensible, useful, and doable if one works at it. They add that a better fluency in one strand will help to better the others, they are all interrelated and support one another. All of these strands are developed and nurtured in a classroom that implements a culture of math talks (National Research Council, 2001).

Research has revealed that classrooms seem to support learning more if they have an environment that cultivates a community of learners, rather than students who are isolated as individuals (Boaler, 2015.; National Research Council, 2001). Proficiency is much more likely to occur in these classrooms (National Council of Research, 2001). Adding discussions and implementing questioning strategies to daily math lessons build on strategies and result in greater clarity and accuracy in student thinking (National Council of Research, 2001).

Kindergarten Standards. According to Minnesota Academic Standards in Mathematics (2003), by the end of kindergarten, students are expected to be able to compose and decompose numbers up to 10, using objects and pictures. They are also expected to solve addition and subtraction problems using objects and pictures (Minnesota Department of Education, 2007). In order for students to be able to perform these types of tasks, they need to have an understanding of numbers that goes beyond rote counting (Williams, 2016).

Speed and Memorization. Mathematical fluency is also associated with proficiency. Historically, fact fluency has been 'developed' by a focus on rote memorization, drilling with flashcards, and timed tests (Kling, 2011). Educators have believed that speed has been an indicator of mathematical proficiency and fluency. Research shows that this approach is failing the majority of American students (Kamii & Dominick, 1998). A shift in instructional focus is needed to guide students in developing efficient and effective ways to use known facts to derive unknown facts as well as evolving and utilizing efficient strategies (Kling, 2011). An example Kling (2011) offers is a typically difficult problem for first graders, 7+5. One way this can be thought of is 5+5 and add 2 more, as 5+5 is often a known fact that can be used to derive unknown facts with fluency (Kling, 2011). This prevents students from simply forgetting a fact and reverting to a count-by-ones strategy and gives them an effective strategy to derive unknown facts.

Kling (2011) adds that a common misconception is that speed and memorization are not important in mathematical proficiency, memorizing some basic facts is essential

in being able to derive other facts efficiently without the need for counting by ones. On the other hand, speed and memorization alone have no indication of the child having a true understanding of mathematics (Kling, 2011). A child who has developed a deep mathematical understanding may struggle with fact recall, especially in stressful situations like timed tests. Mokros, Russell, and Economopoulos (1995) warn that we should not confuse quick memorization of facts with authentic skill in mathematics. What truly matters in mathematical fluency is efficient and effective strategies (Boaler, 2015.; Mokros, Russell, & Economopoulos, 1995.; National Research Council, 2001.; Williams, 2016).

Basic Facts. Mathematically proficient students have cultivated an ability to use effective math strategies, decomposing and recomposing numbers (Kling, 2011). Students are only able to do this if they have had rich experiences that constructed more advanced understanding than their counterparts who were in environments that focused on drilling basic facts (Kling, 2011). To develop fluency in a classroom, there must be an emphasis on developing and applying strategies (Kling, 2011). For instance, rather than using flashcards to 'drill and kill', students could sort the cards into piles of known and unknown facts and write a clue under each unknown fact to remind them how they could derive the unknown (Kling, 2011). An example of this would be, if a student knows that 6+6=12, but doesn't automatically know 6+7, they might write '6+6' as a clue to remind them to use what they know. This allows students to develop the skill of recognizing a starting point rather than resorting to other lower level thinking strategies, such as

counting fingers. Kling (2011) states that students can derive most any difficult fact if they have mastered the combinations that make ten and doubles.

Teachers can begin to help students learn these important facts early by using five frames, ten frames, and dots patterns to have students subitize (Kling, 2011). Subitizing is instant recognition of a quantity without counting (Kling, 2011). Clements (1999) says that even infants can subitize. There are two types of subitizing: perceptual and conceptual. We think of perceptual subitizing as just knowing a quantity without using any strategy or subsets. An example of this would be the configuration of dots on a deck of cards or the pips on a die. Our experience with these materials has made those patterns familiar. So familiar, in fact, we see them and we immediately know their value. Conceptual subitizing is where one utilizes subgroups to determine the total, such as, "I know there are 7 because there are 4 here and 3 over there. 4 and 3 make 7." Students can begin to learn conceptual subitizing in first grade (Clements 1999). This skill is not only important for mathematical fluency, but also composing, decomposing, and developing the ability to count on (Clements, 1999).

Students should also reflect on the use of physical objects such as blocks, beans, and sticks to deepen their understanding of mathematics (National Research Council, 2001). "Physical materials should not simply be used as tools to calculate answers. Students need to be able to move from using physical objects to finding solutions numerically. Teachers must provide opportunities for students to make explicit connections between activities with the objects and the math concepts and procedures that the objects are intended to help teach" (National Research Council, 2001, p. 29).

Standard Algorithms. Kamii & Dominick (1998) gave several classes of elementary students a problem that required mathematical reasoning, 7+52+186. Students who were in classes in which they were taught the standard algorithm were less likely to have the correct answer than their counterparts who had learned different strategies. In fact, they add that students who were in classes that learned the standard algorithm were much less likely to have a reasonable answer, ranging from 29-838 (Kamii & Dominick, 1998). By the time students were in fourth grade, many of them gave up and did not work the problem.

Another phenomenon discovered was that many students in classes who learned the standard algorithm, when referring to a three digit number, they said it as three separate single digit numbers. For example, 1, 3, 2 instead of 132. Kamii & Dominick (1998) say that algorithms "encourage children to give up their own thinking and unteach what children know about place value, thereby preventing them from developing number sense" (p. 4). While some students may be able to use teacher taught algorithms to successfully get the correct answer, there is often little understanding of the mathematics involved and students seem to lose their sense of place value (Kamii & Dominick, 1998).

Number Sense. Number sense is the most important foundation for mathematical success (Boaler, 2015). Boaler (2015) says the best way to develop number sense in students is through math talks and that one cannot be successful in higher levels of math without it. Rote memorization of algorithms and facts that are often pushed in traditional classrooms actually work against number sense according to Boaler (2015).

Summary. The traditional math classroom sets importance on the teacher presenting procedures and algorithms for students to use successfully to produce the correct answer. This setting values speed and memorization, however this is not an effective system for our students (Kamii & Dominick, 1998; Boaler, 2015). Students who are educated in a traditional classroom are more likely to have inefficient strategies and lower level thinking (Kamii & Dominick, 1998). In order to help our students develop mathematical proficiency and number sense, students should interact with manipulatives and engage in conversation with one another (Boaler, 2015; National Research Council, 2001).

Equity

According to Hiebert, Carpenter, Fennema, Fuson, Wearne, Murray, Olivier, and Piet (1997), though not always perceived as such, every child is capable of learning mathematics with understanding. Each student who enters our classroom, no matter the achievement level or background, has something to share and add to the conversations that take place within our four walls. All students should be engaged in challenging tasks, reflect on the thinking they have done, and share their thinking with their classmates (Hiebert, et al., 1997).

Access to the Problem. Each individual plays a vital role in a math class (Hiebert, et al., 1997). In order for a math class to be successful, all students must participate. Every child has important thoughts to share that will contribute to the group's learning. There need to be appropriate tasks for all learners to be engaged at their level, giving

them the opportunity to contribute to conversations. All students should be expected to be able to learn to communicate effectively about math (Hiebert, et al., 1997).

In order to maintain equity in our classrooms, the context of problems should be accessible to all students (Hiebert, et al., 1997). For example, if there are only a few athletes in the class, it would not be appropriate to pose sports questions laden with jargon that the majority of the class will not understand. Students need to be able to visualize the problem they are solving, thus word problems should be based off of shared experiences and commonalities (Hiebert, et al., 1997). Teachers should also encourage students to provide alternative strategies and multiple representations to foster understanding for diverse learning styles (Leinwand, 2000). This pushes all students to reach mathematical success.

Gifted and Talented Programs. It is no secret that the American school system has had a history of unequal opportunities and resources depending on student demographics. To this day, the majority of students in gifted and talented programs in the United States are of European descent and come from affluent families (Chapin, O'Connor, and Anderson, 2009). In fact, the districts who serve primarily non-White and low income students often do not even offer gifted and talented programs (Chapin et al., 2009).

In a school district with 85% of students who qualify for free and reduced lunch and 75% of students speak a language other than English at home, only 4% of students had test scores that indicated a high probability of giftedness in mathematics, 23% scored as above average, and 73% were considered average or below average (Chapin et al., 2009). After implementing a program that incorporated math talks into daily math

lessons, the percentage of students who would qualify for a gifted and talented program jumped to 41%, 36% were above average, 23% scored as average, and there were not any students who scored as below average. After three years of daily math talks, 90% of sixth graders scored higher in mathematics than the affluent students in neighboring school districts.

Summary. There is a large imbalance in the services provided to affluent schools and districts and those that are offered in schools and districts that primarily serve children who come from poverty (Chapin et al., 2009). Teachers can either perpetuate this disservice by posing questions in a context not accessible to all students or work to break inequities by ensuring all students have access to the problems. By incorporating math talks in the school day, students, regardless of their socioeconomic status, perform better (Chapin, 2009; Boaler 2015).

Classroom Environment

The notion that students 'build mathematics together' through conversation is central in the practice of math talks (Hiebert, et al., 1997). After all, children who are able to construct their own knowledge outperform those who cannot (Kamii & Rummelsburg, 2008). Just as collaboration is important in professional fields, it is invaluable in a math class. It is the teacher's responsibility to create a safe environment in which all students are valued and heard. Every student should be viewed and view themselves as an important member of the community.

If students solely appeal to the authority of a teacher, they avoid mathematical justification, an integral part of understanding (Carpenter et al., 2003). According to

Hiebert, et al. (1997), students need opportunities to solve problems together and share their thinking. In fact, student logic develops when they are encouraged to think hard and debate to convince one another (Kamii, 2006).

In order for this to happen, the entire class needs to accept the norms of social interaction, thus developing a safe environment in which all feel comfortable in contributing. According to Chapin, et al. (2009), the first step to create this safe environment is to create a firm set of expectations. They say these rules must include: 1. Every student listens to others, 2. Everyone can hear what the speaker is saying, and 3. Every student participates by sharing their thoughts at some point. Students must know that everyone must be treated with respect, with no exceptions, and that their must be consistent consequences for any infractions (Chapin, et al., 2009). Even one small violation can disrupt the environment can hinder children from sharing (Chapin, et al., 2009).

Summary. The environment a teacher develops plays an important role in the success, or lack thereof, of the students in the class (Carpenter et al., 2003; Chapin, et al., 2009). Students need to have a set of standards to abide by in order to create a safe space for students to share and explore their thinking and that of their classmates (Chapin, 2009). Once this environment has been developed, students are able to deepen their mathematical understanding by sharing and justifying their thinking and challenging one another (Hiebert, et al., 1997; Carpenter et al., 2003; Kamii, 2006).

Math Talks

According to Boaler (2015), math talks should be implemented at the beginning of each math class. Boaler (2015) adds that they do not need to be long, only around 15 minutes, everyday. It is a time when the teacher presents a question or problem for students to work on, it should be crafted or selected with a goal in mind. The goal can be anything from reviewing a prior lesson or introducing a new concept (Boaler, 2015). Students are given time to solve the problem, either individually, with a partner, or a group, and then students share their strategies with the class. The discussion of the problems should be led by the students (Humphreys & Parker, 2015).

There are many benefits to implementing math talks in a classroom that go beyond the obvious (Boaler, 2015; Humphreys & Parker, 2015). While learning that there are various strategies to solve a problem is powerful, according to Humphreys & Parker (2015), there is much more that students learn from math talks. They learn to work flexibly with numbers and mathematical principles, gain confidence, and create a solid foundation for higher levels of mathematics (Humphreys & Parker, 2015).

The Importance of Mistakes. Mistakes play an invaluable role in developing problem solving skills, although the way adults respond to children when they make these mistakes plays a role in whether or not children will have the opportunity to grow from them (Wells & Coffey, 2005). If educators can shift their focus from getting the right answer and view an incorrect answer as correct, depending on how the child interpreted the question, our attention moves to the child's mathematical thinking. This will deepen students' mathematical understanding and boost their confidence as capable problem solvers (Wells & Coffey, 2005). This mental shift also encourages students to view

answers as more than just right or wrong (Wells & Coffey, 2005). It gives the class the opportunity to recognize and value the variety in students' reasoning (Wells & Coffey, 2005).

Schifter (2007) suggests that we teach math as an investigation for children to explore, rather than the traditional math subject that places high value on facts and procedures to get to the right answer. When an incorrect answer arises, the class should investigate not only what worked, but what went wrong (Schifter, 2007). This gives students the opportunity to expose and explore their misconceptions and develop a deeper understanding for the mathematics involved than they would gain if they had been given a set of procedures to copy (Schifter, 2007).

Schifter (2007) describes teachers' reactions to a classroom in which the teacher asked a child to share an unsuccessful strategy with the class and assigns homework for the class to examine his strategy and revise it. Many teachers were shocked and disappointed that the student would be embarrassed by being called out and that the teacher punished the rest of the class by assigning homework for one student's mistake (Schifter, 2007). Though she says this is exactly how successful mathematicians are developed, by finding and exploring mistakes (Schifter, 2007). If the teacher views mistakes as opportunities, the class is more likely to adopt this opinion and look for ways to grow.

Growth Mindset. Students who have a growth mindset are able to view mistakes as opportunities to learn and explore in order to gain new knowledge (Dweck, 2006). Students with a fixed mindset try to avoid mistakes at all cost and attempt to cover them

up when they arise (Dweck, 2006). We want students to adopt a growth mindset because mistakes are necessary for learning (Humphreys & Parker, 2015). Conceptual errors are at the root of many mistakes, if they do not present themselves in a conversation, students do not have the opportunity to shift their misconceptions (Humphreys & Parker, 2015).

Science has proved that mistakes, and the process of reflecting on them, are actually good for us. Making and examining mistakes can actually physically change the brain. When an individual examines a mistake, synapses in the brain fire (Dweck, 2006). The firing synapses cause neurons to grow and make stronger pathways in the brain. As this process occurs, the brain grows as a result (Dweck, 2006). Mathematical discourse is central in math talks (Shumway, 2011). Shumway (2011) says we need to focus on developing four skills with our students: how to explain their thinking, be active listeners, have a conversation, and be supportive of their classmates. A large piece of this is teaching students how to have academic conversation. It is suggested that teachers ask students to use 'think time' and patience, disagree politely, and to stay on topic. Shumway (2011) has developed a list of scaffolds to be used during math talks to help students develop the four skills.

How to explain your thinking:

- What did you look at first?

- What number did your brain think of next?

- How did you know what to do after that?

How to be an active listener:

- Will you repeat that?

- I understand _____, but I don't understand _____.

- Where do you see the _____?

- Do you mean _____?

How to have a conversation:

- Let one person talk at a time while the rest listen.

- Face the speaker and use eye contact.

- Ask questions.

- Nod your head when you understand.

- Hold your thoughts until the speaker is done speaking.

- Disagree politely.

- Stay on the topic.

- Ask the speaker to 'prove it' or ask him or her 'How does that work?'

- Learn from each others' ideas and mistakes.

- Make sure you talk, but also give others a chance to talk.

- Wait to raise your hand until the person speaking is done speaking.

- Use 'think time' and patience.

- Respond to the speaker with comments or questions.

"Connective Language Sentence Starters" to facilitate math talks:

- I agree with _____, because _____.

- I disagree with _____, because _____.

- I understand what you're saying, but I disagree because _____.

- I think this part is true, but I don't think _____.

- I want to add on to what _____ said. She said _____, and I think

  _____.

- This is like what _____ said: _____.

According to Hiebert, et al. (1997), the conversations to be had need to be centered around the strategies students use to solve problems. These conversations should take the focus away from the individual and onto the process. Rather than teaching strategies, it is more beneficial and effective if we allow students to construct their own strategies. This is more than simply providing opportunities to reflect on math. The importance of math talks is to develop communication and social interaction patterns (Hiebert, et al., 1997). Students are to learn from others and learn to apply their ideas to new problems, not copy their work.

Mental Math. Computing math mentally, or 'mental math', is a important piece of number talks because it encourages students to build on number relationships to solve problems instead of relying on memorized procedures (Boaler, 2015; Parish, 2010). According to Parrish (2010), one of the purposes of a number talk is for the students to focus on number relationships and use these relationships to develop efficient, flexible strategies with accuracy. Mental math pushes students to use their number sense and the relationships between numbers rather than rote memorization that requires little to no thinking about the work being done. Drilling facts and definitions is not effective in the long run for students, instead, educators should work to develop language rich environments (Moschkovich, 2010).

Small Groups. Maldonado, Turner, Dominguez, & Empson (2009) would add that small group sharing should come before whole group sharing. This gives students an opportunity to clarify and prepare to share their ideas in a more comfortable environment before sharing with the whole group. It will also help them gain confidence in the skill of articulating their thinking in an environment with rich mathematical language (Carpenter, Franke, & Levi, 2003). Students should be supported while conversing to use precise language in talking about their ideas (Carpenter et al., 2003). Maldonado et al. (2009) believe that, while, this is especially helpful for English Language Learners, all students benefit from small group and partner conversations to build confidence before sharing with the whole group.

Conjectures. Carpenter et al. (2003) suggest keeping track of student developed conjectures during math talks and even posting them on the wall. This gives students the sense of accomplishment and reinforces the idea that their ideas are valued. They add that teachers should reference these conjectures throughout the year, build upon them, and even revise them as the need arises. We cannot expect our students to truly understand a concept or strategy after only one experience (Van de Walle, 2001). They need to have multiple activities, conversations, and other experiences with the same concept to internalize it (Van de Walle, 2001).

Summary. According to Shumway (2011), student discussion is a fundamental component in their development of mathematics. When students are engaged in mathematical conversations, they are not only using, but creating knowledge (Shumway 2011). Shumway (2011) goes on to say that this occurs through two pathways. The first is

through the student's own speech. During math talks, students have the opportunity to use a thought process to verbalize their own thinking, thus clarifying their own ideas. This exchange of ideas that occurs constructs new knowledge (Shumway, 2011). The second pathway to create and use new knowledge is via listening to the ideas of others. While a

child engages with others' ideas, he is able to construct meaning, examine new ways of thinking, and extend his own understanding (Shumway, 2011).

The Role of the Classroom Teacher

Traditionally, the responsibility of the classroom teacher has been to clearly demonstrate to students to procedures they should follow. The goal was to enable students to be able to quickly and successfully follow the same procedure independently. According to Parrish (2010), "Our classrooms are filled with students and adults who think of mathematics as rules and procedures to memorize without understanding the numerical relationships that provide the foundation for these rules" (p. 4). Parrish (2010) believes this is because teaching mathematics has been viewed as a set of rules and procedures to be used quickly and with accurately, without necessarily understanding the mathematics involved. While for some people, this system has worked, Parrish (2010) says it has not been successful for the majority of the American population. Parrish's (2010) research shows that nearly two thirds of American adults are fearful of mathematics and have avoided careers that would require them to study higher math.

The Role of the Teacher. Hiebert, et al. (1997) favor a different approach for the modern classroom. They propose that the teacher's role is to facilitate discussions and

create an environment in which it is safe to do so with the belief that this will change Americans' feelings and beliefs about math. Baroody & Benson (2001) affirm that number sense cannot be directly taught, it needs to happen through everyday interactions and experiences. Children need to be allowed to explore strategies without being told how to use them if they are to truly understand what a problem is asking of them (Baek, 2006). Mathematics should be about constructing and developing sophisticated strategies, not following steps (Baek, 2006). Educators need not forget that the instruction of mathematics is a sense-making discipline (Kamii & Dominick, 1998). Kostos & Shin (2010) agree that when students are nurtured in an environment in which they are able to articulate their thinking, they reach higher academic achievement than their counterparts who are not given such opportunities.

Parrish (2010) says that math curriculum today should give students the skills needed to have accuracy, efficiency, and flexibility in the strategies they use. In order to do this, Parrish (2010) beliefs the implementation of math talks is imperative. This does not mean we suddenly need to completely change everything about the way we teach math overnight. To start this process, it can be as simple as changing the question from, "What did you get for your answer?" to, "How did you get your answer?" in order to gain insight into how students are thinking about mathematics (Parrish, 2010, p. 6). The teacher then guides student conversations by posing questions to build upon one another's understandings and make connections between strategies. One of the most important questions we can ask our students, according to Leinwand (2000), is, "How do you know?"

Teachers must determine what skills are truly essential, those that they must master in order to move to higher levels of math (Leinwand, 2000). The tasks we provide to our students must be of high quality and thoughtfully planned to elicit strategies or understandings that will help push students in their learning. We must also integrate the math concepts in the current lesson with related math concepts as well as other disciplines and ensure that they are coherent and mutually supportive (Leinwand, 2000).

Helping Students. To use Hiebert et al.'s words (1997), one of the most difficult conflicts a teacher faces is discovering how to help our students to experience and take on powerful mathematical ideas without helping so much that they abandon their own reasoning skills in order to follow the teacher's directions. It is the teacher's duty to create an environment that honors both our students as mathematical thinkers and mathematics as a discipline (Ball, 1993). When students perceive that teachers want them to solve problems using a particular strategy, they desert their own reasoning skills to appease the teacher (Hiebert et al., 1997). Kamii & Rummelsburg (2008) say that rather than suggest to students things they could do differently next time, we need leave it up to them to figure it out and reflect on their work. Students who are able to construct their own understanding and knowledge outperform those who cannot (Kamii & Rummelsburg, 2008).

In order to allow students the integrity to do this, we must be cognizant of the feedback we give them. Effective feedback must be timely and specific (Tomlinson & McTighe, 2006). Students also need to be able to understand what was said and allow for adjustment (Tomlinson & McTighe, 2006). If feedback lacks any of these factors, it is

rendered useless to its audience (Tomlinson & McTighe, 2006). An idea Tomlinson and McTighe (2006) offer is to share exemplars from other students who are at approximately the same level as our students who did or did not show proficiency in their work. This gives students an opportunity to see what their work might look like while, at the same time, see what the next steps in quality might look like if they put forth more effort and receive more support (Tomlinson & McTighe, 2006).

    <u>Math Moves.</u> Chapin et al. offer what they refer to as math moves. These are tools that the teacher uses to push students into more critical thinking and deeper conversation. Move one is revoicing. This is simply asking questions to ensure we've heard them correctly and give them an opportunity to clarify their reasoning. Move two is repeating, or having students paraphrase what their classmate said. Move three is reasoning. This is asking students to use their understanding to evaluate that of others, such as asking if they agree or disagree with someone else's reasoning.

    Adding on is the fourth math move, asking if there is something that someone would like to add on to what a classmate shared. The fifth move is waiting, this is to give students the time they need to put their thoughts together and clarify them without pressure to speak or think quickly. They believe that through these five math moves, students will have plenty of opportunities to use classroom discussions to practice their reasoning without pressure to have the correct answer. Thus, allowing students to gain power in mathematics through accuracy, precision, insight, and reliable reasoning (Chapin et al., 2014). Carpenter et al. (2003) add that we can guide student conversations

by pushing them on their big ideas with questions like, 'Do we know it will always work? How will this help you? Why is it important for us to think about this?'

      <u>Teaching Mathematical Concepts.</u> There are some socially agreed upon conventions, such as the operation signs and relational symbols, that can be taught through direct instruction because they are not open for interpretation. However, in order for students to truly learn and develop a deep understanding for mathematical concepts, educators need not correct students and tell them their answer reasoning is incorrect (Chapin et al., 2009). Rather, students should be allowed the time and space to go through a process of "processing information, applying reasoning, hearing ideas from others, and connecting new thinking to what they already know" (Chapin et al., 2009, p. 29). By being allowed to experiment, interact with an idea, and connect what they already know to what they hear from their peers, students will learn and be able to apply their new skills (Chapin et al., 2009). To support student learning, teachers should push for details through methodical follow up questions (Maldonado et al., 2009). This will help everyone learn and deepen their understanding (Chapin et al., 2009; Maldonado et al., 2009).

      It is imperative that educators use true statements and definitions during instruction and math talks (Ball et al., 2005). Ball et al. (2005) say that many teachers make false statements, such as, 'we cannot subtract a large number from a smaller one.' If statements like this are used, students are left with misconceptions and can be set up for failure (Ball et al., 2005). This concept could be brought up in a series of math talks and explored by students.

The teacher truly sets the tone for student learning and the classroom environment (Ball et al., 2005; Bay-Williams, 2010; Chapin et al., 2009; Hiebert et al., 1997). In order for students to respect and value one another, the teacher has to view each child as capable, intelligent participants (Hiebert et al., 1997). Our beliefs influence our teaching practice, our students readily interpret our beliefs and oftentimes adopt them (Bay-Williams, 2010).

Supporting Students. Maldonado et al. (2009) add that teachers should treat all students as competent problem solvers and allow them to document their thinking in whatever way makes sense to them. For some students this may be by using numbers, but for others this might be the use of words or even pictures. Sun & Zhang (2001) say that children should be exposed to these explorations and math talks early in their education as to lay a foundation so that they can "apply their knowledge of the basic facts and these strategies to other mathematical content" later in their schooling.

The National Council of Teachers of Mathematics, or NCTM (2014), says that teachers should use an approach that supports students in their ability to communicate their thinking and be able to invent and utilize their own invented strategies. They also say that students should be able to think flexibly and use a variety of efficient strategies, not a one size fits all algorithm provided by the teacher. It seems the NCTM (2001) backs Hiebert et al. (1997) in the belief that the teacher needs to foster an environment in which students are given safe opportunities to explore together. The students in the class will intuitively be able to decipher whether or not this is genuine (Hiebert et al., 1997;

National Council of Teachers of Mathematics, 2014). In order for students to respect one

another's thinking, they need to see that the teacher values it (Hiebert et al., 1997).

Teacher's Mathematical Understanding. Teachers need to have a deep

understanding of mathematical concepts and of their students' understanding and

misconceptions so that they are equipped to challenge students with appropriate tasks that

will further their learning (Hiebert et al., 1997). Ball et al. (2005) say that student success

and growth is directly related to how well their teacher knows and understands math.

They go on to say that the students who gain the most have teachers who use instructional

materials wisely, are able to assess student progress, and make "sound judgements about

presentation emphasis and sequencing." Shulman (1986) adds that effective teachers have

a strong understanding of the expectations of their curriculum and a "knowledge of

educational contexts." Teachers must be able to decipher both student understandings and

any misconceptions their students may possess. With this knowledge, teachers must set

goals for students that should be worked toward throughout the year. Instruction should

be based around these goals by being intentional about the sequence of problems posed to

students (Hiebert et al., 1997).

To be successful in selecting and sequencing tasks, it is imperative that teachers

are knowledgeable in how other children, similar in age, might solve the tasks (Hiebert et

al., 1997). This gives us an advantage to anticipate what tools students will use as well as

how they will begin and finish a task (Hiebert et al., 1997). We can purposefully

sequence tasks to push students beyond their current understanding and challenge them.

Once we know what level students are at, we know how to proceed (Battista, 2006).

Parrish (2010) would agree, stating that, "Classroom conversations and discussions around purposefully crafted computation problems are at the very core of number talks. The problems in a number talk are designed to elicit specific strategies that focus on number relationships and number theory". The Cognitively Guided Instruction project, CGI, has discovered through its research that teachers who understand how their students are likely to solve addition and subtraction problems are more likely to develop and use more of a variety of word problems and focus on the strategies their students developed to solve them (Carpenter et al., 1989).

Summary. Teachers have the great responsibility of teaching students in a manner in which we may not have experienced in our own education. We must guide students through carefully planned tasks and questions that build upon one another to move students to higher learning. In order to to this, we must possess a deep understanding of mathematics as well as a knowledge of where our students are in their mathematical understanding.

Rationale for Research

This study explores the effects of math talks on kindergarteners' mathematical success. Kindergarteners will be given a baseline assessment before participating in a series of daily math talks. Students will have opportunities to share, discuss, and justify their thinking. Current literature suggests that sharing and discussing one's thinking not only has a positive impact on student growth in mathematics, but that the ability to share and justify one's thinking with clarity is a crucial piece of mathematical proficiency (Carpenter et al., 2003).

Conclusion

American teachers have struggled to find and utilize teaching strategies that produce true mathematical understanding in all of their students. Current research suggests that the answer to this dilemma is to have high quality, intentional tasks for students to interact with and discuss with one another. Teachers can cultivate an environment that values exploration and views mistakes as opportunities to deepen mathematical understanding. The following chapter describes the research study, setting, tools, and methodology.

CHAPTER THREE

Research Methods

Introduction

How do daily math talks impact student achievement in kindergarten? Chapter

Three will provide an overview of the methods and methodology used in this research

study. In order for students to be successful in mathematics, they need opportunities to

explore tasks and discuss them with their peers (National Research Council, 2001;

Boaler, 2001; Hiebert et al. 1997; Kamii & Rummelsburg, 2008). The purpose of this

study is to examine just how much student achievement is affected by math talks in a

kindergarten setting. This chapter begins with a description of the research methodology.

The next section describes the participants and setting of the study, followed by a

description of the research tools and data analysis techniques used.

Methodology

I am conducting this study with the intent of not only discovering ways to

improve student mathematical achievement, but also to improve my professional practice.

I believe that by exploring ways to improve mathematical achievement for all students, we will provide equitable educational environments and close the achievement gap. As professionals, we should continue to strive for professional development and constantly seek ways to improve our practices. If we become stagnant, believing that we are doing well enough, our students will suffer. Mills (2007) states that throughout our practice, we are provided opportunities to reflect and improve our practice, sparking change and improved environments for our students.

Mixed Methods. In this study, I have employed a mixed methods methodology. According to Creswell (2014), this type of approach provides a deeper understanding of the research than either quantitative or qualitative can, if only one approach is used. The methods in this study include a district created assessment, the Kindergarten Concepts of Math, as well as student interviews during the assessment process. A sample of students were interviewed one on one and asked to solve a series of tasks to understand their mathematical understanding in a variety of mathematical strands. The substrands of number sense that were examined include rote counting forward and backward, the cardinal principle, addition and subtraction strategies, composing and decomposing, and one more and one less. Students were scored on whether or not they were able to successfully solve the tasks using grade level strategies.

Research Setting and Participants

Student demographics. This study took place in a kindergarten classroom in a Title I school that is located in a second ring suburb. The following statistics were reported on the Minnesota Department of Education Report Card website and pulled in

the summer of 2016 (http://rc.education.state.mn.us/). With a licensed staff to student

ratio of 12:1, the school serves 523 students. Of the student population, 60% of students

are White, 21% of students are Black, 9% are Asian, 3% are American Indian. There are

only two schools in the district with higher statistics of non-White students (VerDuin,

VanDenTop, & James, 2015). The amount of students eligible and participating in the

English as a Second Language program is just over 11% (VerDuin et al., 2015). Over

sixty-four percent of the student population receives free and reduced lunches, most of

these students (53.57%) are eligible for free lunches, and over five percent are homeless

(VerDuin et al., 2015). The participants in this study model the demographics of the

school.

Participants. There are 15 students in the experimental group, all of whom are in

my classroom for the 2016-17 school year, participating in daily math talks. There are 15

students in the control group, these students are in a different classroom in the same

school. Students in the control group are exposed to the same curriculum, without the

additional math talks.

Before I began my research, I received permission from both the school district

and Hamline University's Human Subject Committee. After permission had been

granted, I provided each family with a permission form (Appendix A). The students who

had parental consent were then grouped to ensure there was the same mix of achievement

levels in each group for the student interviews. There is one student in each group who

scored low, average, and high on the Concepts of Math Assessment. These six students

were randomly selected by rolling a die. I rolled a three, therefore each student who was

listed third in each group became a student who would be interviewed, once I sought and

received additional permission from the families (Appendix C). I have matched students

in each group as suggested by Mills (2007) in order to preserve validity, reliability, and

generalizability.

I have labelled each student who participated in the interviews with their initials

and an 'E' for experimental or a 'C' for the control group. Student OT-E scored a five on

the baseline assessment. She fell below the grade level goal for backward counting and

the composing and decomposing task. Student JC-E scored an eleven, she scored below

the grade level goal for composing and decomposing. Student AL-E scored a

twenty-four. He met or exceeded the goal for all tasks.

Student JA-C scored a six on the baseline assessment. He scored below the goal

on the composing and decomposing task. Student LY-C scored a ten. He met or exceeded

the goal for all tasks. Student PM-C scored a twenty-one. She exceeded all areas of the

assessment. None of the students in either the control group or the experimental group

attempted to use the manipulatives.

Research Tools and Data Analysis

Concepts of Math Assessment. The Kindergarten Concepts of Math Assessment

(Appendix D) is given to all kindergarten students in the district at the beginning of each

year to assess their level of mathematical understanding. This assessment is utilized with

the intention of providing the classroom teacher with insight as to what students

understand and which strands of math with which they will need additional support.

There are several tasks students are asked to complete one on one with the classroom teacher within the first week of school, taking about twenty minutes to complete.

I selected this assessment for several reasons. It is a standards based assessment that assesses student ability to carry out mathematical tasks as well as their understanding. It poses a variety of questions to test multiple strands of mathematics that students in kindergarten are expected to understand. The Concepts of Math has also been used in this district as a tool to predict student achievement in the higher levels of math. By having a snapshot of these predictions, educators are able to use this to carefully craft meaningful tasks that will support students in the furthering of their mathematical understanding and achievement (Williams, 2016).

The district's Math Specialist has said that there is an accuracy of 78% using the Kindergarten Concepts of Math results to predict Measures of Academic Progress (MAP) scores when students are in second grade (Williams, 2016). Generally, correlation coefficients of .70 or higher are considered to demonstrate reliability. Using the Cronbach's alpha as a measure of reliability, the district's Research, Evaluation, and Testing Department also found the reliability of using the Concepts of Math Assessment as a baseline to be .893 (Williams, 2016).

Williams (2016) adds that the elementary school in which this study is conducted fell below the district's average for math proficiency for second grade students in 2016, 37.3% and 54.7% respectively. In fact, with over 20 elementary schools in the district, there are only 3 schools who scored lower. This school is on the district's radar as a concern (Williams, 2016). District officials will be working with the school's

administration and intervention specialists to examine the problems and what can be done to increase student proficiency in the 2016-17 school year (Williams, 2016).

Methods. All kindergarten students were given the Kindergarten Concepts of Math Assessment as baseline data, per district directive. There were two classes participating in this study, one is my own and the other is another kindergarten classroom in the building. Three students were selected from each class by the classroom teachers using this data. We selected a struggling student, an at grade-level student, and a highly proficient student from each class for one on one interviews. I defined 'struggling students' as those who did not meet benchmark standards in two or more areas and 'highly proficient students' as those who exceeded grade level expectations in two or more areas. Students were matched by gender, ethnic background, and by levels of understanding and misconceptions in the same strands.

These six students were interviewed three times during the study, at the beginning, in the middle, and at the end as a means to monitor their progress. Each of these interviews lasted between fifteen to thirty minutes. In these interviews, students were asked to solve join-result-unknown, separate-result-unknown, and multiplication tasks. I selected the first two types of of tasks because they are challenging, yet accessible for these young learners embarking on their formal learning (Carpenter et al., 2015). I included a multiplication task because, as noted in Carpenter et al.'s research (2015), these tasks help children develop reasoning skills. These tasks also support the development of early ideas about composite units from which they will draw as they are

developing a deep understanding of our number system as a system that is based off of the multiplicative rate ten (Carpenter, 2015).

I conducted all of the interviews myself to ensure inter-rater reliability. Student responses were audio recorded and students were asked about their thinking. In addition, I maintained a working journal in order to record student progress throughout the study and collected student artifacts.

Each classroom was taught the same math curriculum. The difference was that in the experimental group, the teacher implemented math talks during math instruction. In these math talks, teachers worked with students on learning to verbalize their thinking, justify it, and respectfully disagree with others. The teacher cultivated an environment that was safe for students to share out and express their thoughts by having a firm set of expectations as outlined in Chapter Two.

All students were expected to share their ideas with the group and to stay on topic during math talks. They were also expected to listen to one another as well as respond and add on to each other in order to add to the discussion. A goal for each math talk was also to help students to learn how to make connections between their own thinking and that of others. The teachers modeled sentence starters such as:

- I agree with _____, because _____.
- I disagree with _____, because _____.
- I understand what you're saying, but I disagree because _____.
- I think this part is true, but I don't think _____.

- I want to add on to what _____ said. She said _____, and I think

    _____.

- This is like what _____ said: _____.

Data Analysis. After six weeks of consecutive math talks, the participants were

given the same assessment, Kindergarten Concepts of Math, again to determine student

mathematical growth (Appendix D). This aligns with district protocol, as the end of the

research period was at the end of the first trimester. All kindergarten students are given

this assessment at the end of each trimester. Students from both classes were then scored

to determine growth in the varying strands of mathematics. Aside from whether or not the

answer given was correct, the assessor also noted whether the student was automatic in

answering or if he/she counted.

Conclusion. This chapter introduced the research methodology and methods as

well as a description of the setting and participants of the study. It also included

descriptions of the tools and data analysis involved. This study is an exploration of the

effects of a newer framework for mathematic classrooms, one that focuses on student

exploration and contribution through conversation. The following chapter will discuss the

results of this study and the major findings.

CHAPTER FOUR

Results

Introduction

How do daily math talks impact student achievement in kindergarten? This study

began with a district assessment that is given to all kindergarteners at the beginning of the

year as well as at the end of each trimester. Throughout the study, there were daily math

talks with a teacher which were audio recorded. Vignettes can be found throughout this

chapter that show the variety of problems posed to children as well as student thinking

and engagement. There were also three randomly selected students in both the control

and experimental group that were interviewed at the beginning, middle, and end of the study. During the interviews, I recorded data on strategies used, word count, use of tools, as well as length of interviews. Students were given the same district assessment at the end of the trimester, per district protocol and this data serves as the final data in this study to show student growth.

In this chapter, I will discuss the results of this study along with the major findings. This chapter will begin with a comparison between the two classes' baseline data using district and teacher created assessments. It will then move to an overview of observations during math talks, as well as during student interviews. It will conclude with the data on oral language development and engagement in mathematics.

Baseline Data

When students come to kindergarten, the goal is for each to have a composite score of ten on the district-created Kindergarten Concepts of Math Assessment (Appendix D). An outside assessor assessed both the control and experimental groups. In the experimental group, 53% of the students met the baseline goal. Sixty-seven percent of the control group met the baseline goal, making the experimental group more emergent than their counterparts in the control group. This section provides tables that show student scores for each mathematical strand assessed in the baseline assessment.

Appendix D contains a copy of the Kindergarten Concepts of Math Assessment with the breakdown of the intermediate attainment targets for each strand. Students are labelled with initials as well as an 'E' for experimental or 'C' for control group. The first

table shows the scores of the experimental group and the following table shows the data

of the control group.

Table 1

Baseline Data: Experimental Group

Student	Baseline Composite Score	Forward Counting	One More	Numeral ID	Order	Backward Counting	One Less	Compose & Decompose	Counting a Collection	Addition	Subtraction
AA-E	23	3	3	2	3	0	3	1	3	3	2
AB-E	13	3	1	1	1	2	0	0	3	2	0
BB-E	16	3	0	3	3	3	0	2	2	0	0
JB-E	10	2	0	1	3	1	1	0	2	0	0
JC-E*	11	3	0	1	1	1	0	0	3	2	0
AE-E	4	1	0	1	1	1	0	0	0	0	0
KG-E	5	2	0	1	0	2	0	0	0	0	0
GK-E	11	3	1	1	2	2	0	1	1	0	0
AL-E*	24	2	3	2	2	2	0	4	3	3	3
NM-E	5	1	0	0	1	0	0	1	2	0	0
AO-E	1	1	0	0	0	0	0	0	0	0	0
LR-E	14	3	1	1	3	2	0	2	3	0	0
DS-E	2	1	0	1	0	0	0	0	0	0	0
OT-E*	5	1	0	0	0	0	0	0	2	2	0
ZT-E	0	0	0	0	0	0	0	0	0	0	0

*Students who were interviewed three times one-on-one during this study.

**The baseline composite score goal is 10, for more specific information on trimester targets for disaggregated tasks, see Appendix D.

Table 2

Baseline Data: Control Group

Student	Baseline Composite Score	Forward Counting	One More	Numeral ID	Order	Backward Counting	One Less	Compose & Decompose	Counting a Collection	Addition	Subtraction
NA-C	5	1	0	0	1	1	0	0	2	0	0
KB-C	10	3	0	1	0	2	0	1	3	0	0
RG-C	16	3	3	3	2	2	0	0	3	0	0
RD-C	15	1	0	1	2	2	2	2	0	3	2
AI-C	10	3	0	1	1	2	0	0	3	0	0
JA-C*	6	1	0	1	0	2	0	0	2	0	0
PM-C*	21	3	1	1	2	2	2	2	2	3	3
RM-C	2	1	0	1	0	0	0	0	0	0	0
MR-C	15	3	3	1	1	2	2	0	3	0	0
MS-C	18	3	3	3	2	3	0	1	3	0	0
KS-C	16	3	3	3	2	2	0	1	2	0	0
CV-C	7	1	0	1	0	2	2	0	1	0	0
ZW-C	1	1	0	0	0	0	0	0	0	0	0
OW-C	15	3	1	3	2	2	0	1	3	0	0
LY-C*	10	2	0	1	0	1	0	1	3	2	0

* Students who were interviewed three times one-on-one during this study.

**The baseline composite score goal is 10, for more specific information on trimester targets for disaggregated tasks, see Appendix D.

The control group started at a much higher proficiency rate than the experimental group, 67% and 53% respectively. This showed that almost half of the students in the experimental grouped lacked the foundation that kindergarteners need in order to be successful in grade level mathematics. The number of students in the experimental group who did not have these foundational skills made it clear that I would need to address the prerequisite needs before addressing grade level standards. The overall district baseline percentage of students proficient was 62% and School-Wide Title schools had a baseline

proficiency of 54%. This places the experimental group slightly below the district average and the control group higher than the district average.

The lack of strong mathematical foundations in the class meant that I would need to provide structured tools, such as Unifix cubes and rekenreks. These tools enabled the students to reason through problems and develop visualizations of quantities. This also made me aware that my own mindset toward my students' ability would be crucial and their mindset would be critical as well. If I were to see my students as incapable of success based upon their scores, they would not grow to achieve their current levels of mathematical success.

Math Talks

I began this study with what now seems like a lofty goal of developing stamina in my students to be able to have 20-30 minute math talks with them daily. What I found was that by the end of the study, I was able to keep the class engaged for 10-15 minutes, half of what I expected. There were times I genuinely wondered if math talks were as important for kindergarteners as they are for older children. While I knew from the literature review that math talks are vital for student success in mathematics, I questioned whether it would make any difference at all for 5 and 6-year-olds. It was difficult to keep these young minds engaged in learning without going off-topic and, for some, even to remain seated and physically with the rest of the class. This section provides a vignette of a student-led conversation during a math talk surrounding a multiplication problem.

Once I adjusted my goal based on student stamina, I found that after weeks of math talks, students who once spun in circles on the floor were eager to participate and

several even asked, "Can I justify my thinking?" By the end of the study, students were more willing to go back to the problem and reevaluate their thinking. For instance, Student LR was easily embarrassed and even angry when her thinking was questioned by a teacher or her peers. She would shut down and not listen to others, responding with, "I still think my answer is right!" without listening to or considering their ideas. By the end of the study, she was still skeptical of others' justifications, but thought critically about what she heard and was willing to adjust her strategies if she caught her mistakes and the new strategy made sense to her.

Manipulatives were extremely important in the study, as kindergarteners are embarking on their formal understandings of mathematics. This also provided a means to help students clarify and solidify their justifications. For example, a multiplication problem was posed to students in the vignette below. If JC-E had not had access to math tools, she would not have been able to readily show how she thought about the problem and where the mistake was made. It provided a reference point to support her in her learning.

Teacher: *There were four children at home. They each put a pair of shoes in a basket. What question might I ask about that?*

KG-E: *How many shoes are in the basket?*

Teacher: *Ok, what do we know about shoes? How many shoes does a person usually have on their feet?*

Class: *2.*

Teacher: *Let's use that to help us solve the problem. There were four kids and each kid put their pair of shoes in a basket. How many shoes are in that basket?*

(Students begin to count out unifix cubes from the 10 train they have and organize them.)

Teacher: *Mathematicians, how many more minutes do you need to solve the problem?*

Some students: *We're good to go!*

Other students: *1 minute.*

Teacher: *I'll give you a little more time to solve it, if you're done, check your work.*

As students work, I walk around and listen to students solving the problem.

JC, I heard you say you had to borrow some cubes to solve this. Why?

JC-E: *Because I made a basket, but I didn't have enough for it. I needed to borrow some from NM.*

Teacher: *How many shoes are in the basket?*

JC-E: *4, but that's not the answer because NM said no and I still need more.*

Teacher: *How many more cubes would you need to solve the problem?*

JC-E: *2, but he won't give them to me.*

(JB-E gives her 2 more.)

Teacher: *How many shoes are there?*

JC-E: *6.*

I ask if I may share her work with the class.

Teacher: *How can we check JC's work?*

Several students: *We can count the pairs! 1, 2, 3*

Teacher: *Are there enough pairs, too many, or just right?*

KG-E: *We need two more cubes.*

Several students: *Yeah! One more pair.*

JC-E: *No, I have enough.*

Teacher: *Let's think back to our problem. How many kids were there?*

JC-E: 4.

Teacher: *So how many pairs do we need?*

JC-E: *Oh, 4.* (Adds two more cubes.) *There are 8 shoes.*

Teacher: *Are you sure?* (JC-E nods yes.) *Class do you agree?* (Class puts thumbs up.)

Figure 1: JC-E's 'basket of shoes'

Students began to take over the conversation after one week of consistent, regular math talks. I provided at least one word problem daily and, depending on the length of conversation, would pose more problems. A sample from the third week of math talks is below.

Teacher: *I had 2 windows. I saw 3 stars in each window. How many stars did I see?*

LR-E: *There were 3 stars in each?*

Teacher: (nods)

GK-E: *2 and 3 make 5!*

LR-E: *No, she said there were 3 stars in each window. So there are 6, 3 and 3 makes 6.*

At this point, I saw some students on the right track and some adding 3 and 2 instead of multiplying.

Teacher: *I'm going to repeat the story, look at your board to make sure it matches the story.* (Repeated story)

BB-E: *I got 3 and these 3, because Mrs. Payán said there were 3 in each.*

JB-E: *Well I got 3 and 3 and 3.*

BB-E: *I don't think that matches.*

Teacher: *Do you want to hear it again?*

JB-E: (nods)

Teacher: (Repeats story)

JB-E: Oh! It's 3 and 3! (erases extra set of 3). That's 6.

Teacher: *Are you sure?*

JB-E: (nods) *6*

Teacher: *How do you know?*

JB-E: *Because if you count the three in this window and then the 3 in the other*

window, that makes 6. See? 1, 2, 3, 4, 5, 6!

During math talks, throughout the study, it was important not to be the source of

knowledge for the class. They needed to come to their own conclusions and reason

through one another's thinking in order to do so. By asking students simple questions

such as, "How do you know?" or, "Are you sure?" Regardless of whether or not their

answer was correct, the responsibility was put on them to justify their ideas and work

through their thinking.

Experimental Group Interviews

I randomly selected and interviewed three students from the control group and

three from the experimental group three times throughout the study. In each group, there

was one student who scored low, average, and high on the Concepts of Math Assessment.

These six students were randomly selected by rolling a die. I rolled a three, therefore each

student who was listed third in each group became a student who would be interviewed,

once I sought and received additional permission from the families (Appendix C).

Each of the six students were interviewed in the beginning, middle, and end of the

study. All three interviews included three tasks, one join-result-unknown, one

separate-result-unknown, and one multiplication task. The first two tasks were selected

because they are challenging, yet accessible for these young learners embarking on their

formal learning (Carpenter et al., 2015). A multiplication task was included because, as

noted in Carpenter et al.'s research (2015), these tasks help children develop reasoning

skills. These tasks also support the development of early ideas about composite units

from which they will draw as they are developing a deep understanding of our number system as a system that is based off of the multiplicative rate of ten (Carpenter et al, 2003).

During each interview, I recorded student strategies and word count. The intent behind collecting this data was to capture student oral language development as well as their understanding of each task and their reasoning and justification skills. I also recorded student use of manipulatives and the length of interviews in order to examine student engagement in the mathematics involved in each task.

Student OT-E, who scored 5 on the beginning of the year district assessment, seemed to pick any number in the problem and tell me that "it sounds like there were ___ (insert a number she heard in the problem)." During the second interview, she used a combination of fingers, drawing, and manipulatives to solve the tasks and was able to successfully solve the addition and subtraction tasks, but not the multiplication task, though she had a valid strategy. During the final interview, she was so intrigued by drawing out her thinking, she sometimes got distracted from the task at hand and forgot to give an answer. She was able to successfully solve each task with the exception of the multiplication task. For the final task (2*3), she began to draw the problem out on the whiteboard, stopped after drawing the first set and replied, "15, because (flashed five fingers three times.)"

In the first interview, Student JC-E, who scored 11 on the beginning of the year district assessment, answered questions very quickly, incorrectly, and was unable to provide a true explanation of how she came upon her answers. When asked how she

knew the answer, she repeatedly responded with, "I heard you say it" (even if her response was not mentioned in the problem). During the second and third interview, she was eager to use manipulatives to explore the problem. She also attempted to write the equation for each problem before the curriculum introduced the symbols. She spent a few minutes struggling to make an equation that made sense to her for the multiplication task, and hesitantly wrote '2+2-4' on the whiteboard because she was unsure of how to correctly write the expression '2x2=4'.

At the beginning of the study, Student AL-E, who scored 24 on the beginning of the year district assessment, was able to correctly solve each task, though he was not able to explain his strategies, saying that his brain 'told' him. In the second interview, he was able to use manipulatives to explain his thinking. By the last interview, he was able to use known facts, catch a mistake he made, and explain his thinking by restating the problem.

By the final interview, Student AL-E was using known facts and restated the problem to explain his thinking. He made an error in the subtraction task and caught it during his explanation, told me his "brain just got stronger" and corrected himself. Students JC-E and OT-E were correctly using manipulatives and drew out their thinking in the final interview. All students in the experimental group had valid strategies, although Student OT-E had an implementation error in one of the tasks. Two of the students asked clarifying questions throughout the final interview to ensure their understanding of the task throughout their problem solving.

Control Group Interviews

Students in the control group were in a different classroom, without math talks. The mathematical instruction these students received included the district adopted curriculum (2007). The three interviewed students met with me at the same points in time as the experimental group, the beginning, middle, and end of the study. This allowed me to keep track of student growth compared to their counterparts in the experimental group.

In the first interview, Student JA-C, who scored 6 on the beginning of the year district assessment (the goal is for students to enter with a score of 10 and 14 points by the end of the first trimester), was able to successfully solve the subtractive task using his fingers and restated the problem in his explanation. For the other two tasks, he seemed to pick a number that was in the question as his answer and, when prompted for his thinking, stated, "Cuz I know 2+2 is 2." During the final interview, he was able to solve the addition and subtraction problems using his fingers, but provided an interesting explanation for the subtractive task (5-2). He stated, "3 more. I heard she ate 2 more and then I heard 3 more." He did not seem to attempt the multiplication problem (2*3) and stated that it was one. After being prompted for his thinking, he responded with, "I heard 2 and I didn't know there was 2 but now I did know it was 2."

In the first interview, Student LY-C, who scored 10 on the beginning of the year district assessment, was unsuccessful with the addition and multiplication tasks. He attempted unsuccessfully to use his fingers for the first problem (3+2) and concluded the answer was 4. He was able to solve the subtractive task successfully but was unable to provide any insight into how he solved it other than, "I know all my numbers." For the

multiplication task, he seemed to pick a number he heard in the story problem and, after prompting, stated that he knows that "2 comes after 3."

During the final interview, Student LY-C attempted to use his fingers for the first two tasks responded with answers such as, "4, because I knew that 2+5 is 4" for the task that asked for 5-2. For the 3+2 task, he used his fingers and wrote the number ten on his board. After prompting, he told me that he knows that 5+5=10. For the final task (2*3), he wrote a three on the whiteboard and, after being prompted, said "because I heard you say 3."

In the first interview, Student PM-C, who scored 21 on the beginning of the year district assessment, was able to direct model successfully for two of the tasks and used a known fact for the subtractive task. After solving, she wrote her answer on the available whiteboard. When asked how she solved the problem, she responded with statements such as, "3 and 3 is 6." During the final interview, she performed in the same manner.

It was interesting to note that none of the students in this group attempted to use the manipulatives available. By the third interview, all students in the control group wrote their answer on the whiteboard without saying a word until I asked them how they got their answer. Their responses were overall still very short, as they were in the first interview (see Tables 3 and 4).

In the control group, none of the students correctly used manipulatives. The only student who attempted any interaction with the manipulatives was Student JA-C, who played with the manipulatives while talking. Student PM-C used known facts for her explanations, such as, "because 2+3 is 5." None of the students in the control group

caught their mistakes or asked clarifying questions during the interviews. It seems that, while JA-C was able to successfully solve portions of the final interview, LY-C regressed in his problem solving and justifications. In addition, by the time this study concluded, PM-C was being serviced in an intervention group focused on addition and subtraction strategies.

Oral Language

According to Carpenter et al., (2003), "Justification is central to mathematics and even young children cannot learn mathematics with understanding without engaging in justification" (p. 75). This section discusses the growth in oral language in students who participate in daily math talks, shows an example of students justifying their thinking during a whole group math talk. There are also two tables that show the word count and length of each interview to demonstrate student growth and the differences between the control group and experimental group.

Most of the students, with the exception of Student PM-C, began with superficial justifications such as, "my brain told me" or "I heard you say it." These types of responses are referred to as "appeals to authority" and show the lowest level of understanding (Carpenter et al., 2003). By the end of the study, all students in the experimental group were using the next level of understanding, "justification by example" (Carpenter et al., 2003). They were all able to describe and demonstrate their thoughts.

During math talks, I often included a picture, whether drawn by me or one I could show on the Promethean Board, to help ground students' understanding of the problem.

In second week of the study, I showed a picture of a beach scene. There were two children building a sand castle on the beach and three children in a grassy area flying a kite. Part of the conversation is below.

Teacher: *There were 5 kids playing at the beach, 3 left to fly a kite. How many are at the beach now?*

OT-E: (counted all of the children) *5.*

LR-E: *But 3 left, so there aren't 5 anymore.*

OT-E: *Yeah, but 3 and 2 makes 5.*

LR-E: *Yeah, there were 5, but 3 of them left, so now there are 2.*

OT-E: *No, there are 5 kids, see?* (counts the 5 total again.)

Teacher: *I think I see what you are saying. You see 2 kids playing on the beach and 3 kids flying kites, so there are 5 kids?*

OT-E: *Yes.*

Teacher: *I agree with you, 2 and 3 does make 5, but you might be answering a different question. The question I asked was: There were 5 kids at the beach and 3 left to fly kites, how many are still at the beach?* (I added the word 'still' to provide more support and to clarify that some left.)

OT-E: *2, but 3 are over here.* (pointed to the children with the kites)

LR-E: *Yeah, but we're not talking about those ones because they left.*

OT: *Oh, there are 2.*

During the first round of interviews, all took less than two and a half minutes (See Table 3 and 4). This was because none of the students, with the exception of Student

PM-C, were genuinely engaging in the mathematics involved and none wanted to explain their thinking or use tools. By the end of the study, the control group interviews did not increase in length of time, however OT-E and JC-E's interviews increased to over 8 minutes and 5 minutes respectively. Another observation was that all of the students in the experimental group used manipulatives to engage in tasks for which they did not have known facts. They were also willing to share their thinking as they solved the tasks without prompting by the interviewer, as though it came naturally to explore one's thinking while solving mathematical tasks.

Based on the data collected during the interviews, students in the experimental group had a greater increase in their ability to verbalize their thinking. There were significant increases in both the number of words used to explain their strategies, but also in the quality of explanation (See Tables 3 and 4). In the beginning interviews, all students in both groups used explanations such as, 'my brain told me', 'I heard you say it', or 'It sounded like there were __'.

It was notable that during the third round of interviews, all three of the students in the experimental group were asking clarifying questions to ensure their understanding of the task (See Table 4). None did this during the first interview. They were also more apt to use manipulatives by the second and third interview. In the final interview, students OT-E and JC-E were especially focused on the process, not the product and placed high importance on explaining their thinking, more so than they had in prior interviews. I did not have to prompt any of these students for their thinking. It appeared as though they were accustomed to sharing their thinking while solving their problem.

Table 3: Oral Language

Student	Initial interview (average words per task)	Second interview (average words per task)	Final interview (average words per task)	Increase in oral language (average words per task)
OT-E	17	83	75	+58
JA-C	14	16	22	+8
JC-E	8	32	53	+45
LY-C	6	10	8	+2
AL-E	8	23	10	+2
PM-C	7	11	10	+3

Table 4: Length of Interviews

Student	Length of first	Length of second	Length of third

	interview (mm:ss)/manipulatives used (Clarifying questions)	interview (mm:ss)/manipulatives used (Clarifying questions)	interview (mm:ss)/manipulatives used (Clarifying questions)
OT-E	01:49/none (0)	03:11/drawing (1)	08:30/drawing (1)
JA-C	01:45/none (0)	01:54 /none (0)	01:48/none (0)
JC-E	01:14/none (0)	06:07/drawing (5)	05:04/drawing (4)
LY-C	00:55/none (0)	02:05/none (0)	02:12/none (0)
AL-E	01:37/none (0)	01:52/counters (2)	01:40/fingers, known facts (1)
PM-C	01:45/fingers (0)	02:01/fingers (0)	02:02/fingers, known facts (0)

Final Assessment

At the end of the first trimester, kindergarteners across the school district are given the Kindergarten Concepts of Math again. The district goal by this time is for students to have a composite score of fourteen. In the control group, 67% met the proficiency level of 10 in the beginning of the year, by the end of the study, 80% of the met grade level proficiency level of 14. The experimental group started the year at only 53% proficient, making this a more emergent group than the control group. Yet, by the

end of the study 100% of the experimental group were considered proficient. This group

not only met, but exceeded the district goal. The students in the experimental group also

averaged 13 points growth from the baseline assessment to the end of the study, the

control group averaged 10 points growth. (See Tables 5 & 6.)

The outside assessor who assessed my class for the final results of this study

noted that the experiential group seemed better at using manipulatives appropriately,

making sense of mathematics, and rational counting than many other classes in which she

had assessed. The assessor added that the students in the experimental group were

performing similar to the schools with students with higher socioeconomic status, as if

there was no achievement gap for students of color or children from poverty. After

assessing the control group, the assessor did not have any general statements about the

group. In addition to the skills that the assessor noted, she added that a classroom in

which all students have met the district's goal (a composite score of 14) is rare, especially

in a Title I school.

Table 5

Final Data: Experimental Group

Student	Final Composite Score	Growth (Points)	Forward Counting	One More	Numeral ID	Order	Backward Counting	One Less	Compose & Decompose	Counting a Collection	Addition	Subtraction
AA-E	31	+8	3	3	3	3	3	3	4	3	3	3
AB-E	28	+15	3	2	3	3	3	3	2	3	3	3
BB-E	29	+3	3	3	3	3	3	3	2	3	3	3
JB-E	23	+3	2	2	1	2	2	2	2	3	3	3
JC-E*	25	+14	3	2	3	2	2	2	2	3	3	3
AE-E	20	+16	3	2	1	1	2	1	2	3	2	3
KG-E	22	+17	2	2	1	2	2	2	2	3	3	3
GK-E	25	+14	3	3	2	3	2	2	2	2	3	3
AL-E*	31	+7	3	3	3	3	3	3	4	3	3	3
NM-E	22	+17	2	0	2	2	2	2	3	3	3	3
AO-E	17	+16	3	0	1	1	2	0	1	3	3	3
LR-E	27	+13	3	3	3	3	3	3	1	3	3	2
DS-E	19	+17	2	1	2	1	2	1	1	3	3	3
OT-E*	15	+10	2	0	1	2	2	0	2	3	3	0
ZT-E	20	+20	2	2	1	2	2	2	1	2	3	3

**The Trimester 1 composite score goal is 14, for more specific information on trimester targets for disaggregated tasks, see Appendix D.

Table 6

Final Data: Control Group

Student	Final Composite Score	Growth (points)	Forward Counting	One More	Numeral ID	Order	Backward Counting	One Less	Compose & Decompose	Counting a Collection	Addition	Subtraction
NA-C	13	+8	1	0	1	2	2	0	3	2	2	0
KB-C	21	+11	3	3	1	3	2	1	2	3	3	0
RG-C	25	+9	3	3	3	3	3	3	2	3	2	0
RD-C	28	+13	3	3	3	3	3	2	3	3	3	2
AI-C	23	+13	3	3	3	3	3	2	1	3	2	0
JA-C*	18	+12	3	0	1	2	3	0	2	2	3	2
PM-C*	31	+10	3	3	3	3	3	3	4	3	3	3
RM-C	9	+7	1	1	1	3	2	0	1	0	0	0
MR-C	21	+6	3	1	2	3	2	2	2	3	3	0
MS-C	29	+11	3	3	3	3	3	3	3	3	3	2
KS-C	25	+9	3	3	3	3	2	3	2	3	3	0
CV-C	20	+13	3	1	1	2	2	2	2	3	2	2
CW-C	7	+6	1	0	0	1	0	0	0	2	3	0
OW-C	29	+14	3	3	3	3	2	3	3	3	3	3
LY-C*	21	+11	3	1	3	3	2	2	2	3	2	0

* = students who were interviewed three times during the study.

**The Trimester 1 composite score goal is 14, for more specific information on trimester targets for disaggregated tasks, see Appendix D.

The significant difference in the increase of composite scores, comments from from the outside assessor, oral language development, and use of manipulatives between the two groups in this study led me to look at the district's data as a whole. Anoka-Hennepin has 133 kindergarten classrooms. Nine classrooms in the district scored 100% proficiency at the end of the first trimester (a composite score of 14). Only two of those classrooms, including the experimental group in this study, were identified as coming from a Title I school and having 100% of the students meet proficiency. This information will be covered in the following chapter along with the connections between

the literature review and the conclusions from this study. The following chapter will also

include a discussion of the limitations of this study.

CHAPTER FIVE

Conclusions

Introduction

How do daily math talks impact student achievement in kindergarten? This

chapter will discuss the conclusions from this study and how they relate to the literature

review. This will be followed by a discussion of the limitations of this study along with a

plan to move forward in my practice while utilizing and sharing this information.

Increases in Scores

The most obvious conclusion in the study is that the students in the experimental

group made significant growth on the Kindergarten Concepts of Math assessment in

comparison to the control group (see Table 5 & 6). The average growth in the

experimental group was an increase of 42% in the composite scores by the end of the first

trimester, compared to a 31% increase in the control group. This shows that, while the

experimental group started this study as a more emergent group than the control group,

they surpassed the level of achievement of the control group. Student ZT-E, for example,

started with a composite score of 0 and increased to 20, exceeding the district's end of

Trimester 1's goal by six points. As a footnote to this study, district data indicates that the gains were maintained in the experimental group through the second trimester.

A classroom in which all students have met end of the trimester proficiency - a score of 14 - is not considered an expectation. Classrooms in the district that are close to having 100% are typically in schools that represent higher socioeconomic backgrounds (Williams, 2016). The students in this study were able to achieve 100% proficiency for the first trimester, yet they are in a Title I school that has a free and reduced lunch rate of over 64%, over 5% of the students are homeless, and the district has listed this school as a concern (VerDuin et al., 2015; Williams, 2016). In fact, eight students in the experimental group either met or exceeded the goal for the end of the second trimester (a score of 23) and two of these students exceeded the end of the year target (a score of 30).

Of the District's 133 kindergarten classes, 84.5% of the students were proficient on the Kindergarten Concepts of Math at the end of the first trimester (the end of this study). In the twelve Title I schools (including the school in this study), there were 81% of students who met proficiency by the end of Trimester 1, only slightly below the district average. Only nine classrooms across the district had 100% of students meet proficiency in the first trimester. Two of these classrooms, including the experimental group, were in low socioeconomic schools. In the other Title I school, the class that met proficiency started with over 94% of students already at the proficiency goal in beginning of the year baseline assessing. The data from this study supports what Chapin (2009) and Boaler (2015) articulate in their research: Regular math talks have a positive impact on student achievement, regardless of socioeconomic status.

Intentional Tasks

As suggested by the National Council of Mathematics (2001), I was intentional in my math talk planning. I thought about what I wanted students to be able to do and which tasks, numbers and materials I would need to provide to get them there. If there were misconceptions that arose based on student sharing, whether or not students seemed to agree by the end of the conversation, I created additional tasks to come back to the same topic to give students more opportunities to explore the mathematics involved in a given task (Carpenter et al., 2015; Van de Walle, 2001).

I have been in kindergarten classrooms in which the teacher focuses math instruction on one type of problem before moving on to another. In these classrooms, students are taught procedures of how to follow a set of steps to find the correct answer. This type of instruction falls into the same category as teaching standard algorithms and sets students up for the frustrations and failure mentioned by Kamii & Dominick (1998). I gave students a mix of problems each session to ensure they had to make sense of the task on their own while developing number sense (Boaler, 2015). Allowing my class to construct their own knowledge through collaborative conversations helped them to outperform the other kindergarteners, as stated by Kamii & Rummelsburg (2008).

An example of an opening for a lesson was a problem about turkey legs. I started by showing a photograph of four turkeys in a neighborhood, something that is commonplace in my school's area and something that students were able to relate to. The question was, "there were four turkeys outside of the school. How many legs were there?" Two pairs of turkey legs were visible, one pair was not, and one leg of the fourth

turkey was visible. I intentionally chose this problem, knowing that I would need to do some unpacking, because students would need to think logically about the story. The conversation is below.

> Teacher: *Let's think about what we know about turkey legs. How many legs does a turkey have?*
>
> Class: *2!*
>
> JB-E: *We should count the legs!* (goes up to count and skips the legs that were not visible.)
>
> LR-E: *We know that turkey has legs, even though we can't see them, so I counted them and got 8.* (shows how she counted.)
>
> JC-E: *I don't agree.*
>
> LR-E: *Why don't you agree with me?*
>
> JC-E: *See!* (counts the turkeys.)
>
> LR-E: *Yeah, but each turkey has 2 legs.*
>
> JC-E: *Oh! I made a mistake, I was counting the turkeys. I agree now.*
>
> LR-E: *Yeah, because 4+4 makes 8.*

Mental Math

Parrish (2010) suggests the importance of mental math in supporting students to build their understanding of number relationships and free them from the dependence of memorized procedures that is fostered in traditional classrooms. While I have personally benefited as a mathematician from mental math, it was inappropriate to expect these young mathematicians to be able to perform tasks without manipulatives, as discussed in

Carpenter et al.'s research (2015). Having manipulatives available allowed students to engage with the mathematics on a deeper level, with higher numbers than they would have been able to otherwise (Carpenter et al., 2015). One of the most intriguing parts of this study was observing how the students re-enacted the problems.

An example of this was with a multiplication story that involved pairs of shoes in a basket. Each student had a ten train of Unifix cubes to help them solve the problem. Student JC-E borrowed the extra cubes from her classmates so that she had enough to represent the shoes in the story as well as create a basket made of unifix cubes to put them in. Manipulatives were especially important to give students something concrete to develop a mathematical foundation on which they will build more conceptual understandings in higher levels of math (Boaler, 2015; National Research Council, 2001). Having developed a solid foundation in the kindergarten, it is my belief they will be able to develop flexible mental math strategies in the coming years.

Deeper Understanding of Mathematics

Developing an environment in which students were expected to share their thinking and listen to that of others deepened their mathematical understandings, as shown through Carpenter et al.'s research (2003). All but one student, PM-C, began the year using "appeal to authority" as a means to justify their answer. Only the interviewed students in the experimental group moved beyond this lower level thinking into "justification by example" (Carpenter et al, 2003).

As noted in Kamii's 2006 research, students develop logic when debating and trying to convince one another. In our classroom, it was expected that students defend

their answers, which pushed them to develop the ability to think logically and critically about mathematics. So many of the students were able to catch their mistakes and strengthen their understanding of the mathematics involved in a task simply by trying to justify their thinking and listen to the justifications of their classmates.

Wells & Coffey (2005) assert that a child's ability to learn and grow after making mistakes is dependent on the reaction of adults. I believe this to be true in my classroom, I was cognizant of my response when a student made a mistake. I did not rush to 'save' them and help them fix their strategy, I used questioning to draw out their thinking and help them sort it out. The exchange between OT-E, LR-E, and myself capturing how to interpret the students left on the beach after some went off to fly kites exemplifies this instructional practice. When students realized they made a mistake and worked to explore their misconceptions, I celebrated their effort and perseverance (Schifter, 2007).

Chapin et al. (2009) say that in order for these results to occur, the classroom must be a safe environment in which students treat one another with respect. They also warn that even one small violation of this expectation can hinder student learning and growth. The students in the experimental group responded to my enthusiasm about math time and took their roles as integral parts in the learning process for our class. Because of their desire to grow and support one another, there were no such violations in my class.

Mindset

Toward the beginning of the year, I overheard Student DS-E telling another teacher through tears that he hated math. I wondered how this could happen in a child who had never experienced a school environment before in the beginning of the year. It

had always been my goal to foster a growth mindset in my students. He made the need for growth mindset even more obvious.

I made an intentional decision to incorporate Dweck's (2006) mindset research into our daily conversations. I led the class in discussions about how making and examining mistakes can actually physically change the brain. When an individual examines a mistake, synapses in the brain fire (Dweck, 2006). The firing synapses cause neurons to grow and make stronger pathways in the brain. As this process occurs, the brain grows as a result (Dweck, 2006).

Throughout the study, I integrated Boaler's (2015) work on growth mindset by giving feedback to students based on their effort, not the answers they provided. I also became transparent with my own mistakes and talked with students about the brain development that occurs with mistakes. I showed them pictures of the brain going through the process of synapses firing and we celebrated our mistakes and congratulated one another on the brain getting stronger.

We had regular conversations in which students were expected to think of and share something that was difficult for them that required perseverance. We congratulated one another after we shared and students began to look forward to being able to share something that was challenging. I overheard a student say, "This is hard!" in reference to a math activity. Student JC responded by saying, "I'm glad it's hard! That means it's challenging and our brains are getting stronger." There were several examples of this after a few weeks of beginning the study. I also had several students approach me daily to excitedly tell me about mistakes they had made.

It appears this celebration of mistakes helped foster an environment in which students were willing to share their thinking during math talks because they were not afraid of making mistakes in front of others. In the middle of the study, Student DS-E, who cried during his baseline assessment, would come up repeatedly to me at random times throughout the day to tell me, "I love math!" He has not cried about math since his initial assessment and has been eager to share his thinking with the class, whether or not it was correct.

Limitations

There were challenges that arose during the course of this study. One of the main concerns was my colleague's desire to find the balance between providing the best instruction for her class and maintaining the integrity of this study. In the summer before this study, she agreed to follow only the district's math curriculum without supplementing additional materials during her math planning and instruction. After beginning this study, it came to my attention that she was receiving additional advice and materials that were not a part of the curriculum from other teachers in the school. It is possible that, had she not brought in additional materials to her practice, the results would have shown a greater difference. Nevertheless, even with the supplementing in the control group classroom, there was a twenty percentage point difference in the number of students who met proficiency benchmarks between the two classrooms at this point in the academic year. It is also to be remembered that the control group began with more advanced proficiency scores (67%) compared to the experimental group (53%) at the beginning of the study.

This study is also limited in that it is only a portion of one school year. It would be more revealing to have a longitudinal study that follows students not only over the course of an entire school year, but over many years to determine the long term effects, if any, of having a foundational school experience in a classroom that implemented math talks. For many of the students in the experimental group, this classroom was their first experience with formal education, making this unique in that they have been taught from the very beginning that they are capable of shaping their futures and have the ability to succeed.

I plan to informally follow these students for the rest of the year to see if the gap between classes increases in their final assessment at the end of the year. Though, beyond the scope of this study, it would be interesting to see the scores on future assessments in higher grades, both district assessments and standardized testing to see if students maintain the gains they made in kindergarten. I would also like to see whether or not the growth mindset and passion for exploring mathematics stays with students throughout their education or if it wears off once they are in a different environment with a different teacher.

Moving Forward

When the last day of this study came, I told my class that this would be the last day that I would be recording them during our math talks. The class responded with groans and pleading to continue. This was because they thought that, if I was not recording the math talks, we would no longer have this time in our day. When I clarified for them that we will still proceed with our normal routines, only without being recorded,

they cheered and many began to talk about how much they enjoy solving problems and talking about their strategies. I will most certainly continue to implement daily math talks with my students and encourage my colleagues to do the same.

The conclusion of this study coincided with the end of the school trimester. This meant that the scores from all classes were shared with the grade level teachers. I have already begun to share my findings with my colleagues as well as resources for them to implement math talks in their classrooms. The results have peaked the interest of district staff and they have come out to videotape my students during math talks. These recordings have been utilized for trainings within the district.

Conclusion

According to the data collected in this study, student achievement increased well beyond what was expected for the first trimester of kindergarten. This is shown through Concepts of Math assessment scores as well as students' ability to understand, solve, and explain the mathematics they encounter. It appears that the implementation of daily math talks and holding students accountable for making sense of their work as well as the thinking of their peers had a significant and positive impact on kindergarteners' growth on assessed substrands of mathematics.

EPILOGUE

At the end of the second trimester, all kindergarteners who had not met end of year benchmarks were re-assessed with the Concepts of Math. There were seven classrooms out of 133 that had 100% proficiency. Of those seven classrooms, two were in Title schools. My classroom was, again, one of those two.

BIBLIOGRAPHY

Baek, J. M. (2006). Children's mathematical understanding and invented strategies for multi digit multiplication. *Teaching Children Mathematics*, *12*(5), 242-247.

Ball, D. L., (1993). With an eye on the mathematical horizon: Dilemmas of teaching elementary school mathematics. *Elementary School Journal* 93, 373-397.

Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator*, 14-46.

Baroody, A. J. & Benson, A. (2001). Early Number Instruction. T*eaching Children Mathematics, 8*(3), 154-158.

Battista, M. T. (2006). Understanding the development of students' thinking about length. *Teaching Children Mathematics, 13*(3), 140-146.

Bay-Williams, J. M. & Karp, K. (2010). Elementary school mathematics teachers' beliefs. In D. V. Lambdin & F. K. Lester, Jr. *Teaching and Learning Mathematics: Translating Research for Elementary School Teachers*, 47-54.

Carpenter, T. P., Ansell, E., Franke, M. L., Fennema, E., & Weisbeck, L. (1993). Models of Problem Solving: A Study of Kindergarten Children's Problem-Solving Processes. *Journal for Research in Mathematics Education, 24*(5), 428.

Carpenter, T. P., Fennema, E., Loef Franke, M., Levi, L., Empson, S. (2015). *Children's Mathematics, Second Edition*. Portsmouth, NH: Heinemann.

Carpenter, T. P., Fennema, E., P. L., Peterson, P., Chiang, C.& Loef, M. (1989). Using

    Knowledge of Children's Mathematical Thinking in Classroom Teaching: An

    Experimental Study. *American Educational Research Journal*, 499-531.

Carpenter, T.P., Franke, M.L., & Levi, L. (2003). *Thinking Mathematically: Integrating*

    arithmetic and algebra in elementary school. Portsmouth, NH: Heinemann.

Chapin, S. H., O'Connor, M. C., & Anderson, N. C. (2009). *Classroom discussions:*

    Using math talk to help students learn, grades K-6. Sausalito, CA: Math Solutions

Clements, D. H. (1999). Subitizing: What is it? Why teach it? *Teaching Children*

    Mathematics, 5(7), 400-405.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed method*

    approaches. Thousand Oaks, CA: Sage Publications.

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

    House.

Frank, J. L. (2013). Effects of Math Talks to Improve Instruction in a Kindergarten

    Classroom (Unpublished master's thesis). St. Catherine University.

Hiebert, J., Carpenter, T., Fennema, E., Fuson, K., Wearne, D., Murray, H., Olivier, A.

    and Piet, H. (1997). *Making sense: Teaching and learning mathematics with*

    understanding. Portsmouth, NH: Heinemann.

Humphreys, C., & Parker, R. (2015). Making Number Talks Matter: Developing

    Mathematical Practices and Deepening Understanding, Grade 4-10. Stenhouse.

Jacobs, V., Ambrose, R. (2003). Individual Interviews as a Window into Teachers'
Practice A Framework for Understanding Teacher-Student Interactions During
Mathematical Problem Solving.

Kamii, C. (2006). Measurement of length: How can we teach it better? *Teaching
Children Mathematics, 13*(3), 154-158.

Kamii, C., & Dominick, A. (1998). The Harmful Effects of Algorithms in Grades 1-4. In
L. J. Morrow & M. J. Kenney (Eds.), *The teaching and learning of algorithms in
school mathematics: 1998 NCTM yearbook*, 130-140.

Kamii, C., & Rummelsburg, J. (2008). Arithmetic for first graders lacking number
concepts. *Teaching Children Mathematics, 14*(7), 389-394.

Kilpatrick, J., Swafford, J., & Findell B. (Eds.) Adding it up: Helping children learn
mathematics, *Washington, DC: National Academies Press*, 115 – 155.

Kling, Gina. (2011) Fluency with Basic Addition." *Teaching Children Mathematics
18*(2), 80-88.

Kostos, K., & Shin, E. (2010). Using Math Journals to Enhance Second Graders'
Communication of Mathematical Thinking. *Early Childhood Education Journal,
38*(3), 223-231.

Leinwand, S. (2000). *Sensible mathematics: A guide for school leaders*. Portsmouth, NH:
Heinemann.

Maldonado, L.A., Turner, E.E., Dominguez, H., & Empson, S.B. (2009).
English-language learners learning from, and contributing to, mathematical
discussions. In D.Y. White, J.S. Spitzer, & C.E. Malloy (Eds.), *Responding to*

Diversity Grades Pre-K-5, 7-21. Reston, VA: National Council of Teachers

of Mathematics.

Mills, G. E. (2007). *Action research: A guide for the teacher researcher*. Upper Saddle

River, NJ: Merrill.

Minnesota Department of Education. *Minnesota academic standards: Mathematics K-12.*

(2003). Minnesota: Minnesota Dept. of Education.

Minnesota Report Card. (2015). Retrieved July 15, 2016, from

http://rc.education.state.mn.us/

Mokros, J.R., Russell, S.J., & Economopoulos, K. (1995). *Beyond arithmetic: Changing*

mathematic in the elementary classroom. Palo Alto, CA Dale Seymour

Publications.

Moschkovich, J.N. (2010). Language, culture, and equity in elementary school

mathematics classrooms. . In D.V. Lambdin & F.K. Lester, Jr. (Eds.), *Teaching*

and Learning Mathematics: Translating Research for Elementary School

Teachers, 67-72. Reston, VA: National Council of Teachers of Mathematics.

National Research Council (2001). Chapter 4: The strands of mathematical proficiency.

In J. Parrish, S. (2010). *Number talks: Helping children build mental math and*

computation strategies, grades K-5. Sausalito, Ca: Math Solutions.

Schifter, D. (2007, November). What's Right About Looking at What's Wrong?

Association for Supervision and Curriculum Development, 22-27.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching.

Educational Researcher, 15(4), 4-14. *American Educational Research*

Association.

Shumway, J.F. (2011). *Number Sense Routines: Building Numerical Literacy Every Day in Grades K-3.* Portland, Me.: Stenhouse.

Sun, W., & Zhang, J.Y. (2001). Teaching addition and subtraction facts: A Chinese perspective. *Teaching Children Mathematics, 8*(1), 28-31.

Tomlinson, C. A., & McTighe, J. (2006). *Integrating differentiated instruction & understanding by design: Connecting content and kids.* Alexandria, VA: Association for Supervision and Curriculum Development.

Van de Walle, J.A. (2001). *Elementary and Middle School Mathematics: Teaching Developmentally*. New York: Addison Wesley Longman.

VerDuin, J., VanDenTop, M., & James, M. (2015). *Enrollment Report* [Pamphlet]. Anoka, MN: Anoka Hennepin School District 11.

Wells, P.J., & Coffey, D.C. (2005). Are they wrong: Or did they just answer a different question? *Teaching Children Mathematics, 12*(4), 202-207.

Williams, M. E. (2016, July 14). Validity of Concepts of Math Assessment [Telephone interview].

Appendix A

Letter of Consent, Experimental Group

Dear Parent or Guardian,

I am your child's kindergarten teacher and a graduate student working on an advanced

degree in education at Hamline University, St. Paul, Minnesota. As part of my graduate

work, I will conduct research in my classroom from October 10-December 1, 2016. The

purpose of this letter is to ask your permission for your child to take part in my research.

This research is public scholarship, the abstract and final product will be cataloged in

Hamline's Bush Library Digital Commons, a searchable electronic repository.

I want to study how implementing "math talks" affects student achievement. This is a

newer approach to teaching math and it is being implemented in schools across the nation

with great success. I would like to collect information on their effectiveness between

October 10-December 1, 2016. I also want to use information from the beginning of the

year assessments to show student growth. Math talks are conversations about math

questions that students explore and talk about together to further their understanding by

sharing and hearing each other's ideas. While students are participating in math talks and

interviews about their thinking, I will audio record the conversations, take notes, and collect student work samples.

There is no risk for your child to participate in this study. All results will be confidential and anonymous. I will not record information about individual students, such as their names, nor report identifying information in the capstone. Participation is voluntary and you may decide at any time and without negative consequences that information about your student will not be included in the capstone. Students will receive the same instruction and assessment, regardless of their participation in this study. If you choose to decline to have your student participate, his/her data will not be included in the report.

I have received approval for my student from the School of Education at Hamline University and from the Anoka-Hennepin School District. The capstone will be catalogued in Hamline's Bush Library Digital Commons, a searchable electronic repository. Your child's identity and participation in this study will be confidential.

If you give your child permission to participate in this study, please keep this page for your records. Please complete the agreement to participate on the next page and return to me no later than September 30, 2016. If you have any questions or concerns, please contact me via email or phone.

Sincerely,

Emily Payán

Informed Consent to Participate in Study

Return this page to Emily Payán

I have received your letter about the study you plan to conduct in which you will research

student achievement while participating in math talks. I understand there is no risk

involved for my child, that his/her confidentiality will be protected, and that I may

withdraw from this project at any time.

_____   _____

    Parent/Guardian Signature   Date

_____

      Child's Name

Appendix B

Letter of Consent, Control Group

Dear Parent or Guardian,

I am a kindergarten teacher at your child's school and a graduate student working on an advanced degree in education at Hamline University, St. Paul, Minnesota. As part of my graduate work, I plan to conduct research in my classroom from October 10-December 1, 2016. The purpose of this letter is to ask your permission for your child to take part in my research. This research is public scholarship, the abstract and final product will be cataloged in Hamline's Bush Library Digital Commons, a searchable electronic repository.

I am studying how implementing "math talks" affects student achievement. This is a newer approach to teaching math and it is being implemented in schools across the nation with great success. I will collect information on their effectiveness between October 10-December 1, 2016. I also want to use information from the beginning of the year assessments to show student growth. I would like to interview your child about his/her

problem-solving three times throughout this period. During these interviews, I will audio record the conversations, take notes, and collect student work samples.

There is no risk for your child to participate in this study. All results will be confidential and anonymous. I will not record information about individual students, such as their names, nor report identifying information in the capstone. Participation is voluntary and you may decide at any time and without negative consequences that information about your student will not be included in the capstone. I have received approval for my student from the School of Education at Hamline University and from the Anoka Hennepin School District. The capstone will be catalogued in Hamline's Bush Library Digital Commons, a searchable electronic repository. Your child's identity and participation in this study will be confidential.

If you give your child permission to participate in this study, please keep this page for your records. Please complete the agreement to participate on the next page and return to your child's teacher no later than September 30, 2016. Please contact me with any questions or concerns.

Sincerely,

Emily Payán

Informed Consent to Participate in Study

Return this page to Emily Payán

I have received your letter about the study you plan to conduct in which you will research student achievement while participating in math talks. I understand there is little to no risk involved for my child, that his/her confidentiality will be protected, and that I may withdraw from this project at any time.

_____   _____

       Parent/Guardian Signature   Date

_____

            Child's Name

Appendix C

Consent Letter, Interviews

Dear Parent or Guardian,

I am a kindergarten teacher at your child's school and a graduate student working on an advanced degree in education at Hamline University, St. Paul, Minnesota. As part of my graduate work, I plan to conduct research in my classroom from (add date here)-December 1, 2016. The purpose of this letter is to ask your permission for your child to take part in my research. This research is public scholarship, the abstract and final product will be cataloged in Hamline's Bush Library Digital Commons, a searchable electronic repository.

I am studying how implementing "math talks" affects student achievement. This is a newer approach to teaching math and it is being implemented in schools across the nation with great success. In addition to using information from the beginning of the year assessments to show student growth, I would like to interview your child about his/her problem-solving three times throughout this period. These interviews will take place in my classroom, during math centers. They would typically be doing similar work with

their classroom teacher during this time. During these interviews, I will audio record the conversations, take notes, and collect student work samples.

There is no risk for your child to participate in this study. All results will be confidential and anonymous. Any comment or student work that is highlighted will be described via a pseudonym. Participation is voluntary and you may decide at any time and without negative consequences that information about your student will not be included in the capstone. I have received approval for my student from the School of Education at Hamline University and from the Anoka Hennepin School District. The capstone will be catalogued in Hamline's Bush Library Digital Commons, a searchable electronic repository. Your child's identity and participation in this study will be confidential.

If you give your child permission to participate in this study, please keep this page for your records. Please complete the agreement to participate on the next page and return to your child's teacher no later than (add date here). Please contact me with any questions or concerns.

Sincerely,

Emily Payán

Informed Consent to Participate in Study

Return this page to Emily Payán

I have received your letter about the study you plan to conduct in which you will research student achievement while participating in math talks. I understand there is little to no risk involved for my child, that his/her confidentiality will be protected, and that I may withdraw from this project at any time.

_____ _____

    Parent/Guardian Signature　　　　　　　　　　Date

_____

    Child's Name

Appendix D

Kindergarten Concepts of Math

Concepts of Math Kindergarten
© Anoka-Hennepin I.S.D. 11

Student:			School Classroom:				
Assessors							
Baseline:		Tri. 1:		Tri. 2:		Tri. 3:	

CoM Task List		Baseline Date		End of Tri 1		End of Tri 2		End of Tri 3	
1	**Forward Counting** 3 Points Possible		1/3		2/3		3/3		3/3
2	**One More** 3 Points Possible		x/3		1/3		2/3		3/3
3	**Numeral ID** 3 Points Possible		x/3		1/3		2/3		3/3
4	**Order** 3 Points Possible		x/3		1/3		2/3		3/3
5	**Backward Counting** 3 Points Possible		1/3		2/3		2/3		3/3
6	**One Less** 3 Points Possible		x/3		1/3		2/3		3/3
7	**Compose & Decompose** 4 Points Possible		1/4		2/4		3/4		4/4
8	**Counting a Collection** 3 Points Possible		1/3		2/3		3/3		3/3
9	**Addition** 3 Points Possible		x/3		x/3		2/3		3/3
10	**Subtraction** 3 Points Possible		x/3		x/3		2/3		3/3
	Total Points Achieved		10/31		14/31		23/31		30/31

- In order to distinguish what notes on the test pages were written when, please use the following colored ink/pencil: Fall – **GREEN**   End of Tri 1 – **BLUE**   End of Tri 2 – **PENCIL** End of Tri 3 - **RED**
- When a child has achieved the end of year target on any given task, the child **does not** need to be reassessed on that task on subsequent administrations.
- An "x" on the chart above denotes where a child MAY receive points. By the end of Tri 1, the child should receive 2 points in **either** Task 9 or 10.
- **Do not provide more than one prompt per task!**

ASSESSOR NOTES:

Concepts of Math Kindergarten
© Anoka-Hennepin I.S.D. 11

Task 1: FORWARD Rote Counting MN Benchmarks K.1.1.3

SAY: "Start counting from 1. I will tell you when to stop." (Stop at 31.)

Record student's thinking.	
1-31	

Evidence	Scoring Guide		Score		Directionality
Task 1 Counting forward from 1 to 31	☐ correctly **counts to 31+**	T2	3		Go to TASK 2
	☐ correctly **counts 1-20**	T1	2		
	☐ correctly **counts 1-10**	B	1		
	☐ made at least one error or is unable to count to 10		0		

Task 2: One More MN Benchmarks K.1.1.4

SAY: "What is 1 more than _____?"
(4, 8, 5, 9, 12, 17, 23, 29)

Record the information.

✓ - correct and automatic		C - correct but counted			If incorrect record the answer given.		
4	**8**	**5**	**9**	**12**	**17**	**23**	**29**

Evidence	Scoring Guide		Score		Directionality
Task 2 Names One More up to 31	☐ automatically names **one more** than any number, 1-31	T3	3		Go to TASK 3
	☐ automatically names **one more** than any number, 1-20	T2	2		
	☐ automatically names **one more** than any number, 1-10	T1	1		
	☐ made at least one error or is unable to name 1 more		0		

Task 3: Numeral ID MN Benchmark K.1.1.2

DO: Using the provided set of 32 numerals cards. Display the numerals as shown on the right, one at a time.

SAY: "These cards have numbers on them.
Tell me what number is on each card."

Task 3	✓ if correct.		If incorrect, record the answer given.						
4	**8**	**2**	**5**	**1**	**9**	**7**	**0**	**3**	**6**
10	**13**	**12**	**17**	**19**	**11**	**14**	**16**	**18**	**15**
25	**29**	**22**	**20**	**24**	**31**	**21**	**30**	**28**	**23**	**26**	**27**

Evidence	Scoring Guide		Score		Directionality
Task 3 Numeral ID	☐ correctly **ID's to 31**	T3	3		Go to TASK 4
	☐ correctly **ID's** all teen numbers **(10-19)**	T2	2		
	☐ correctly **ID's** all digits **(0-10)**	T1	1		
	☐ made at least one error or is unable to identify numerals to 10		0		

Concepts of Math Kindergarten
© Anoka-Hennepin I.S.D. 11

Task 4: Ordering Numerals (to 20)   MN Benchmark K.1.1.5

Part A: Orders Numerals to 5

DO: Use the provided cards (4, 2, 5,1, 3)

SAY: *"Put these cards in order, from least to greatest."*

NOTE: If successful, go to Part B.

Part A: Record thinking student's thinking

Part B: Orders Numerals to 10

DO: Use the provided cards (9, 6, 8, 7, 10)

SAY: *"Put these cards in order, from least to greatest."*

NOTE: If successful, go to Part C.

Part B: Record thinking student's thinking

Part C: Orders Numerals to 20

DO: Use the provided cards (12, 15, 18, 13, 20)

SAY: *"Put these cards in order, from least to greatest."*

Part C: Record thinking student's thinking

Evidence	Scoring Guide		Score		Directionality
Task 4 Ordering Numerals	☐ **Part C:** correctly orders to **20**	T3	3		Go to TASK 5
	☐ **Part B:** correctly orders to **10**	T2	2		
	☐ **Part A:** correctly orders to **5**	T1	1		
	☐ made at least one error (0-5) or does not know how to order		0		

Task 5: BACKWARD Rote Counting   MN Benchmarks K.1.1.3

Part A: Counts back from 10

SAY: *"Please count back from 10."*
   If necessary during counting, prompt (no more than once) by saying: *"What comes next?"*

NOTE: If the child counts forward rather than backward, say:
   "You are doing a good job of counting forward. Can you start at 10 and count backward?"

NOTE: If the child is still unable to do the task, model counting back from 3.
   Then say: *"Now you try counting back from 5."*   Record the results below and skip to TASK 6.

Part A: Record the student's thinking for **10-1**

Part B: Back from 20

SAY: *"Now count back from 20. I will tell you when to stop."*   (Stop at 10.)

Part B: Record the student's thinking for **20-10**

Evidence	Scoring Guide		Score		Directionality
Task 5 Counting backward from 20	☐ **Part B:** counts **back from 20**	T3	3		Go to TASK 6
	☐ **Part A:** counts **back from 10**	T1	2		
	☐ counts **back from 5**	B	1		
	☐ made at least one error or is unable to count back from 5		0		

Concepts of Math Kindergarten
© Anoka-Hennepin I.S.D. 11

Task 6: 1 Less   MN Benchmarks K.1.1.4

SAY: "*What is 1 less than _____?*"

(3, 8, 5, 9, 13, 20, 16, 12)

Record the Information.

	✓ - correct and automatic		C - correct but counted		If incorrect record the answer given.		
3	**8**	**5**	**9**	**13**	**20**	**16**	**12**

Evidence	Scoring Guide		Score		Directionality
Task 6 Automatically names 1 less	☐ automatically names **1 less** than any number up to 20	T3	3		Go to TASK 7
	☐ automatically names **1 less** than any number up to 10	T2	2		
	☐ automatically names **1 less** than any number up to 5	T1	1		
	☐ made at least one error (0-5) or is unable to name one less		0		

Task 7: Composing and Decomposing   MN Benchmark K.1.2.2

Part A: Regular Dot Patterns to 6

SAY: "*The cards I'm going to show you next have dots on them. I can only show you each card one time. I'm going to show it very quickly. Are you ready? Tell me what you see.*"

DO: Show the dot cards one at a time. Flash the cards for about one second. Only show the card one time. If they ask to see it again, repeat that you can only show the card once and say: "*Tell me what you think you saw.*"

Part A: Mark with a ✓ if correct **WITHOUT counting** and record student's thinking.

5			4			6	

NOTE: If the child needs to count or has an error in Part A, go to TASK 8.

Part B: Automatic with Parts of Numbers to 5 (with materials)

DO: Display a blank 5 frame. Ask the child to describe what they notice. The goal is for the child to notice there are 5 empty squares.

SAY: "*Now I'm going to show you frames with dots on them. I can only show you each frame one time and I'm going to show it very quickly. Tell me how many dots you see.*"

DO: Show the 5 frames one at a time in the order described below.

If the child answers "how many dots" correctly, ask them: "*How many more dots do we need to make five?*"

Part B: Mark with a ✓ if correct **WITHOUT counting** and record student's thinking.

4	1		2	3		5	0	

Part C: Automatic with Parts of Numbers to 5 (without materials)

Parts of 5	1st Pair	2nd Pair	Parts of 4	1st Pair	2nd Pair

SAY: "*Tell me two numbers that go together to make 5.*"

DO: If the child says 5 and 0 or 0 and 5, or a turn-around fact, ask the child for 2 different numbers.

SAY: "*Tell me two more numbers that go together to make 5.*"

SAY: "*Tell me two numbers that go together to make 4.*"

DO: If the child says 4 and 0 or 0 and 4, ask the child for 2 different numbers.

SAY: "*Tell me two more numbers that can be added together to make 4.*"

NOTE: If the child **needs to count,** go to TASK 8.   Possible Prompt: :What goes with 1 to make 5?"

Concepts of Math Kindergarten
© Anoka-Hennepin I.S.D. 11

Part D: Automatic Finger Patterns

SAY: "I will tell you a number and you will show me that amount with your fingers."

DO: Say the numbers below.

Part C: Mark with a ✔ if correct. C if counting. Record student's thinking.				
7		**10**		
8		**6**		

Part E: Automatic with Parts of Numbers to 10 (with materials)

DO: Display a blank 10 frame. Ask the child to describe what they notice. The goal is for the child to notice there are 10 empty squares.

SAY: "Now I'm going to show you frames with dots on them. I can only show you each frame one time and I'm going to show it very quickly. Tell me how many dots you see."

DO: Show the 10 frames one at a time in the order described below.

Part E: Mark with a ✔ if correct **WITHOUT counting** and record student's thinking.							
7			**9**			**4**	

Evidence	Scoring Guide		Score		Directionality
Task 7 Composing and Decomposing A) Dot Patterns; B) Parts of 5 C) Build to 10; D) Parts of 10	☐ correctly answers **Parts A – E w/o counting**	T3	4		
	☐ correctly answers **Part A, B & C w/o counting** (parts of 5 w/o materials)	T2	3		
	☐ correctly answers **Parts A & B** (dots & parts of 5) **w/o counting**	T1	2		**Go to TASK 8**
	☐ completes **Part A** (dot patterns) **w/o counting**	B	1		
	☐ makes an error or has to count in Part A		0		

Task 8: Counting a Collection   MN Benchmark K.1.1.1

DO: Lay out 20 counters. (All one color)

SAY: "Please count these so I can hear you. You may move them if you like."

Do: Let the student count.

SAY: "How many counters are here?" *Cardinal Principle*

Cardinal Principle: The student understands that the number reached when counting the items in a set represents the entire set. A student who has this understanding would not need to recount when asked this question.

NOTE: If the child is unsuccessful with 20 counters, repeat with 10 counters. Note if you used 10 counters and continue the assessment.

Part C: ✔ strategies observed	
☐ uses 1- to -1 correspondence	☐ manages collection
☐ uses correct number words	☐ uses the Cardinal Principle

*Cardinal Principle: The student understands that the number reached when counting the items represents the entire set. A student who has this understanding would not need to recount when asked "How many are here?"

Evidence	Scoring Guide	Score		Directionality
Task 8 Counting a Collection	☐ accurately counts a **collection of 20** _AND_ uses the **Cardinal Principle**	T2	3	
	☐ accurately counts a **collection of 10** _AND_ uses the **Cardinal Principle**	T1	2	**Go to TASK 9**
	☐ accurately counts a **collection of 10** but **doesn't** use the Cardinal Principle	B	1	
	☐ unable to accurately count a collection		0	

Concepts of Math Kindergarten
© Anoka-Hennepin I.S.D. 11

Task 9: Additive Tasks   *MN Benchmark K.1.2.1*

Part A: Sums to 5:

Do: Have a collection of counters available but off to the side.

SAY: "*There are 3 birds in the tree. 2 more birds come to the tree. How many birds are in the tree now?*

NOTE: *If the child hesitates, ask if the counters or paper/pencil could help the child work out the problem. If the child is successful, go to Task 10.*

Part A: Record thinking for **3+2**

Part B: Sums to 10:

Have a collection of counters available but off to the side.

SAY: "*There are 6 books on the shelf. I put 3 more books are on the shelf. How many books are on the shelf now? How do you know?*"

How do you know?"

Part B: Record thinking for **6+3**

Evidence	Scoring Guide		Score		Directionality
Task 9 Additive	☐ accurately solves **Part B**	T3	3		Go to **TASK 10**
	☐ accurately solves **Part A only**	T1	2		
	☐ unable to solve the task accurately even with counters visible		0		

Task 10: Subtractive Tasks   *MN Benchmark K.1.2.1*

Part A: Minuends to 5:

DO: Have a collection of counters available but off to the side.

SAY: "*There were 5 children playing outside. Three children went home. How many are still playing outside?*

NOTE: *If the child hesitates, ask if the counters or paper/pencil could help the child work out the problem. If the child is successful, you may stop the assessment.*

Part A: Record the student's thinking for **5-3**

Part B: Minuends to 10:

DO: Have a collection of counters available but off to the side.

SAY: "*You had 7 crackers. You gave me 4 of the crackers. How many do you have now? How do you know?*"

NOTE: *If the child hesitates, ask if the counters or paper/pencil could help the*

Part B: Record the student's thinking for **7-4**

Evidence	Scoring Guide		Score		Directionality
Task 10 Subtractive	☐ accurately solves **Task B**	T3	3		**END Assessment** ☺
	☐ accurately solves **Task A only**	T2	2		
	☐ unable to solve the task accurately even with counters visible		0		

Appendix E

Interview Questions

For each interview, students will have access to manipulatives to assist them in solving the problem. They will also have access to a piece of paper and marker to assist them, if desired.

Interview #1:

Task One (Join-Result-Unknown):

"I have a few problems for you to solve. You can draw a picture and use counters if you would like to solve the problem. Please think aloud so that I can hear your thinking and I will write down what I hear you say. Are you ready to begin? The first problem is:"

Miguel saw 3 ducks swimming in the pond. Later he saw 2 more swimming in the pond. How many ducks did Miguel see?

I will revoice what I hear the child say, whether correct or incorrect, thank them, and move to task two.

Task Two (Separate-Result-Unknown):

Mackenzie had 4 carrots. She ate 1 carrot. How many carrots does she have now?

I will revoice what I hear the child say, whether correct or incorrect, thank them, and move to task three.

Task Three (Multiplication):

Elijah has 2 flowers. Each flower has 3 petals. How many petals are there?

"Thank you so much for sharing your thinking with me, you can go to your next center."

Interview #2:

"I have a few problems for you to solve, just like you did a few weeks ago. You can draw a picture and use counters if you would like to solve the problem. Please think aloud so that I can hear your thinking and I will write down what I hear you say. Are you ready to begin? The first problem is:"

Task One (Join-Result-Unknown):

Sara had 2 pencils. Her mom gave her 2 more. How many pencils does she have now?

Task Two (Separate-Result-Unknown):

There were 5 children playing on the playground. 2 of them went home. How many children are at the playground now?

Task Three (Multiplication):

Maggie has two bags. Each bag has two teddy bears in it. How many teddy bears does she have?

"Thank you so much for sharing your thinking with me, you can go to your next center."

Interview #3:

"I have a few problems for you to solve again. You can draw a picture and use counters if you would like to solve the problem. Please think aloud so that I can hear your thinking and I will write down what I hear you say. Are you ready to begin? The first problem is:"

Task One (Join-Result-Unknown):

Colten picked out 3 stickers. His friend gave him 2 more. How many stickers does he have now?

Task Two (Separate-Result-Unknown):

Asia had 5 carrots in her lunchbox. She ate 2 of them. How many carrots does she have now?

Task Three (Multiplication):

There are 2 benches on the playground. There are 3 students sitting on each bench. How many students are on the benches?

"Thank you so much for sharing your thinking with me, you can go to your next center."