Sponsoring Committee: Dr. John Dilendik, Moravian College
Dr. Laurie Kahn, Moravian College
Mrs. Nicole Nagle, Bethlehem Area School District

MATH INTERVENTIONS IN THE FIRST GRADE CLASSROOM:

TIERED, TRIED, AND TRUE?

Samantha Strickler

Submitted in partial fulfillment
of the requirements for the degree of
Master of Education
Moravian College
Bethlehem, Pennsylvania
2019

In loving memory of my grandmother,

Ellen Arlene Strickler

1-4-3

Abstract

The purpose of this teacher action research study was to examine the effects of Tier Two math interventions on students' number sense and basic fact fluency. Eleven first grade students in eastern Pennsylvania received 20-minute math interventions two to three times a week over the course of an 11 week period. Those students qualified for additional assistance based on their below grade level performances on a beginning of year universal screener. The intervention sessions targeted early numeracy skills such as subitizing, counting, number identification, and addition strategies through explicit instruction, a Concrete-Representational-Abstract approach, and by providing hands-on experiences with manipulatives and gameplay. The DIBELS Math universal screener, Rocket Math two-minute test, diagnostic assessments, and a practitioner field log were collected as quantitative and qualitative data throughout the study to gauge the effectiveness of supplemental instruction. Overall, the findings suggest that math interventions promote number sense, basic-fact retrieval, and higher-order thinking skills by building a strong foundation for more advanced mathematics.

Acknowledgments

First and foremost, I thank my students, past and present, for embracing change with enthusiasm. When I say that I have my dream job, I mean it. I could not ask for better, or more amusing, coworkers. I would also like to thank Mr. Steidle and Dr. Wright for trusting me to take a leap of faith. I am lucky to work in a district that maintains high standards and builds students and teachers up to reach them.

I consider myself very fortunate to have completed my graduate degree at Moravian College, a learning environment that empowers educators to transform their practice. I am especially grateful to Dr. Dilendik, Dr. Shosh, and Dr. Kahn for their unparalleled expertise and guidance.

Kari, there is not enough pizza in the world to repay you for the painstaking job of being my editor-in-chief. Your contributions and revisions were invaluable.

And finally, to my family, I am grateful for your steadfast support in everything I do. Whether it’s a swim meet or a musical, I know that my home team will be there to cheer me on. To Syd, thank you for the awful puns that brightened my days. To Dad, thank you for reminding me that I’m “iron,” even when I had forgotten it myself. And Mom, by leading as an example, you have inspired me to go through life as an unapologetically independent and passionate woman. I love you guys!

Table of Contents

List of Tables

List of Figures

A Researcher's Stance: Diving into Mathematics

My college application essay was entitled: "Why I Didn't Shave my Legs for 83 days." A shrine to Michael Phelps remains intact on the wall of my childhood bedroom. The scent of chlorine gives me flashbacks to the 11 years I spent in the York Suburban natatorium. The fact of the matter is, even though my swimming career has long since passed, I will never forget the immeasurable impact swimming had on my work ethic, my interests, and my eventual career. I certainly took more from the sport than just how to swim up and down a pool as fast as possible.

Swimming taught me that there is no substitution for hard work. While in high school, I woke up at 5:00 am every day from September to March. In the peak of a season, I swam as much yardage as the cross country team ran. It took dedication and grit to dive into a frigid pool at the crack of dawn. But the effort always paid off as we headed into the postseason. One of my most prized possessions is an eighth-place medal from a state meet.

Looking back, I wonder how I was able to juggle school work and daily four-hour workouts. Today, I am balancing teaching and the pursuit of a graduate degree in what has proven to be a different, but also demanding endeavor. Taking the time to further my own education has been strenuous and all-consuming.

Without a doubt, it is also one of my proudest accomplishments. As I dive into my action research, I often recall the lesson I learned on a pool deck: I am capable of unimaginable things if I dare pursue my dreams.

Being an athlete helped me to achieve my goals. However, it was coaching that allowed me to help others achieve theirs. When I was in high school I worked as a part-time swim instructor during the offseason. I distinctly remember giving private lessons to a little boy named Josh, a squirmy seven-year-old. During our first session, Josh sat on the edge of the deck, only willing to dangle his toes in the water. During our second session, Josh got into the water but clung to me, fearful for his life. Little by little, week by week, Josh became more comfortable in the water and trusting of me. First, he floated on his back with the support of pool noodles and then without them. He flutter kicked the width of the pool with a kickboard and then without one. I will fast-forward this story to six months later when Josh swam freestyle down the pool independently. It was at that moment that I realized I wanted to become a teacher. I wanted to help kids accomplish what they once thought was impossible. Nearly a decade later, this goal is still one of my driving forces. As a teacher, I hope to facilitate change within my students and inspire them to pursue their dreams. There is simply no greater feeling than bearing witness to growth.

Albeit rewarding, coaching was not always easy. I learned that every swimmer had their own strengths and weaknesses. My breaststrokers struggled to keep their legs straight while swimming backstroke. My freestylers never seemed to press their chest forward in the butterfly. I learned to model for my swimmers. I pulled them out of the pool, and we practiced "chicken, airplane, soldier" on land. I incorporated drills into my practices to reinforce techniques. I praised efforts and celebrated successes. I cheered until I was hoarse during swim meets.

In hindsight, I see that coaching swimming was not unlike teaching mathematics. Both skills require strong foundations. You must float before you swim, and you must count before you add. You would never ask a beginning swimmer to compete in a 400-yard individual medley. You would never hand a kindergartener advanced calculus. Both of those tasks could only be accomplished by an expert. It takes time and scaffolded practice to reach those levels of mastery. I did not realize it then, but I was successful with Josh because I kept him within his Zone of Proximal Development (Vygotsky, 1978). In my first grade classroom, I aim to challenge my students while providing enough guidance for them to be successful. I model think alouds as I solve word problems. We warm up with our Doubles facts. I celebrate when students move onto the next set of Rocket Math.

Coach? Teacher? These terms are synonymous in my mind. Coaches and teachers alike provide children with the support they need to achieve their goals.

A decade spent in the swimming pool yielded many secondhand talents. I can fix any pair of goggles and can hold my breath for a minute and a half. Swimming also gave me a knack for mental math. An understanding of time is a prerequisite for this sport. From a young age, swimmers are told to complete sets on timed intervals. I remember developing patterns to help me remember when I should push off the wall. When swims were on the 40-second interval, I would leave on the :00, the :40, the :20, and so on. When a coach told us to warm up with a "600," I was forced to quickly convert the yards into laps. If a 100-yard swim was 4 lengths of the pool, a 600-yard swim was 24 lengths of the pool. During some of the longer practices, I would even calculate exactly how long a set would take. I suppose that doing math while I swam kept my mind off the fact that my body was aching and oxygen deprived.

Math was one of my favorite subjects in school. There is something so simplistically beautiful about our base-ten numeration system. In numbers, there is absolute truth. There is one correct answer. My passion for the subject did not go unnoticed. In eighth grade, I studied algebra in a hall closet because my teacher could see I was working well beyond the rest of the class. As a sophomore, I poured myself into the geometry proofs that so many of my peers dreaded. My senior year, I took statistics as an elective because I thought it would be fun. (It was!)

As almost all aspiring teachers do, I fantasized about what it would be like to have my own classroom and to teach the subject that I loved myself. In these rose-colored fantasies, the students were perfectly well-behaved and borderline geniuses. The realities of teaching are not quite as I imagined. One of the worst realizations I came to during my first year of teaching was that there simply wasn't enough time in the day to accomplish everything. It was April when I told my class that we would have social studies after lunch. One student raised his hand and asked, "What's social studies?" I felt like a complete and total failure. I was not a failure, but there was no balance in my schedule.

There is still a huge discrepancy in the allotment of time given for each subject. Phonics takes a priority over everything else. I spend three hours every day on English/language arts and a mere 45 minutes on math. It breaks my heart. Do not get me wrong; I have my reading specialist certification and I know that early literacy is crucial to academic success. But I can't help but wonder if our focus on literacy has limited the time primary teachers spend developing early numeracy skills. Students may have already fallen victim to a lack of quality math instruction. Every year I have a handful of students who are hyperlexic but struggle in math class. These students can follow step-by-step procedures, but do not possess an understanding of why algorithms work. Those same students make senseless errors that show a lack of number sense. They lack fact fluency and rely on their fingers and number lines to find the answers.

When it comes to struggling readers, we have universal screeners, diagnostic assessments, and highly effective tiered interventions to help close the gap in reading achievement. However, in my experience, students with mathematical difficulties are just as prevalent, and far less likely to see any strategic intervention. Math often takes a backseat to literacy. I find this to be a gross disservice for our students. Children need to understand numbers at the foundational level if they are ever going to engage with more advanced concepts. After all, you cannot sprint before you float.

It is time for me to step up to the block and make a change in my own practice to alleviate this problem. I will combine my passions for math and coaching by implementing math interventions. Sessions will be tactile and kinesthetic to build a connection between concrete materials and abstract concepts. It is my hope that providing more opportunities for students to explore math concepts with support from a teacher will solidify their understanding of numbers and promote fluency. I will collect data to guide my instruction and to ensure that learning is targeted and individualized.

Conducting action research will not be easy, but if my swimming career taught me anything, it is that some of the biggest challenges reap the sweetest rewards. This is my researcher's stance: fingertips gripping the edge of a diving block, arms pulling back, legs ready to explode into the depths. I am ready to dive into uncharted territories of my own practice.

Literature Review

When it comes to mathematical performance in the United States, our scores simply are not adding up. On the 2015 Programme for International Student Assessment mathematics literacy tests, the United States' average score placed in the bottom half of all participating education systems. Regrettably, these most recent scores were lower than the scores from both 2009 and 2012 (OECD, 2018). This downward trend in mathematical performance is not an isolated event; On the 2017 National Assessment of Education Progress, mathematics scores decreased from just two years ago for the lowest 25th percentile of fourth-graders across the country (National Center for Educational Statistics [NCES], 2017). Despite efforts to add rigor with the Common Core State Standards, mathematical achievement at the national level is missing the mark.

There are likely several causes for these disappointing results that include students, teachers, and the math constructs themselves. The National Research Council (2001) theorizes that one cause may be how "mathematics learning has often been more a matter of memorizing than of understanding" (p. 16). Students follow the rules but lack the mathematical knowledge to justify why procedures work. In order to have both a conceptual and procedural understanding of math concepts, children need to have a firm grasp of early numeracy skills.

The following review of literature will discuss the importance of those early numeracy skills, including number sense and basic fact retrieval, and review the extant research on how to help students develop a concrete understanding of these fundamental skills. Then, I will detail how a Response to Intervention (RtI) approach, specifically Tier Two intervention, has been used to alleviate and prevent the math difficulties that are adversely affecting our nation's students.

Early Mathematical Skills

For decades, both neuroscientists and psychologists have wondered if the human mind is hardwired for mathematics. There is research to support an innate mathematical ability. Babies as young as six-months-old are able to discriminate between numerical magnitudes (Lipton & Spelke, 2003). Other studies suggest that humans possess a brain mechanism that acts as a mental number line (Núñez, 2017). Despite this predisposition for mathematics, some students enter formal schooling with limited proficiencies and poor number sense. If children are to master complex math concepts before entering middle school, elementary teachers will need to lay a solid foundation in both number sense and basic fact retrieval.

Number sense. In their seminal study, Gersten and Chard (1999) draw parallels between phonological awareness and number sense. They conclude that just as children must possess strong phonological awareness in order to read and write, students must possess a strong number sense to develop sound mathematical thinking (Gersten & Chard, 1999). Jordan, Glutting, and Ramineni (2010) state that number sense "is a powerful predictor of later mathematics outcomes" (p. 6). Furthermore, Jordan and colleagues' (2010) longitudinal study found a strong correlation between students' number sense in first grade and their applied problem-solving and computation abilities in third grade. It appears that both phonological awareness and number sense are indispensable to their corresponding disciplines.

Students who do not develop a strong number sense in their early years risk failing later on. One reason for this failure may be a limited ability to check work effectively. Children with poor number sense are unable to gauge the reasonability of their answers, preventing them from self-correcting their responses (The National Mathematics Advisory Panel [NMAP], 2008). For example, a child with poor number sense would not realize that 6 + 3 = 39 is unreasonable. A deficiency with number sense makes advanced mathematics increasingly difficult and limits a child's ability to monitor reasonableness. The aforementioned studies demonstrate how imperative it is to promote comprehensive instruction on whole numbers.

Although it is plain to see that number sense is crucial for mathematical development, it is a complicated concept to grasp fully. Consider Gersten and

Chard's comparison of phonological awareness and number sense again. Phonological awareness involves dozen of subskills (e.g. blending, isolating, deleting, and manipulating sounds). Similarly, young mathematicians will need to possess fluidity and flexibility with numbers. Number sense is as multifaceted and complex as phonological awareness. When attempting to define number sense, one should consider a multitude of early numeracy skills.

Early and advanced number sense. The complexities of number sense have made it a difficult concept to define. In fact, few researchers can agree on one single definition. The National Research Council (2009) refers to number sense as the "interconnected knowledge of numbers and operations" (p. 95). Albeit succinct, this definition is a limited description of a broad term. It does not delve into all of the competencies students must master in order to truly possess number sense.

In an attempt to unravel these competencies, the NMAP breaks down number sense into two separate stages of development: early and advanced. Early number sense is limited to the rudimentary understanding of numbers children have before entering formal schooling. Some of those early skills are being able to subitize (i.e. recognize a small amount without counting, often using a visual pattern), having knowledge of the count-sequence, and estimating the magnitude of small values (NMAP, 2008).

As students progress throughout elementary school, they develop more advanced number sense. These skills often require direct instruction from a teacher for student mastery. Advanced number sense involves an understanding of place value, decomposition of large numbers, and a grasp of basic arithmetic operations that include knowledge of the commutative, associative, and distributive properties (NMAP, 2008). For the purpose of conciseness, when I refer to number sense in the following section, I will be referencing both early and advanced number sense. Now that I have established what number sense entails and its importance, I will look at extant studies that detail how manipulatives and a concrete to abstract teaching method help to develop a deep understanding of numbers.

Using manipulatives. The Pennsylvania Common Core state standards list eight different standards of mathematical practice that teachers should aim to instill in their students. These mathematical practices prioritize conceptual understanding instead of rote memorization. Pennsylvania Common Core suggests that students demonstrate their comprehension using both models and tools (National Governors Association Center for Best Practices, & Council of Chief State School Officers [NGACBP], 2010). Using manipulatives to represent problems is one way to promote deep conceptual understanding of whole numbers. For example, when teaching students how to add two-digit numbers together, it may be beneficial to demonstrate the concept with base-ten blocks before moving to a traditional vertical algorithm.

Carbonneau, Marley, and Selig (2013) explored this phenomenon within a meta-analysis of 55 studies that compared the use of concrete manipulatives in mathematics instruction to teaching that relied solely on abstract symbols. Although their findings show that the use of manipulatives had only a small-to-moderate effect on student learning, the effectiveness of the manipulatives was often attributed to other instructional variables (e.g. level of guidance). Therefore, if teachers provide ample guidance with the students, using hands-on materials can positively impact student learning.

Concrete-Representational-Abstract method. The notion that manipulatives can build conceptual understanding is ingrained into the Concrete-Representational-Abstract (CRA) teaching strategy. Agrawal and Morin (2016) define the CRA method as the "process in which the teacher guides the student through a mathematical concept and its corresponding computational process through the use of manipulatives and visual representations that illustrate the concept along with numbers" (p. 35). Simply stated, within the CRA process a teacher guides students through three stages of a mathematical concept, gradually becoming more abstract.

The first stage of the CRA method uses concrete materials that can be held and manipulated by the child, such as counters, chips, cubes, and base-ten blocks. Figure 1 presents how a teacher could use cubes and a balance to compare two-digit numbers. The second stage of instruction moves to semi-concrete representation, and primarily uses pictures and models to represent the concept. When modeling magnitude comparison at the representational stage, a teacher may use drawings of tens rods and ones to show the greater number. Finally, when the child has mastered the concept at both the concrete and representational levels, the teacher can introduce the concept in abstract terms. At the abstract level, concepts are shown only with numbers and symbols (i.e. 23 < 51).

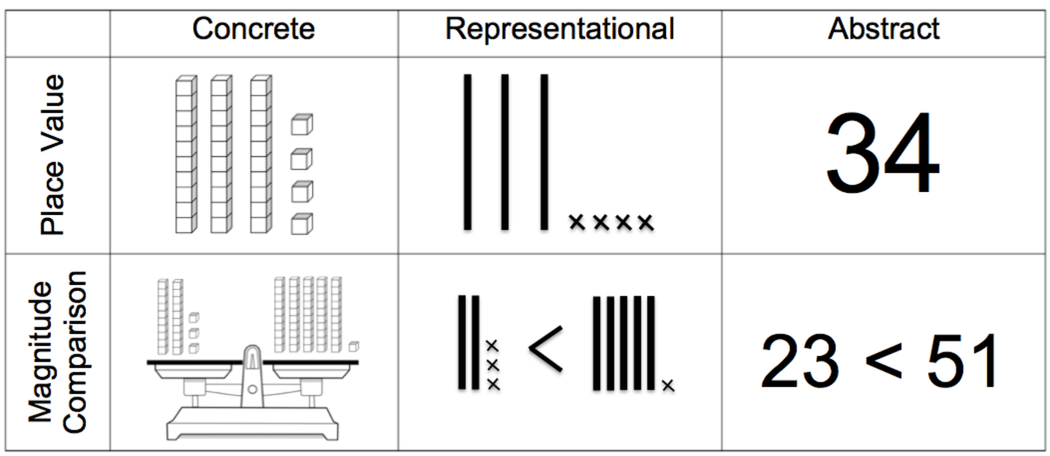


Figure 1. Math skills scaffolded using the Concrete-Representational-Abstract method

The National Research Council (2001) states that “students’ experiences using physical models... can be effective if the materials help them think about how to combine quantities and, eventually, how these processes connect with written procedures” (p. 198). The goal of the CRA technique is to help students make a connection between the manipulatives and the symbols. Bryant and colleagues (2008) corroborated this notion, finding that effective math interventions included opportunities to use number cards, number lines, hundreds charts, and models that reinforced the count sequence. Flores (2010) used the CRA method to teach subtraction with regrouping to elementary students who were failing. After receiving interventions that followed a CRA sequence, students’ subtraction fluency scores increased dramatically. Agrawal and Morin (2016) also found that the CRA approach is beneficial for students with mathematical difficulties (MD). Taken together, these findings indicate that quality math instruction follows a CRA transition and uses concrete manipulatives and models before introducing abstract concepts.

The CRA teaching method can be applied to nearly any mathematical concept. The NRC (2001) notes that “acting out” problems with real objects is a “simple but powerful approach [that] keeps procedural fluency closely connected to conceptual understanding and strategic competence” (p.184). Not only does a CRA sequence promote conceptualization, but it is also inherently scaffolded. Studies show that when activities build on previous skills, there is a higher likelihood of transfer to more complicated tasks (Jordan & Dyson, 2014). New content is made accessible and comprehensible when students engage in hands-on learning. When developing early numeracy skills, teachers should provide ample opportunities to work with real objects and follow a CRA teaching method.

Basic fact retrieval. Once children have been introduced to whole numbers, they can start manipulating them. In preschool, children first interact with concepts of addition and subtraction as "adding to" and "taking from." By the end of first grade, children have honed their skills and should be able to represent and solve addition and subtraction problems within 20 (NGACBP, 2010). Addition and subtraction facts with a sum or minuend of less than 20 are commonly referred to as basic facts. Also by the end of first grade, students are supposed to "use place-value concepts and properties of operations to add and subtract within 100" (NGACBP, 2010, p. 2). Although there is no mention of mental strategies within these standards, it is exceedingly difficult to add two-digit numbers if basic facts are not yet mastered. For example, if a child cannot solve 2 + 4 using mental math, solving an equation like 72 + 14 becomes daunting, if not impossible. That child may resort to using their fingers or jumping on a number line to solve the problem. Using a number line to solve basic facts is a reliable but timely strategy. Research has shown that students who have not memorized their basic facts are likely to experience cognitive overload when performing more complex procedures (Woodward, 2006). This cognitive overload can lead to frustration and poor accuracy.

Automaticity. To avoid this frustration, it stands to reason that young learners should strive for automaticity in solving basic facts. Automaticity is defined as "the ability to deliver a correct answer immediately from memory without conscious thought, as opposed to relying on calculation" (Stickney, Sharp, & Kenyon, 2012). Most researchers agree that a child has reached automaticity if he or she can recall an answer within three seconds (e.g. Woodward, 2006). Although automaticity is a priority for both American students and teachers, children still do not know their basic facts as well as they should. NMAP (2008) notes how children in the United States today, when compared to children from other nations and even previous generations of American children, are not reaching "the point of fast and efficient solving of single-digit addition, subtraction, multiplication, and division with whole numbers" (p. 26). Students with special needs have a more difficult time memorizing their basic facts. Hasselbring, Goin, and Bransford (1988) found that first graders with learning disabilities recalled significantly fewer facts than their peers. By middle school, this gap had widened; Students with learning disabilities only retrieved a third of the facts their classmates recalled. Across the nation, both students with and without disabilities struggle to answer basic facts automatically.

Development of addition problem-solving. These students may be having difficulties with automaticity, in part, because they rely on immature and rudimentary approaches to problem-solving. Geary (2004) broke down the typical progression of problem-solving procedures used for tackling addition equations. Geary found that children systematically progress through a series of stages to solve addition facts, including:

Counting all. Younger children start solving addition equations by counting both addends using finger counting or verbal counting. For example, when given five red candies and four yellow candies, a novice may touch each candy individually to derive the total.

Counting on. As children develop a more conceptual understanding of the count sequence, they will transition from counting all units to merely counting on from the higher addend. For example, the child would start at five and count on "six, seven, eight, nine."

Decomposition. Often after direct instruction has taken place, a child will notice how basic facts relate to one another. For instance, a child may realize that 4 + 5 is simply 4 + 4 + 1. Students often decompose equations using facts that are already memorized.

Direct retrieval. When children can retrieve correct answers from long-term memory, that is known as direct retrieval. If students can respond without hesitation, they have also achieved automaticity.

Geary (2004) compared the problem-solving methods used by students with and without mathematical difficulties. The study found that students with mathematical difficulties relied on earlier stages of problem-solving (i.e. counting all) and made more counting errors than their typically achieving counterparts. Explicitly teaching problem-solving strategies can hasten a students' progression through these stages and help them become automatic in their basic fact retrieval.

Strategy-based approaches. When considering how to help students move from the rudimentary to advanced stages of problem-solving, a great deal of research recommends teaching facts based on rules, rather than mere memorization (Tournaki, 2003; Woodward, 2006). Woodward (2006) explored the dichotomy between strategy-based instruction and drilled practice with fourth-grade students learning their multiplication tables. Students who were instructed on multiplication rules (e.g. Doubles, times nine patterns) outperformed students whose interventions only incorporated timed drills. Tournaki (2003) found similar results with second-grade students learning addition facts; Second graders with learning disabilities only showed growth after receiving interventions that focused on strategy. Bryant and colleagues (2008) also found that when interventions followed a CRA sequence and featured fact families (the commutative property) basic fact retrieval was improved. Taken together, it is clear that focusing instruction on strategies instead of memorization helps improve fact fluency. Table 1 summarizes the most common strategies for teaching addition facts.

Table 1

Strategies for Teaching Addition Facts

Strategy	Description	Example
Counting On	Counting on is typically reserved for addition equations that have an addend that is either one or two. Children are taught to quickly identify the larger number and then count on to find the sum.	7 + 1
Doubles	Doubles facts are those equations which add the same addends together. Doubles are often taught with mnemonic devices to help memorization, such as referring to 4 + 4 as the "spider fact."	3 + 3
Making Ten	Making ten equations are when both addends add up to ten. Teachers commonly use ten-frames as concrete representations of these facts before expecting direct retrieval.	4 + 6
Identity Property	Addition equations that add zero to an amount illustrate the identity property. When zero is added to a number, the number stays the same.	9 + 0
Commutative Property	Equations that feature the same addends and sum follow the rules of the commutative property. These facts are commonly referred to as related facts or "fact families."	3 + 5, 5 + 3

Note. This is a compilation of the most common strategies within the literature.

Strategy-based instruction might be effective because it promotes transfer. Purpura, Baroody, Eiland, and Reid (2016) assert that highly guided discovery of a skill connects prior knowledge with new content to transfer competencies. When educators instruct students on strategies, children start to organize their basic facts into a comprehensive repertoire. When aiming to improve basic fact acquisition, strategy-based instruction should be used instead of "drill and kill."

The challenge of teaching early numeracy skills. Within the previous sections, I discussed why both number sense and basic fact fluency are imperative for later mathematical success. I also addressed some instructional methods that practitioners may use to develop these critical skills. If teachers designate ample time and provide opportunities for students to enhance their number sense and basic fact acquisition, students will thrive.

On the other hand, the NRC (2009) fears that the breadth of content teachers must cover (e.g. geometry, measurement, fractions, etc.) during a single school year, may spread "mathematical experiences too thinly" (p. 124). Instructors who rush through curriculum may inadvertently limit number sense and computational development opportunities. Educators should consider alternatives to whole group instruction in order to develop the number skills and early operations that are critical for advanced mathematics.

Response to Intervention

Too much content and too little time are just some of the challenges teachers face when teaching math. On a questionnaire about the problems of teaching mathematics, 90% of elementary teachers strongly agreed that the various ability levels of students were a major challenge (VanDevender, 1988). Teachers are well aware of the diverse needs of their students. It is estimated that between five and eight percent of school-age children have mathematical difficulties (MD) that impact their ability to perform on grade-level (Geary, 2004). When faced with struggling students, educators may be unsure of how to effectively close the achievement gap. Morgan, Farkas, and Maczuga (2015) found that many first grade teachers continue to employ ineffective teaching strategies with students with MD. Taken together, these studies show that some students face inherent difficulties, while teachers struggle with adequately supporting a wide range of student (dis)abilities.

A closer look at classroom practices may give insight as to why MD arise and how they worsen. One cause may be that classroom teachers are relying too heavily on whole-class instruction. Whole-class instruction reaches all students at the same time but lacks individualization. If a shopper came across a shirt that was marketed as one-size-fits-all, he or she would be justifiably skeptical. They might wonder how a single shirt could be suitable for a wide range of body types.

Similarly, practitioners might wonder how one-size-fits-all instruction possibly meets the needs of every learner. With plummeting mathematics scores and a population of students with MD, traditional whole-class teaching may be falling short (OECD, 2018; Geary, 2004). It is time to look at how math challenges can be alleviated and prevented by supplementing whole-class instruction.

The history of RtI. A Response to Intervention (RtI) approach involves adding tiered, small-group interventions that supplement core instruction. RtI is defined by Gersten and colleagues (2009) as "an early detection, prevention, and support system that identifies struggling students and assists them before they fall behind" (p. 4). RtI became popularized after the enactment of No Child Left Behind in 2001 (Howell, Deiotte, & Patton, 2008). Former President George W. Bush sought for school accountability. For the first time, schools accepted that all students, even those with special needs, can be successful with proper support (Howell et al., 2008). In part, this support came from RtI's tiered and targeted interventions that were developed to support at-risk students and prevent further problems.

The RtI model is typically represented by a triangle, depicting the hierarchy of interventions. Figure 2 shows each of the three levels of prevention. The bottom and largest portion of the triangle represents the quality universal instruction that every student receives from their classroom teacher. This first

Figure 2. Tiers of intervention by percentage (Howell et al., 2008)

level is often referred to as core instruction. The middle of the pyramid is the second tier of prevention. The lowest performing 10 to 15% of students receive targeted interventions in addition to core instruction. For example, in a classroom of 25 students, three or four students might need to be pulled out for additional support. Finally, the highest tier of the pyramid represents the one to five percent of students who receive the most intensive and rigorous interventions. In that same classroom of 25 students, one or two students may be pulled out for extra practice from half an hour to an hour every day. These times are approximations and could be higher or lower depending on the number of interventionists available within schools (Howell et al., 2008). Clarke, Doabler, Nelson, and Shanley (2015) state that "when implementing a multitiered model of academic support in mathematics, some students will struggle to achieve grade-level mathematics objectives with only Tier One instruction" (p. 3). One-size-fits-all instruction simply does not work for all learners. In the next section, I will detail the components of sound RtI interventions, specifically explicit and systematic instruction, and detail why students with mathematical difficulties may benefit from this approach.

Explicit and systematic instruction. One of the central tenets of RtI is the use of explicit and systematic instruction. A great deal of research has shown the benefits of using direct instruction when conducting targeted interventions. Explicit instruction is defined as "an unambiguous and direct approach to teaching that includes both instructional design and delivery procedures" (Archer, 2011, p. 1). Mathematical interventions commonly follow systematic stages by gradually releasing student responsibility. Bryant and colleagues (2008) suggest that intervention lessons consist of a review of prior skills, a preview of new content, teacher-modeling, and guided practice with corrective feedback.

The scaffolded nature of explicit instruction lends itself well to working with students with mathematical difficulties. Explicit and systematic instruction can improve students with learning disabilities' computation and problem-solving proficiencies in both familiar and novel situations (NMAP, 2008). Additionally, direct instruction can expose young learners to the abstract concepts of the base-ten numeration system and help them to develop a comprehensive understanding of number sense, place value concepts, and early operations

(Bryant et al., 2008). Despite the push for student-centered instruction, Morgan and colleagues (2015) found that more frequent teacher-directed instruction was associated with greater gains in achievement for first-grade students with mathematical difficulties. This suggests that curricular interventions are more effective when practitioners use precise language and structured scaffolding. When students have poor number sense and lack fact fluency, it may be necessary to conduct Tier Two interventions before these delays become detrimental.

Tier Two interventions in mathematics. Ample research has shown that tiered and targeted interventions can significantly increase a child's reading ability (e.g. Foorman, Francis, and Fletcher, 1998). Although the effects of math interventions have been less widely studied, more and more research is being conducted on this topic. In 2005 when RtI in mathematics was becoming popularized, Fuchs and colleagues conducted a randomized controlled trial to analyze the effects of Tier Two interventions on first graders' math achievement. Participants of this study included 564 students from 10 metropolitan schools. The 139 lowest performing first-grade students were randomly assigned to receive tutoring (n = 70) or control conditions (n = 69). The tutoring group received intensive 30-minute interventions that focused on building number sense through a CRA model and 10 minutes of fact fluency with computerized practice (Fuchs et al., 2005). At the end of the trial, results showed that Tier Two instruction had significant impacts on at-risk students' number sense and word problem-solving abilities. The only area where intervention students did not show growth was on fact fluency, which was the major emphasis of the technological component (Fuchs et al., 2005). These findings validate the use of tiered models for underperforming students but highlight the risk of relying on computerized practice. Teachers should be cautious if they elect to designate intervention time for computer or iPad games.

Other research supports the use of two tiers of prevention and suggests that supplementary instruction can alleviate mathematical difficulties. Bryant and colleagues (2008) conducted a study with first graders in a suburban school district in central Texas during the 2006-2007 school year. Students with math difficulties received scripted "booster" lessons four times a week within small groups. At the end of the year, results from the Texas Early Mathematics Inventories (TEMI) assessment showed significant improvements on Tier Two students' number sense and arithmetic combination performances. In a similar study, 319 kindergarten students in the metropolitan area of Boston, Massachusetts received the ROOTS intervention for 20 minutes a day, for approximately 10 weeks (Doabler et al., 2016). The ROOTS program prioritized principles of explicit instruction and gave students opportunities to verbalize mathematical thinking and discuss problem-solving methods. Students in the

ROOTS condition made greater gains than control students on five of the six measures that looked at early numeracy skills and number sense (Doabler et al., 2016). Tier Two math interventions provide a necessary boost by a) giving struggling students additional time on fundamental skills and b) providing assistance and feedback from a teacher (Bryant et al., 2008). The research suggests that Tier Two interventions in as little as 20 minutes a day can support students who are, or at risk of, falling behind. Supplemental instruction may not eliminate but, could significantly reduce an achievement gap for students with MD.

Fuchs and colleagues explored the relationship between core (Tier One) and targeted (Tier Two) instruction. Within their 2008 study, 120 third grade classrooms were randomly assigned to either whole-group instruction on HotMath (a schema-broadening program) or conventional instruction. Additionally, any students with MD were then assigned to either receive HotMath tutoring or not. Tutoring sessions were administered to small groups of students for 20 to 30 minutes a day for 16 weeks. At the end of the study, students who received both schema-broadening core instruction *and* tutoring sessions performed better than students who only saw HotMath within intervention (Fuchs et al., 2008). This finding suggests that when interventions occur in conjunction with quality whole group instruction, interventions are significantly and substantially more effective.

Teachers should align interventions with core instruction as much as they can. For example, if the whole class circles keywords within word problems, interventionists should incorporate this strategy in small group settings. Students will be more likely to transfer their understanding to and from interventions when techniques are similar.

In the previous sections, I took a closer look at the downfalls of core instruction and discussed how this one-size-fits-all approach leaves the lowest 20% of students at a disadvantage. A RtI framework may be a viable solution to this problem. While the effects of targeted and intensive reading interventions have been studied for decades, research has only recently turned toward tiered math instruction. Studies suggest that explicit and brief math interventions can alleviate or prevent mathematical difficulties by promoting number sense and basic fact retrieval for our youngest learners.

Summary

Despite the adoption of the Common Core State Standards, the United States' math scores are worsening (OECD, 2018; NCES, 2017). There are a number of reasons that our education system is failing to prepare our students in mathematics. These failures could be a result of the amount of content teachers must cover within a school year (NRC, 2009), an instructional focus on memorization instead of conceptualization, and a broad range of student abilities in a single classroom (VanDevender, 1988; Geary, 2004). These challenges have had lasting effects on students and teachers alike.

Most importantly, these factors have limited the development of early numeracy skills, like number sense and basic fact retrieval, that are crucial for advanced mathematics (Jordan, Glutting, & Ramineni, 2010). Teachers can promote number sense by using manipulatives and a CRA teaching method that scaffolds abstract concepts (Flores, 2010; Agrawal & Morin, 2016). Additionally, practitioners can use strategy-based instruction to increase fact fluency instead of mere memorization (Tournaki, 2003; Woodward, 2006). These instructional techniques foster an understanding of our base-ten numeration system and promote automaticity with basic facts.

There is no doubt that students are experiencing math deficits. Even when employing the aforementioned strategies, relying solely on core instruction may not completely alleviate these problems. Tiered interventions should be used to detect, prevent, and support students with mathematical difficulties (Gersten et al., 2009). Recent research suggests that struggling students benefit from Tier Two interventions that are explicit, systematic, and hands-on (Fuchs et al., 2005; Bryant et al., 2008; Doabler et al., 2016). Within my action research, I will explore the impacts of targeted Tier Two interventions on my first-grade students' number sense and basic fact retrieval.

Research Design and Methodology

Problem of Practice

I had a math problem and the answer was not in the back of the book. As a first grade teacher, I noticed students with poor number sense who were falling behind. It didn't help that the math program my district purchased from a popular publisher was rapid and rigorous. Students were often exposed to a new competency for one brief lesson and moved on to something else the next day. The curriculum, as written, did not allow time for students to interact with previously taught material or integrate skills. I noticed that a handful of my students consistently performed poorly on unit tests. When I conducted error analysis on their mistakes, I often found that the students' answers were unreasonable and showed a lack of conceptual understanding of numbers. The constraints of my program's pacing guide made it difficult, if not impossible, to fill in these gaps in understanding within core instruction. This begged the question: How could Tier Two interventions alleviate these deficits?

Over the course of eleven weeks, I conducted 20-minute small group math interventions two to three times a week, targeting various early numeracy skills. I taught strategies and skills explicitly and systematically, gradually releasing responsibility to ensure student success. I followed a CRA approach by providing hands-on experiences with concrete materials like cubes, counters, and chips, before transitioning to abstract concepts such as numerical equations. I instructed students on addition strategies like Counting On and Doubles. Students played skill games with their peers and the teacher to reinforce any new concepts. Throughout this action research, I documented the impacts of the tiered and targeted interventions on students' mathematical achievement, specifically their number sense and basic fact retrieval.

Setting and Participants

My study was conducted in an elementary school in eastern Pennsylvania that serves 253 students in kindergarten through fourth grade. The rolling hills and farmlands that surround my school provide a distinct juxtaposition from the urban setting of the other schools within my district. Consequently, the elementary school where I teach is the only school in the district that does not qualify for Title I funding. My school serves a largely white and affluent population, with only 23% of the students receiving free and reduced lunches ("Williams Township Elementary School," 2018). My school already has a strong RtI framework in place for supporting emergent readers. Nearly a quarter of all first graders receive Tier Two phonics interventions daily. Although we have been successful using RtI to support readers, no such efforts have been used for math.

My classroom demographics largely mirror the schoolwide demographics. My first-grade class is mostly white, with only 12% of students identifying as ethnicities other than Caucasian. Many of my students' parents are teachers, doctors, or local business owners. This year I have 26 students in my room, thirteen male and thirteen female, aged six- and seven-years-old. Only two students have Individualized Education Programs (IEP) and receive speech and language services. None of my students have been diagnosed with a specific learning disability.

Throughout the course of this study, 11 of my 26 students received the math interventions at some point in time. These 11 students, five male and six female, qualified for additional assistance based on their performance on the beginning of year DIBELS Math benchmark assessment. Of the 11 students, two scored well below benchmark, indicating that they were likely to need intensive support. Five students scored below benchmark. The remaining four students were included in an intervention group because they scored below benchmark on a subtest (e.g. Number Identification Fluency) and scored below 80% proficiency on further diagnostic assessments (e.g. Subitizing 1-10).

Data Collection Methods

I collected both quantitative and qualitative data throughout this action research to determine students' number sense, basic fact retrieval, and ultimately, the effectiveness of tiered math interventions. Before starting the math interventions, a team comprised of myself, my school's RtI specialist, and a learning support teacher, administered the DIBELS Math universal screener. The DIBELS Math measures a variety of skills ranging from place value concepts to strategic counting. All of these competencies relate to an overarching understanding of what numbers represent and how they work together. If a child's composite score indicated a need for strategic or intense intervention, I then administered diagnostic assessments that tested specific competencies (e.g. subitizing) and helped me to form my intervention groups and target skills. Students also completed a Rocket Math two-minute addition test prior to the start of interventions. The DIBELS Math Computation measure and the Rocket Math assessment showed me if students could access their basic addition and subtraction facts quickly and could apply those strategies in order to solve the given problems.

Once the intervention groups were set in motion, I gave daily independent practice opportunities and documented the results within students' intervention logs. Within the intervention logs, I recorded the target skill, the instructional strategies that were used, the results from the daily independent practice, and any behavioral information worth noting. I also collected and coded any student work samples that were completed during the session. When a student showed mastery of a skill, I readministered diagnostic assessments to exit them from their current intervention and determine the next area of need. Throughout this process, I also kept my own detailed field log where I reflected on these experiences.

At the culmination of this study, students took the middle of year DIBELS Math benchmark test and were given a follow-up Rocket Math two-minute test to reassess their number sense and basic fact acquisition. In the following sections, I will describe each of these data collection methods in more detail.

DIBELS Math. My primary tool for pre- and post-intervention data collection were the DIBELS Math measures for universal screening. Despite the fact that DIBELS Math is still in an early release stage, there has been significant research conducted on the measures since their pilot in 2006. The What Works Clearinghouse recommends the use of universal screeners to determine which students are at-risk of mathematical difficulties and may benefit from intervention (Gersten et al., 2009). Furthermore, they implore that schools "evaluate and select screening measures based on their reliability and predictive validity, with particular emphasis on the measures' specificity and sensitivity" (Gersten et al., 2009, p. 13). The DIBELS Math measures are research-based and are a reliable way for me to gauge my students' mathematical understanding. There are five measures that comprise the DIBELS math screener: Number Identification, Next Number Fluency, Advanced Quantity Discrimination, Missing Number Fluency, and Computation.

Number Identification Fluency. The Number Identification Fluency measure is only administered in the fall of first grade. It is a one-minute timed assessment that asks students to orally identify one and two-digit numbers.

Next Number Fluency. The Next Number Fluency measure is also only administered at the beginning of the year. It is a timed one-minute assessment that asks students to say the next number in a sequence. For example, if the administrator says "42" then the student should reply with "43" because that is the next number in sequential order.

Advanced Quantity Discrimination. The Advanced Quantity Discrimination (AQD) measure is administered at the beginning, middle, and end of first grade. It is a one-minute timed assessment that asks students to determine a larger quantity when comparing two two-digit numbers. For example, when looking at 57 and 82 the student should answer "82" because that is the higher amount. AQD assesses if students can identify larger quantities using place value concepts.

Missing Number Fluency. The Missing Number Fluency (MNF) measure is also administered in all three first grade benchmark assessments. It is a one-minute timed test that asks students to determine the missing number in a series. The series could be counting sequentially or by fives and tens. For example, when looking at "45, 50, ____, 60" the student should answer "55" because that is the missing number when skip counting by fives. MNF assesses a child's ability to recognize number patterns and count strategically.

Computation. The Computation measure is also administered at the beginning, middle, and end of the year. It is the only paper and pencil DIBELS Math measure. Students are given two minutes to answers as many addition and subtraction equations as possible.

Composite scores. Scores on the previous DIBELS Math measures are compiled and determine a child's composite score. The composite scores provide clearly defined cut points that are used to predict if a child will need core instruction, strategic support, or intensive support to perform grade-level mathematics.

Rocket Math two-minute test. Rocket Math is a program that was purchased by my school district to help students develop automaticity with their basic facts. In my first grade classroom, we use Rocket Math: Addition. One of the components of Rocket Math is a two-minute test that can be used intermittently to assess students' addition fact fluency. The equations are randomized with sums ranging from one to 18.

Diagnostic assessments. We know that number sense is multifaceted and comprises concepts from cardinality to magnitude. Although the DIBELS Math and the Rocket Math assessments provide an overview of students' early numeracy skills, they lack the specificity needed to organize targeted interventions. To fill in these gaps, I administered several different forms of diagnostic assessments to gauge students' understanding of more nuanced competencies such as subitizing, counting to 100, or adding zero. If students scored below 80% on any of these diagnostic assessments, that was considered an area of need. All of the diagnostic assessments used in this study were purchased from Teachers Pay Teachers. A sampling of these assessments can be found in Figure 16 in the data analysis section.

Intervention logs. Some of the most valuable insights I gained from this study were from my students' intervention logs. I monitored each child's progress through the intervention groups in their own individual folder. Each intervention log had a section for me to record the target skill for that day, the instructional methods and activities that were used, and the results of the student's daily independent practice. The students' intervention logs also included a section for miscellaneous notes.

Student work. Most intervention sessions involved hands-on gameplay, of which there was little concrete evidence to collect. However, there were a few paper-pencil activities, especially during our addition strategies topic, that I analyzed and coded. I collected these student work samples and placed them within the pockets of the students' intervention logs for safekeeping.

Field log. As the saying goes, my researcher's field log is my last, but certainly not my least important data collection method. I kept a very detailed field log and teacher journal on a running Google Doc throughout this process. I captured some important moments in my classroom using vivid descriptions. Every day I typed anecdotes and was diligent in writing the truth: good, bad, and indifferent. I provided reasoning for the decisions I made regarding the grouping of students and instructional methods.

Procedures

I began my research study about a month into the 2018-2019 school year. I started my year as I always do: building a strong rapport with students and establishing classroom routines and procedures. One day in mid-September, I called my students to the carpet and explained that this year, for the first time, we would be having math groups and centers. Over the next few weeks, while collecting baseline data, I introduced the students to the various centers they would be visiting during our math group time. I knew it was important to thoroughly model and explain each of the activities. I wanted to ensure that students could work independently at centers while I pulled small groups to the back table for interventions. By the second week in October, students were gathering materials and navigating the math centers by themselves. I was finally able to start conducting my targeted interventions. For the next eleven weeks, I conducted 20-minute small group math interventions two to three times a week, targeting various early numeracy skills. Below you will find a brief timeline for data collection as well as the skills that were targeted over the course of this study.

September:

- Administered the DIBELS Math universal screener
- Administered the baseline Rocket Math two-minute test
- Discussed the research with students
- Compiled student assent forms
- Sent home parental consent forms
- Completed preliminary field log entries

October:

- Conducted further diagnostic assessments
- Determined the initial intervention group and skill
- Instructed on subitizing amounts less than ten
- Kept student intervention logs
- Collected student work samples
- Completed daily field log entries

November:

- Conducted further diagnostic assessments
- Adjusted the intervention group and target skills
- Instructed on oral counting to 100
- Instructed on number identification to 100
- Kept student intervention logs
- Collected student work samples
- Completed daily field log entries

December:

- Conducted further diagnostic assessments
- Adjusted the intervention group and target skills
- Continued instructing on number identification to 100
- Addressed the "Zero Mirror," Counting On, and Doubles addition strategies
- Kept student intervention logs
- Collected student work samples
- Completed daily field log entries

January:

- Administered the DIBELS Math universal screener
- Administered the Rocket Math two-minute test

Trustworthiness Statement

Every year a new group of children is confidently entrusted to my care. During the school year, my students will often spend more waking hours with me than their own parents. More so than academic achievement or test scores, my focus is on acting in the best interest of my students. Assuring a child's wellbeing is even more important when conducting action research. Parsons (n.d.) describes five ethics guidelines that protect our youngest subjects, including minimizing the risk of harm, obtaining informed consent, protecting anonymity and confidentiality, avoiding deceptive practices, and providing the right to withdraw. I followed these strict obligations to ensure an ethical study. Furthermore, Moravian College's Human Subjects Institutional Review Board (HSIRB) reviewed my research proposal and granted me permission to conduct action research in my first-grade classroom (Appendix A).

Before starting the data collection process, I obtained informed consent from my building principal, my students, and their legal guardians. I presented an overview of my action research proposal to my principal, seeking his permission (Appendix B). Additionally, I sent home letters with my students thoroughly explaining the purpose of my research and how I would be gathering data to gauge the impact of the interventions on students' number sense and basic fact retrieval (Appendix C). These letters also stated that a child's participation was optional and could be revoked at any time. If guardians allowed their child to participate, I kept their signed permission slips for the duration of the study. I also gained student assent before collecting data (Appendix D). During class time, I explained my research in a developmentally appropriate manner. I read aloud the student assent forms before students completed them independently. Informed consent was a crucial first step in this process. Subjects thoroughly understood what the research entailed and how they would be involved.

Although any of my students could receive math intervention as a part of my typical instruction, I only used data from students who were granted permission by their legal guardian and had given assent themselves. Participation in this research study was optional and any student could have withdrawn from the study at any time without being penalized. If at any point within the study a student, or their guardian, felt that interventions or assessments are adversely affecting the child’s mental health, they could withdraw and none of their data would have been used.

Any subjects who participated in this study are protected with anonymity and confidentiality. All students received pseudonyms within written reports. The only other person who had access to my data was my graduate professor. I kept all of my virtual files on my password-protected Google Drive. Hard copies of student work and assessments were kept in a locked filing cabinet in my classroom for analysis until June 2019. At that point, any remaining artifacts will be shredded and deleted.

As a first grade teacher, it was imperative for me to work with six- and seven-year-old subjects. Some of my subjects had speech and language difficulties or other special needs. As noted in McNiff (2017) children and individuals with disabilities are vulnerable populations that require due diligence in preventing harm. To minimize this risk of harm, I did not use any deceptive practices within my study. I was fully transparent with my students and used member checks to ensure that I was interpreting their thoughts and opinions correctly.

My research had the potential to adversely affect subjects by putting them at risk of psychological distress or discomfort. To alleviate any stress caused by additional instruction, interventions were kept brief and never lasted longer than 20 minutes. I provided ample scaffolding and errorless teaching strategies to ensure that my students felt supported and successful. I used positive behavior supports and praised student efforts to foster an empathetic atmosphere. To the best of my ability, I advocated for my students and abided by these ethics guidelines within my action research.

In addition to staying ethical to my students, I also assert trustworthiness by collecting qualitative data that is credible, dependable, confirmable, and ultimately, transferable to my field (Hendricks, 2017). Throughout my study, I recorded my observations regularly and actively within my field log. There, I took anecdotal records after each intervention session. I used rich and detailed descriptions in an attempt to paint a portrait of each scenario. Within these descriptions, I included specific behaviors I saw and heard from the students. Hopefully, these "thick" descriptions will be useful to other practitioners attempting to implement math interventions. After taking careful observations, I offered my hunches and impressions from those interactions. I continuously engaged in written reflection. My interventions and data collection were often modified to meet the needs of the learners. I provided explanations for any decision-making that changed the design of my study.

Hendricks (2017, p. 65) implores practitioners to use "multiple sources to corroborate findings." I collected data from a multitude of sources, not just my field log. I analyzed artifacts such as student work samples, universal screeners, diagnostic assessments, daily quick-checks, and intervention logs to triangulate my theories. I was sure to provide enough data to draw reasonable conclusions. By utilizing three or more pieces of data, clear patterns were demonstrated and the credibility of my results was solidified.

Finally, Hendricks (2017) urges teachers to reflect on their biases as to not let their preconceived notions prevent them from admitting unfavorable results. I was open to any and all findings that arose from the data. Data that did not support my hypothesis was purposefully analyzed in an effort to better understand why an approach was not effective. I met with my teacher research support group every week to discuss my study and my interpretations. By utilizing my peers' feedback, I was given the opportunity to counteract any biases that I may still have held.

Over the past several months, I have employed all of these strategies to ensure that my action research was both ethical to my students, and a credible and valid study. It is my sincere hope that my experiences will inform my own practice, and the teachings of others too.

My Story

Taking on Water: A Math Problem

My high school swim coach was a local legend. He coached for 39 years, with three state championship titles to his name. Although I swam under him in his last years before retirement, old age had not dulled his eagerness to push his swimmers to their limits. His favorite method of torture? Making us tread water while holding a five-gallon water jug over our head. I can still imagine the weight of the jug pushing me deeper and deeper into the water. My legs would churn but to no avail. Eventually, I would slip underneath the surface, exhausted.

In a sense, my students were barely keeping their heads above water within our math block. They may not have flailed their arms or sputtered water, but the signs were there nonetheless. One day, near the beginning of my study, I observed my students during one of our typical math lessons. They were seated at the front carpet while I was at the board modeling how to write an addition equation from a part-part-whole model. From the corner of my eye, I could see Sadie staring out the window, Braden contorting his body, and David whispering to a friend. Certainly, the benefits of direct instruction are lost when the students are not paying attention to what you are showing them!

The students' participation and focus did not improve during the guided and independent practice. Braden sat passively, waiting for me to write the equation on the board so that he could copy it without putting in any effort. When it was his turn to try some independently, I caught him glancing at his partner's paper. Sadie avoided the work in other ways. While writing a fact family, she accidentally wrote "7 + 2 = 5." I could read her expression across the room; She knew something was incorrect but did not know how to fix it. She left the rest of her worksheet blank. Even though this lesson was a review from kindergarten, a handful of my students were already struggling with the content. Clearly, they were feeling inadequate and were withdrawing from the lesson, or giving up entirely. They were slipping underneath the water.

Students' mathematical deficits were made obvious at other times in our day, not just between 12:30 and 1:15. For example, one time I asked my students to open up their reading books to page 96. Most students were able to find the page relatively quickly. When I noticed that Braden was still flipping through the pages, I went over to assist him. He was on page 153 and flipping forward into the higher pages. I explained to him that 96 was a smaller number than 153 and that he should be flipping backward not forward.

Another time, Braden was our calendar leader. One of his first jobs was to read the date. He started off with, "Today is September" and then paused, looking at me for help. He was unable to read the number 24. Later, when we saw that it was our 19th day of school, I asked what day of school would come next. He looked up at me, shrugged his shoulders, and said, “17?” Moments like these were troublesome to me. If Braden was having difficulties knowing the next number in a sequence, how in the world was he going to add numbers to 100?

Mathematical weaknesses may not have been as evident as reading difficulties in first grade. But when I looked closely, I could see how poor number sense permeated into other content areas. It was crucial for me to help students develop early numeracy skills because math is integral in everyday life. I knew that something needed to change, and soon. Someone needed to cast these kids a life preserver before it was too late. It was my hope that supplementary interventions would do just that.

The time came to kick start my study and explain my action research to my students. After taking our very first math test of the year, I noticed that I had about 10 minutes remaining in our class period. I called my students to the carpet and reminded them that even teachers go to school to learn new things. I told them that this year was very special for me because I would be doing research on our math groups and writing a book! I asked for their help with this endeavor. I explained how I would like to talk about what we do in math groups and the things we say when we talk about math. I told them that I might take pictures of their work and write down their scores on quick-checks. I assured them that no one would know whose work it was because in my “book” I would use fake names for them, sort of like how Superman hides his true identity. I promised them that if they decided to not be in my book, that it was “a-ok” and they would not hurt my feelings. If they changed their mind, even if it was all the way in December, that was ok too. Finally, I told them that with their help, other teachers might learn more about math groups and decide to do them in their classroom.

As the students went back to their desks to complete the student assent forms, I had two students come up to me with questions. They both seemed fixated on the idea of pseudonyms. Tanner asked if he should sign the paper with his real name, or his fake name. Chris stated, matter-of-factly, that he was going to be called “Hunter Superhero” because he likes hunting. As I collected their papers, my students were happy to tell me that they colored yes because I “am the nicest teacher!” There was one child who did not grant permission. As we lined up for gym class, I told the students that I was glad for their help with my book, but that it was no big deal if they decided it was not right for them. I am incredibly thankful to get to work with students who are supportive, enthusiastic, and open to change.

Throughout the end of September and the beginning of October, I introduced my students to the various math centers most of them would be working on while I held the interventions. All the while, I was collecting baseline data that would help me to determine students' number sense, fact-fluency, and above all, who was likely to need strategic intervention.

On September 14th I administered the Rocket Math two-minute test. When I started the timer, most students got right to work, chugging away on the problems using fingers, counting on, and number lines. About 15 seconds into the test, Chris raised his hand, visibly frazzled and red in the face. I motioned for him to keep going but he continued raising his hand. When I went over to him he said, "I don't know how to use a number line." I told him to try his best.

At first, I was impressed with the results of the Rocket Math two-minute test. These were the best beginning of year scores I had seen in my career. Students had solved an average of 10.4 equations in two minutes. I realized that boils down to roughly 11 seconds for each equation. That was *far* from the automaticity students needed to possess. Plus, the students overwhelmingly relied on their number lines. The number line can be a great tool before students transition to mental math strategies, but I do not want it to become a crutch. I wondered if they would perform as well on the other baseline assessments.

On September 27th and 28th, a team comprised of myself, a learning support teacher, and my school's RtI coordinator administered the beginning of year DIBELS Math benchmark assessments. All of my students were familiar with the timed one-minute probes from the DIBELS Next measures for early literacy but had never taken the math version of this universal screener. As you can see in Figure 3, 17 of the 24 participating students scored above the benchmark composite score. Five students scored below benchmark and another two scored well below benchmark, suggesting that they will need strategic and intensive instruction in order to be successful.

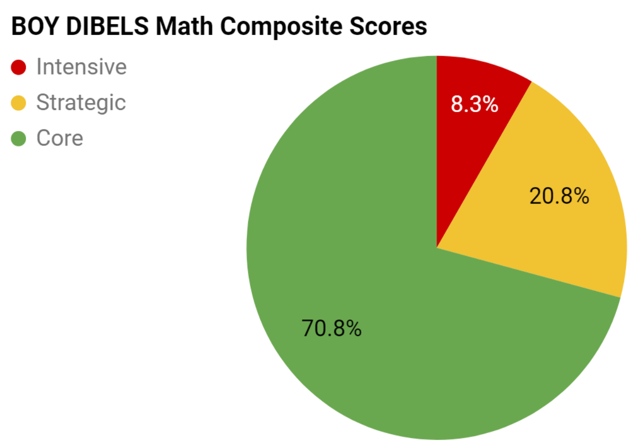


Figure 3. Baseline DIBELS Math composite scores

Considering this was the first time students had seen these measures, I was surprised that only 30% of students fell out below benchmark. Howell and colleagues' (2008) suggest that anywhere from one to 20% of the student body will need a tiered intervention. The baseline composite score breakdown was very close to Howell's recommendation which would make intervening manageable.

Although the DIBELS Math composite scores gave a succinct overview of students' mathematical literacy, the subtest scores offered a more detailed look at each individual's strengths and weaknesses. In Table 2 below, I listed the five measures from the beginning of year DIBELS Math assessment and the number of students who scored above benchmark (core), below benchmark (strategic), and well below benchmark (intensive). Analyzing students' mistakes on each measure also gave me ideas about mini-lessons I could include in my groups.

Table 2

Beginning of Year DIBELS Math Subtest Scores, n = 24

Measure	Core	Strategic	Intensive
Number Identification Fluency	14 students 58.3%	8 students 33.3%	2 students 8.3%
Next Number Fluency	15 students 62.5%	8 students 33.3%	1 student 4.2%
Advanced Quantity Discrimination	14 students 58.3%	6 students 25.0%	4 students 16.7%
Missing Number Fluency	17 students 70.8%	4 students 16.7%	3 students 12.5%
Computation	22 students 91.7%	1 student 4.2%	1 student 4.2%

On the Number Identification Fluency probe, 42% of my students performed below or well below grade level. This indicated that students were not frequently exposed to two-digit numbers and did not understand how place value was used to read them. Many students read the teen numbers as tens. For example, several students read 17 as “seventy” and 15 as “fifty.” Another common error was reading the digits in reverse, such as reading 73 as “37.”

My class did better on the Next Number Fluency probe but 38% of students were still below grade level. I can imagine that this task was easier for students to an extent because it was oral and did not require any number identification. In fact, there were very few mistakes on this measure at all. The only reason students failed to meet the benchmark was because they lacked automaticity.

The Advanced Quantity Discrimination assessment proved to be quite a challenge. Forty-two percent of students fell out below or well below grade level. I can understand how this measure would be difficult for students. Comparing numbers requires two separate skills. First, students need to use place value concepts to determine the larger number. Second, they need to identify that number. Some students knew the larger number but were unable to read that number correctly. For example, when shown 35 and 23, some students answered, “53.” They recognized that 35 was larger, but read the number incorrectly. It makes sense that Braden and Rose fell out on this skill because they also struggled on the number identification probe.

On the Missing Number Fluency test, 32% of my class did not reach the benchmark goal. Most students were able to recognize the missing number when the numbers were sequential. For example, if the sequence was "12, 13, ____, 15" most students could answer correctly. Several students could identify the missing number in a skip counting by tens pattern, with the exception of when the skip counting by tens were atypical such as 19, 29, 39, 49. Few students could find the missing number in a skip counting by five pattern. These results are unsurprising. Students learn to skip count by tens in kindergarten but are not formally instructed on skip counting by fives until January of first grade.

Students overwhelmingly performed best on the Computation measure, despite the fact that it was arguably the most difficult skill. Only eight percent of students were below benchmark on this subtest. This corroborated what I found on the Rocket Math two-minute test. Again, students were able to use their number line and fingers to answer problems quickly. However, more often than not, these responses were not automatic. When it comes to computing equations, students have circumnavigated mental math and have learned to crunch the numbers in other ways.

When I began collecting data at the onset of this study, I fully anticipated to hone in on computation and developing mental math strategies within my interventions. In actuality, it seemed that fact fluency would be the least of my concerns. As indicated by the DIBELS Math early numeracy measures, there were more rudimental skills, like number identification and the count sequence, that had to be covered within my interventions first. Unlike my infamous swim coach, I did not find satisfaction in watching my students flounder. It looked like my small group and I would be going back to the basics to develop number sense. Only then would students be able to keep their heads above water.

Back to the Basics: Subitizing

From the outside looking in, a level one swim lesson hardly looks like a swim lesson at all. As the swim instructor, I wade in the shallow end with a handful of preschool-aged children holding onto the gutter. Throughout the half-hour session, the kids practice blowing bubbles, closing their eyes and putting their heads underneath the water, and extending their legs to splash. Most importantly, the children learn to float. One by one, I take each swimmer just a few feet from the wall. While supporting their backs, I ask them to reach out their arms and legs as if they are a starfish. I remind them to turn their chins to the ceiling and push their belly button up as high as they can. When they are finally stable, I slowly remove my hands. For the first time, they feel the sensation of floating.

I suppose that my first round of math interventions did not appear math related at all. My back table was overflowing with dice, game boards, spinners, and picture cards. From the outsider's perspective, these materials probably appeared like activities from an indoor recess. However, to those who knew what to look for, they would see essential tools that were required in order to foster number sense. Just as floating is the foundation for learning to swim, we were developing the basic skills that were crucial for early mathematics.

When I analyzed the results of the DIBELS Math Number Identification measure, I found that ten of my students were not reading one and two-digit numbers with grade level fluency. As I know from analyzing screening results in literacy, sometimes you must backtrack and assess a child's preliminary competencies to see where problems arise. For example, if a child performed poorly when reading nonsense words, an interventionist would assess the child's phonemic awareness and alphabetic knowledge. If that child struggled with their letter names and sounds, interventions would target those foundational skills first before moving onto words with short vowels. This is exactly the course of action I took once evaluating the DIBELS Math results. Since some of my students struggled to identify their numbers, I assessed their subitizing and counting skills to see if there were weaknesses in these areas as well.

Lo and behold, when I administered a diagnostic assessment for subitizing numbers to 10, seven students scored below 80%, signaling a lack of proficiency. Students struggled the most with subitizing numbers greater than six. This made sense; Instructional materials typically use dice dot patterns, which only go up to six. Students also struggled subitizing the tally marks. They might not have known that a bundle of tallies equaled five. This limited their ability to count on. I knew that within my first intervention sessions I should review subitizing amounts one through six, but focus especially on giving strategies to quickly recognize amounts seven through 10. I would emphasize that dot patterns would not always be organized neatly as they are on a die.

On October 11th, I was finally able to pull an intervention group for the first time. Although there were seven students who needed instruction on subitizing, I knew that I had to keep my interventions small in order to provide quality feedback. Consequently, I only pulled Sadie, Liz, Braden, and David back for this group because they had the lowest composite scores on DIBELS Math. When the students were seated and ready at the back table, I rolled a giant foam die to grab their attention. When it landed, I said that the number I rolled was five. I knew that it was five, without even counting the dots! I told the students that when we recognize numbers quickly without counting, it is called subitizing. We can subitize with dot patterns, tallies, ten frames, fingers, and so much more. As a group, we recited the chant, “With our eyes, we subitize!” Over the next two and a half weeks, we began every intervention by cheering our subitizing slogan.

To illustrate how the students might already subitize, I gave each child a die. For a minute or so, students rolled their die and read the amount to their partner. I complimented how quickly they could rattle off the numbers. When I asked how they knew each amount, David responded, “I play a lot of games with dice.” Liz chimed in, “Yeah, this is easy.”

They were right, subitizing on dice was easy because the dots were organized. I told students that would not always be the case. Sometimes the objects would be scattered around randomly. Secretively, I placed a handful of red and yellow chips into a styrofoam cup. I shook up the cup and dumped the chips onto the table. I shouted that there were four. I noticed how three of them were clumped together and another was by itself. It did not look like a typical die pattern, but I still recognized that three and one more was four. I repeated this process a few times for amounts one through six and allowed the students to shout out the number.

Finally, I introduced our final activity of the day: fall flashcards. The fall flashcards pictured autumn objects like bats and candy corn in abnormal dot patterns. When I flashed a card, the first child to say the correct amount got to keep it. At one point in time, we encountered a card with eight pumpkins. I asked a few students to explain how they were able to derive the value quickly. Some students noticed two groups of four. Another student recognized the typical dot pattern for six and then added two more. After a few students had shared, we considered if one strategy was better than another. The students decided that as long as you recognized the number correctly, any strategy worked. It would have been all too easy to flip through the flashcards and move onto the next activity. However, by giving students the opportunity to have a short discussion, they were able to communicate new strategies to one another. This quick discussion made this experience far more impactful for the entire group. Within all of my interventions, I promoted discourse that encouraged students to share their reasoning.

In all, I held six intervention sessions on subitizing throughout the month of October. As I already described, the first instructional day was spent developing recognition of normal and abnormal dot patterns. The next two intervention sessions focused on subitizing with ten frames and tally marks. I started off by reminding students that ten frames were models that had ten boxes, five on the top row, and five on the bottom row. I told students that if they remembered how a ten frame was organized, it could help them to subitize amounts quickly. I gave each student a paddle with a ten frame and magnetic chips. Together, we built numbers one through ten. As we built the numbers, we discussed what each number looked like. For example, when we built the number six, we noticed that the top row was full with one more on the bottom.

Once we put the paddles away, I showed students some flashcards with ten frames to build automaticity. Despite the ease of flashcard games, I avoided playing them too often and for too long a period of time. Flashcards could become mundane and err on the side of "drill and kill" instruction. Instead, I transitioned the students into playing a game of 10 Frame Races, as you can see in Figure 4. Students flicked a paperclip spinner to land on a ten frame. Then, they

Figure 4. Students playing 10 Frame Races

colored in the correct amount on their recording sheet. The first child to color in all of their numbers won. At one point, I overheard David reading the spinner for his partner. I reminded him to let his partner recognize the number when it was his turn.

The following session was very similar but instead of subitizing with ten frames, students used tally marks. At the beginning of the lesson we used whiteboards and markers to make tally marks for numbers one through ten.

Again, I illustrated the importance of knowing that a bundle of tally marks was equal to five. I stressed how students could quickly count on from five to subitize a larger number. Afterward, students and their partners played a Roll and Color subitizing game that you can see in Figure 5.

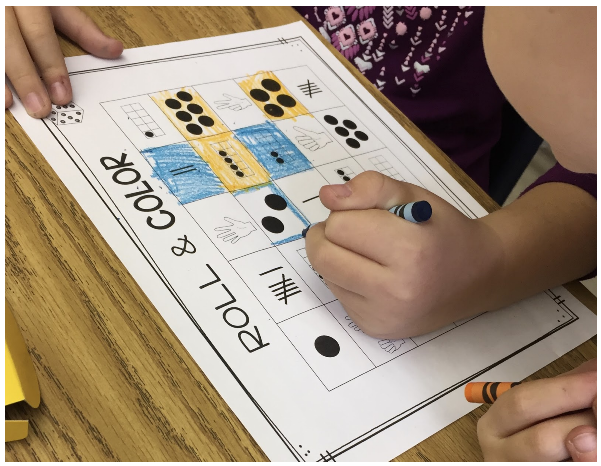


Figure 5. Students playing the Roll and Color game

The final three days of the subitizing intervention were a mixed review that integrated dot patterns, ten frames, tally marks, and fingers. Some of the activities, like subitizing bingo were both effective and engaging. Others fell flat. One of the most fruitful activities was also the quickest. Every day of our review, we played a game called Say It With Speed (Figure 6). Every child was presented with a paper faced down on the table. When I said “Go!” the child flipped over the paper and read the numbers aloud as I timed. To say that the students were motivated by the competition would be an understatement. When I would give students their time, they would cheer and high five one another.

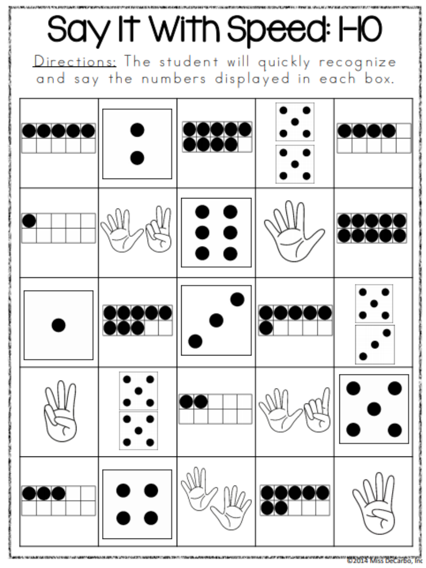


Figure 6. Say It With Speed, a subitizing game

Other activities were not so successful. I purchased a game called Blink. My initial thought was that the fast-paced game would be great for reinforcing subitizing one through six. Blink, similar to Uno, asks the players to match cards in their hand to a discard pile based on a color, shape, or amount. Unlike Uno, the amounts are not in digit-form but shown as picture patterns. When I showed the game to my group, David immediately recognized it and exclaimed, “Hey! I know this game! I play this at home!” However fun it was for students to play, it was not as effective for subitizing practice as I anticipated. Most students used the color and shapes, not the amount, to make their matches.

Despite occasional setbacks, I already started to see a difference in students receiving math interventions. On October 15th, Sadie volunteered to come to the board during whole group instruction, which rarely happened prior to intervention. There was an abnormal dot pattern on our worksheet. When I asked her how she knew the amount, she said, “Well, I see five and then three more. That’s eight.” She clearly applied her subitizing strategy by breaking down the dot pattern. I often wondered how well the targeted intervention skills would carry over into our whole group lessons. Luckily, it seemed that students were transferring concepts easily. Sadie must have felt more confident with her abilities too because coming to the board meant all eyes were on her.

The subitizing interventions were not only strengthening the students’ subitizing skills, but they were also adding to the students’ understanding of core mathematical concepts. On October 25th, our math lesson focused on using ten frames to solve facts with five (e.g. 5 + 3 = 8). My intervention students, who usually struggle during whole class instruction, had all of these facts correct during independent practice. I had an “aha” moment myself when I considered why this skill came so easily to them. Subitizing practice often required students to look at a group of five and add the leftovers. All this time we had been using tally marks and ten-frames, students had unknowingly mastered their +5 facts.

As the end of October drew near and my small group continually did well on mixed subitizing practice, it was time to gauge students' understanding and see if they were ready to move on to another skill. When I gave the second subitizing diagnostic assessment, three of the four students I worked with scored a 95% or higher. Figure 7 illustrates how each student improved from their pre- to their post-intervention test. Braden was the only one who scored below proficiency

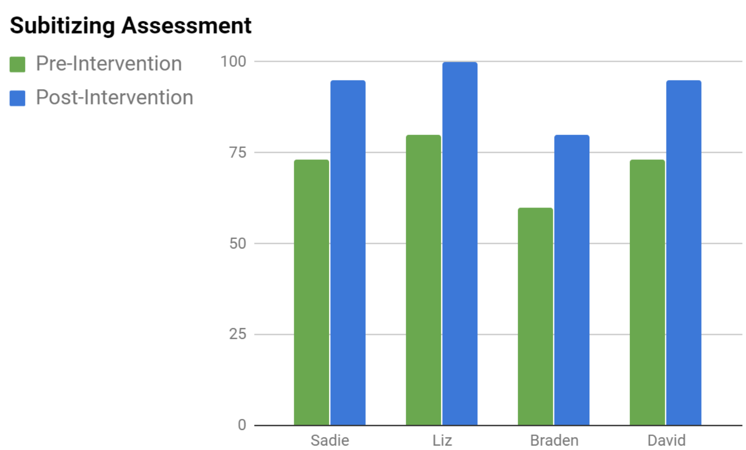


Figure 7. Subitizing diagnostic assessments pre- and post-intervention

with 80%. However, that was still a 20 point improvement for him. All of Braden's errors were with larger numbers, especially seven and eight. Although I felt confident moving our group forward into a different skill, I wanted to warm up every day with subitizing flashcards to help fill in these gaps for Braden.

Finding What Counts: Counting to 100

I was not the fastest swimmer on my high school or college swim team, but I was versatile. I could lead off a sprint freestyle relay and swim the individual medley in the same meet. I was a jack of all trades but a master of none. My coaches often put me in the 500 freestyle event, a grueling 20 lap race. This race presented a particular challenge to those unlucky enough to swim it. You had to hold a swift pace while being wary not to over exhaust yourself. Clocking in between five and six minutes long, this race also required each swimmer to have a counter. Your counter knelt at the opposite end of the starting blocks with a paddle of numbers. As you swam, the counter held the paddle under the water to remind you which lap you were on. It was always difficult to find a volunteer for counting. I can't say I blame my teammates; Counting was boring.

After the success of my subitizing group, I did not have any major concerns about teaching counting. How hard could it possibly be? Give students objects and reinforce one-to-one correspondence. I was sure that students would move out of this skill within a few days. In hindsight, I was wrong in more ways than one. Without having previously taught number identification, teaching counting became difficult when some children did not pick up on the oral pattern. Moreso, the counting activities I planned quickly became tedious and repetitive. The triumph I felt coming off of our subitizing intervention was over.

On October 30th, I called Sadie, Liz, Braden, David, Jade, and Chris to the back table. Each of these students had scored below grade level on the DIBELS Math Next Number measure, indicating that they had weaknesses with number sequences. Now that intervention groups were underway, I felt that I could handle a few more students at a time. As soon as David noticed the q-tips, beads, and toothpicks on the table, he asked, “Are we going to use *those* today?” I was happy that the manipulatives had sparked his curiosity and excitement. I told the group that yes, in this group we were going to use lots of different objects to practice counting. It was important to learn to count correctly. In fact, just that morning I had to count out popsicle sticks to make sure we had enough for our craft.

I explained that today we would be counting to 60. First, I modeled counting to 60 with red and yellow chips. I made sure to touch each chip individually and move it to the side as I went. As I counted, I arranged the chips into piles of 10. This would help me, I told the students, if I lost track of where I was. I could then skip count by tens to double check my work. Next, I divided the students up into pairs and they selected which manipulatives they wanted to use. The partners grabbed their objects and spread out on the floor to start counting.

That is when I realized my first mistake: collaborative counting was not very accurate practice. Chris and Braden attempted to take turns but did not listen to one another. Chris pushed over a q-tip and said “45” and a second later, Braden pushed another over and said “45” again. Jade and Liz were not faring well either. They had only counted about 30 beads. Jade explained, “We kept getting confused and had to start over.” Sadie and David were the only pair to successfully count out 60 toothpicks.

There was not enough time to revisit counting objects with a partner because I wanted to give students their daily independent practice. The students were given a page with 100 stars. They then found a quiet place to color 60 of the stars. Only Sadie, Jade, and Chris counted out the stars correctly. David accidentally counted to 70, and Braden and Liz only counted to 50. While the rest of the students prepared for specials, I pulled Braden aside and together we recounted the 50 stars he had colored. Then, I asked him what came after 50. He said, “60.” Clearly, he was mixing up counting by ones and skip counting. I corrected him, “Not quite. It goes 50, 51, 52. What comes after 52?” Braden hesitated briefly and then answered, “56?” Counting was proving to be a far more difficult concept to teach than I thought.

The following day I planned on revisiting counting to 60, but this time, with more guidance for the partners and using written numbers as a scaffold. I believed that Braden, and probably others in our group, would greatly benefit from connecting the oral counting with a hundred chart to reinforce number patterns. This was certainly not what I had expected would happen on our first day. But sometimes it is the lessons that fell flat that offer the most valuable insights into our practice.

The next day during math, Tanner walked up to me, bubbling, “I have iPad center today!” When I broke the news that he would actually be working with me in a math group, he was visibly disappointed, but still said, “Oh, I don’t care, because you play fun games right?” Hopeful that our session would live up to his expectations, I asked Tanner, Braden, David, Jade, Robert, and Addie to join me at the table. David greeted the new students with a welcoming smile, “This group is a little different than centers. You’ll see.”

From the get go, I started this session differently than I had the day before. I gave students a partial hundred chart. As a group, we pointed to each number on the chart as we counted aloud to 60. It was exciting to hear Robert, a child who is rarely on task during whole group instruction, counting along loud and proud. I emphasized the importance of the tens column on the hundred chart. I noted how after we say a ten we add one more and start the pattern all over again. For example, after 40 comes 41. Next, I modeled counting 60 dice, arranging the dice into groups of ten and then skip counting to check my work.

I did not want to abandon partner work altogether just because it had not been successful the previous day. So before the students chose their own partner and materials, I modeled what a counting collaboration should look like with

Figure 8. Students organize manipulatives while counting to 60

Addie. The partner practice was much better than the day before. The teams organized their piles into tens and even skip counted to confirm they had 60 in all (Figure 8).

Finally, we came back together and used the hundred chart to slash off numbers as we counted. The students' assessment was to color 60 flowers. All of the newcomers scored 100% on the diagnostic assessment. Jade only counted 59 stars. Likewise, David only counted 58 stars because he said, "46, 48, 49," and then "55, 57, 58." Again, Braden only counted 50 of the 60 stars. Before students went back to their seats, Tanner came up to me and said, " I had fun in your group!" This session was certainly an improvement from the first, but I was well aware that a few of those kiddos would need a lot more practice and repetition before they counted to 100 with accuracy.

On the third day of our counting intervention, I introduced a new warm-up game called What's Next. In this game, each child picked up a number strip that listed a series of three numbers and a blank, such as 67, 68, 69, ____. The child had to complete the series to win a point. After a few rounds, the number strips were replaced with single numbers, with the students being asked what number came next in the series. For example, if the number card read 43, the student would say "44." The students really enjoyed the new game and when I helped them to identify the number, they were quick to say what came next in the series.

The rest of our session was very similar to the previous two, except now our goal was to count to 80. On the diagnostic assessment, Liz, David, and Rose all scored 100%. I sat next to Braden as he counted out his candies for his independent practice. He slowed down and guessed randomly when transitioning from one ten to another. Once he was steadily counting, "77, 78, 79" but then paused abruptly before guessing, "6?" After each mistake, I showed Braden the number sequences on the hundred chart and had him point to the numbers as we recounted together.

As the students walked to the back table for our fourth day of counting practice, I heard David moan, "I really want to get out of this group." After he sat down at the table, I asked him why he wanted to be done with math groups. He said, "because I already know how to count to 100." Then Liz chimed in, "Me too." I could not help but be reminded of the kindergartener in Lisa Delpit's *Multiplication is for White People* (2012) who acted out in his reading intervention group. When the kindergartener was asked about his behavior, he expressed that he was sick of the "little p's." With this thought in mind, it did not surprise me that David and Liz were getting sick of counting. As much as I had tried to jazz up our activities by incorporating interesting manipulatives, partner work, and games, the fact of the matter was, counting was boring. I told them that they had shown great improvements in the past few days. I promised that today would be the last day for this group if they continued to do well.

Braden, who overheard this conversation, shrugged and said, "I don't really know how to count to 100." It never fails to astound me how self-aware six- and seven-year-olds can be. On the one hand, David and Liz were feeling unchallenged and perhaps belittled by this seemingly rudimentary skill. On the other hand, Braden realized that counting was something that he struggled with.

Luckily, David and Liz both counted to 100 correctly on that day's assessment. At the end of the session, I congratulated them on a job well done and told them that they were done with our counting group. David replied, "I don't want to do that *anymore*! I never want to do that again!" His sudden resistance towards our math groups was a huge change from just a few weeks ago when he embraced the subitizing games enthusiastically. David was one of my biggest supporters, but he was also a tough critic. Ultimately, he was justified in his criticism; Counting to 100 had been tedious. Thankfully, he could take a break from interventions and visit math centers for a few days while I continued working with Braden. When our group would reconvene for reading two-digit numbers, there would be ample opportunities for game-based learning and, hopefully, the chance to win back David's approval.

On the fifth day of the counting intervention, it was just Braden and me. He smiled and skipped to the back table, excited to work with the teacher by himself. After warming up counting on a hundred chart, we counted out 60 dice. Instinctively, he starting making piles of ten as he went along. I heard many mistakes, again, during the transitions from one ten to another, "28, 29, 30...40." Later, we colored 60 stars on his worksheet. I noticed that Braden performed better when counting pictures instead of real objects. This might have been because he did not have to manipulate or organize the materials. Additionally, when he colored the pictures it was easy to tell what he had counted already. For the first time, Braden counted to 60 correctly on his assessment.

Although Braden was overjoyed by our one-on-one session, I could not shake the memory of David's frustration and resistance. I had been trying my best to make the counting practice engaging and hands on, but despite these efforts, the counting interventions had felt inauthentic. When I pulled Braden to the back table on the sixth day, I told him that we would be doing something different, and that I needed his help. I told him that I needed to figure out whether I should order more dry erase markers to last us for the rest of the year. I asked if he could help me count how many markers I already had to determine if I needed more.

After we counted the chisel tip markers and found out there were 96 of them, I asked if I had enough for the rest of the year. Braden said, “Yeah, we don’t have that many kids in our class! You don’t need to worry. You have enough.” Unknowingly, he had just compared quantities while considering if 96 would be enough for 26 children.

Next, we looked at the fine tip markers. I asked him to estimate how many markers were in the bag. He shook his head and said, “Let’s just count them.” At first, he tried to count the markers while they were still in the bag. I didn’t say anything; I wanted to see how this would pan out. Eventually he said, “Uh, let’s just dump them out. I can’t see them.” I am glad he realized that counting items in a bag was not a sound strategy.

When all 78 markers were counted he said, “All these are probably enough. I don’t want you to spend more money!” I thanked him for his help. He said, “When I need to help, I want to help!” This was a real world application of needing to count something for inventory purposes. Braden felt valued and recognized how he played a significant role in my decision-making. This did not feel like a typical intervention session, for me or Braden. In fact, it seemed that he worked more diligently and carefully because he was counting the markers for an authentic purpose. Perhaps authenticity had been the missing piece all this time.

On the seventh day of the counting intervention, I asked Braden to inventory the 80 unsharpened pencils in my supply closet. Despite his success from the day before, he stumbled right away when counting, "11, 12, 14, 15." As soon as he slipped up, he looked toward the hundred chart and self-corrected, "Oh yeah, *13*, 14, 15."

This was the third day in a row that I had worked with Braden alone. I had hoped that individualized attention would help with Braden's accuracy, but as I listened to him count out the pencils and skip over numbers, I realized that my goal may have been too lofty. Vygotsky would argue that Braden was still within his ZPD because he could count successfully when he was supported by an adult and had a hundred chart to reference. With additional support, Braden would eventually master counting to 100. But in the meantime, students like David, Liz, and Sadie, who also have math difficulties, were not receiving any Tier Two support. I wondered how long I should wait for Braden to master counting before I moved on. I was stuck between a rock and a hard place.

After some thoughtful discussions with my action research support group, I made the decision to stop the one-on-one sessions with Braden and move forward into a number identification group. Ultimately, the decision rested in what was best for the group as a whole. I could not bide time for perfection while jeopardizing the strides I had made with the other students. I knew that Braden would benefit from number identification too, and perhaps, that skill might reinforce the count sequence.

We were quickly approaching our Thanksgiving vacation. After what had been a long and trying three weeks focusing on counting, I was feeling downtrodden. But as any swimmer knows, every race cannot be record-shattering. Sometimes you botch your finish and are out-touched by an opponent. It is no excuse to give up, but rather a reason to keep training harder.

Game On: Number Identification

Swimming isn't a game. There is no ball, no endzone, and no overtime. In high school I had several heated debates with brute football jocks about whether swimming was even a sport. But if you have ever witnessed a men's 50 yard freestyle sprint, you know that swimming is a fierce *competition. As soon as you step behind the block, you are sizing up the swimmers on either side of you. With every breath you take during your race, you look for your opponent in your peripheral vision, hoping they trail you. But whether you are in the lead or are desperate to catch up, your legs kick harder, your arms spin faster, and your lungs* *sting from deprivation. It will all be over soon, your fate determined. You will do everything in your power to win.*

Gameplay in the classroom does not promote the same cut-throat competitiveness of varsity sports. Throughout the year, we discuss how to win humbly, lose gracefully, and stay supportive of our classmates. These are some of the most valuable lessons we learn, because students play games almost every day. But those lessons on graciousness do not make a child desire winning any less. When it comes to gameplay, students are inherently motivated to try their best. This worked to my advantage during my subitizing interventions. Although students were practicing important skills, in their eyes, they were just playing. When instruction incorporated games, practice became play. I was excited to start working on number identification for this very reason; I was brimming with ideas for how to create meaningful, and playful, experiences.

The first step in this process was to draft my players. Forty-two percent of my students were below grade level on the beginning of year DIBELS Math Number Identification measure. Of those ten students who exemplified difficulties reading two-digit numbers, I called six of them to my back table during math centers. Undoubtedly, some of them were coming to the intervention group not knowing what to expect: Were they in store for more games like the ones we used to practice subitizing, or would we be settling into more monotonous practice of counting? I had to reel them in, and reel them in quickly.

I welcomed them all back to group and told them that we would be doing something a little different this time around. I explained that we would be learning to read BIG numbers, like 87 and 99! Tanner's eyes lit up as he gasped with delight. I began by explaining to them that reading two-digit numbers is sometimes challenging. I wrote the number 53 on a whiteboard. This number is not, "five three," I told the group. "It's 53. You must look carefully at the first digit in the tens place to help you read the number." I picked a number card off the top of a pile. As I pointed to the number 84, I thought aloud: "Hm, I see eight is the first digit. That means this number is in the eighties. It is 84." I invited each child to pick a number from the pile to read. On Braden's first turn, he picked 43 and then 44 on his second. He shouted, "Look at this! They're in order!" It was a relief to see that he was making connections to the count sequence. As we went around the circle and students read their two-digit numbers, I pointed to them on a hundred chart.

My students were surprised when I asked them to stand up and pull the chairs away from the table for our next activity. As the students watched, I arranged 20 fly pictures around the table. Each fly was labeled with a two-digit number. I explained that this was going to be a competition: boys versus girls. The goal was to swat the flies as quickly as possible when the number that was displayed on the fly was read aloud. Whoever swatted the fly first, collected that picture. I have never heard so many squeals of laughter during an intervention! Even the kids at centers were gawking at us, envious of the good time we were having. In the throes of competition, some students slapped numbers hastily. Many of their errors were digit reversals. For example, Jade slapped 62 when I said “26.” When all of the numbers had been cleared off the table, the teams counted their flies. The boys had proven victorious. As we pushed the chairs back in, Chris exclaimed, “That was really fun!” Tanner added, “I want to play that again!”

As the students settled into their seats, I wrote the numbers 24 and 42 on a whiteboard. We noticed how 24 and 42 had the same digits, but they were not the same number. Again, I emphasized how the first number, in the tens place, was very important. During the last few minutes of our session, I pulled students aside and asked them to read 18 random numbers for me. Liz, Tanner, and Rose read the numbers fluently and with perfect accuracy. Both Jade and Chris only missed one number. Jade was stumped on 12, understandably, because twelve does not follow the typical naming rules. This was something that I had anticipated, and I already knew that the teen numbers would be something I would have to have target in later sessions. Chris read 77 as 70, forgetting to tack on the ones. Finally, Braden scored 72%. He read very slowly. He read 60 as “sixty zero” and changed 13 to “30.” After three seconds, I read the numbers for him.

The following day, I began our session with similar direct instruction on how to read a two-digit number. However, this time, I told students how to read the tricky teens. Just like teenagers, the teen numbers were rule-breakers! Afterward, we played the same Pick a Number activity. When Chris chose the number 41 he remarked, “If this number was a 1 and then a 4, that would be 14.” He was thinking creatively and directly applying what we had learned about teen numbers.

When we were ready for some more independent practice, I pulled out an authentic Bingo set that I had borrowed from another teacher. I knew that Bingo would be perfect for developing number identification. After all, Bingo was inherently scaffolded because the letters limited the students’ search to a single column. Additionally, there was ample wait time built in as I turned the metal cage to dispense a ball. If yesterday’s fly swatting game had been the most laughter-filled intervention to date, this one had been the most silent. Students were laser-focused on their boards. Occasionally I heard a “Yes!” whispered under the breath, but for the most part, it was radio silent.

As students checked their boards for their numbers, I did too. Once, I caught David marking off 43 for 34. I asked him to double check that he had the correct number. On two occasions I prompted students to look closely at their boards, because they had not marked off a number that was called. Overall, students found most numbers successfully, and even made interesting observations. After I called O73, Robert mentioned that he did not have anything bigger than 70. After about 10 minutes of gameplay, Sadie yelled "Bingo!" She read off her winning numbers, and students cleared their boards. Chris said, "Oh that was so fun!" Bingo: Beloved by seven- and seventy-year-olds alike.

On our number grid diagnostic assessment, Robert rattled off the numbers with automaticity and 100% accuracy. Jade and Chris scored 94% but both of them were also quite fluent. Again, Jade had trouble with the number 12 and Chris simply paused for too long when he saw 29. I felt confident that those three students could be exited from this group.

At the other end of the spectrum, Sadie had 83%. She was unable to read 86, 29, and 26 within three seconds. David struggled the most and only read 56% of the numbers correctly. Most of his mistakes were not even digit reversals. For example, he read 37 as "93." As with this error, David often carried over one digit, but would randomly substitute another.

It was the week before Thanksgiving, and amongst the chaos of parent-teacher conferences, a Pilgrim and Native American feast, and a slew of half-days, I did not have time to hold interventions. I did, however, carve out a few minutes to progress monitor number identification. As I stated above, there were 10 students who were below grade level in Number Identification Fluency at the beginning of the year. Using a DIBELS Math progress monitoring probe, I reassessed each of these students' fluency. As can be seen in Figure 9, I charted the difference in students' Number Identification Fluency from the beginning of the year until November 20th. It is important to note that we had not touched upon two-digit numbers greater than 20 within core instruction at this point in the year. I would argue that any of the gains in number naming fluency could be attributed

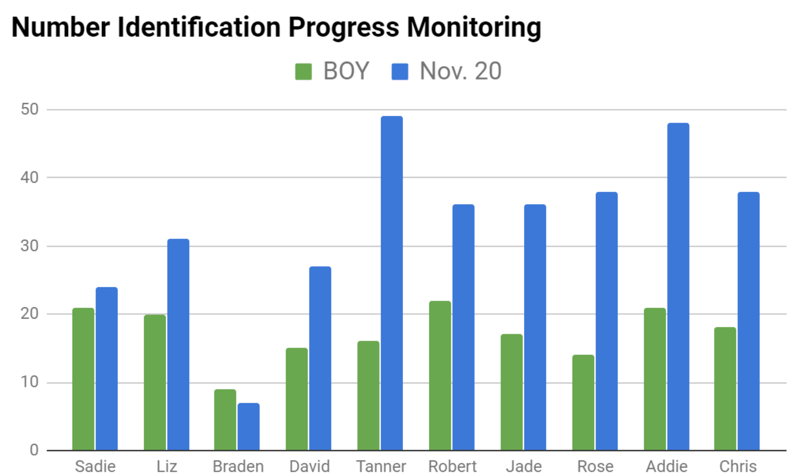


Figure 9. Number identification progress monitoring, November 20th

to exposure from Calendar Math or the number identification interventions. Only Sadie and Braden did not surpass the goal of naming 25 numbers per minute.

David only read 27 numbers. When we returned from Thanksgiving break, I would concentrate my efforts solely on Braden, Sadie, and David.

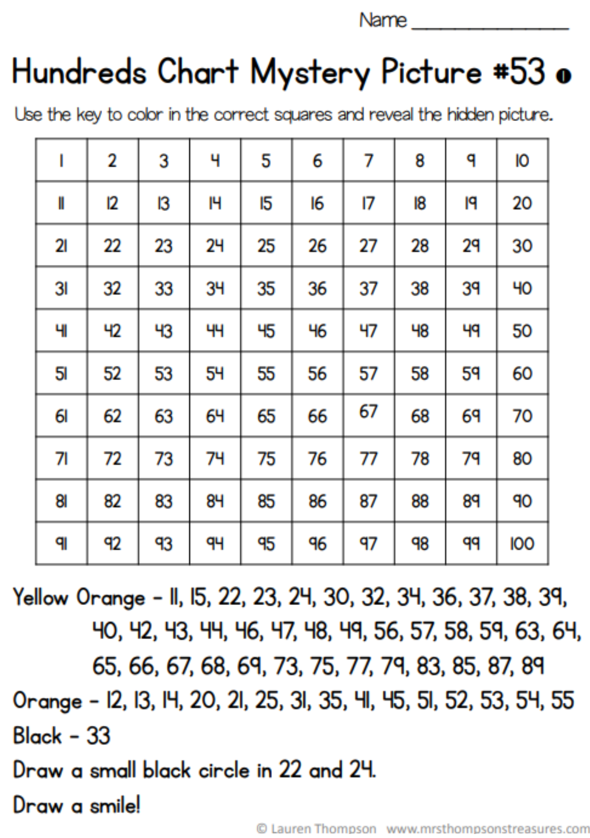
November 27th was our first day back from vacation and David seemed lethargic. When he came to the table, he put his head down right away. I knew I should provide some direct instruction to refresh the students' memories. I modeled reading two-digit numbers with flashcards. When I encountered 14, I emphasized how this one was a tricky teen. I reminded the students that when a one comes first, it is a "teen" number. They each read a few numbers on the flashcards.

To wake students up from their mid-afternoon slump, we played the fly swatting game. This turned David's mood right around! He was literally jumping up and down while cheering on his teammate. There were a few mistakes. David slapped 57 instead of 75. Braden slapped 40 instead of 14. At one point, Braden looked at a fly on the table and read the number 26 as "secondy six."

We did not have specials that day, so we also had time to play Bingo. While playing, I noticed that Braden looked at the balls to see what the number looked like before searching his board. I tried to shield the balls from his view, but then I would catch him forgetting to mark off the numbers altogether. He even said, "What's 23?" At the end of the game, I had each child read the numbers on their board to me for their assessment. Each student had a perfect score.

The following day, our group warmed up by reading numbers on flashcards. While I flipped through the numbers, I had a great idea for a new game. I took the pile and divided it in half, giving one stack to David and Braden, and placing the other in front of Sadie and myself. I told the students that we would be playing War! When it was their turn, they would flip over the top card and read the number. Their adversary would do the same. Whoever had the bigger number would take their opponents card and add it to their deck. Not only was the game a hit, but it also served as a soft introduction to magnitude comparison. Braden and David were giggling and squealing with delight when they won a round. One time I played a 17, and David exclaimed, "I can probably beat that." Another time, Braden laid down a 92. Sadie remarked, "Well, I lost. That is almost the biggest number in here!" Unbeknownst to them, on top of reading numbers, they were comparing quantities and analyzing odds. Quite impressive for a game I had come up with off the top of my head.

We wrapped up our day with a hundreds chart mystery picture as seen in Figure 10. The worksheet pictures a hundred chart with a list of colors and numbers underneath. As students shade in the numbers, a picture is revealed. I helped the students get started by reading aloud the numbers that should be yellow-orange. Once they got the hang of it, they continued independently while I pulled each child aside for their daily assessment. Sadie scored a 94%, reading 61 as 60. Braden had a perfect score and managed to self-correct two mistakes. He exuded confidence as he read off the numbers with assurance. Finally, David had 83% and self-corrected twice.



Name ______________

Hundreds Chart Mystery Picture #53

Use the key to color in the correct squares and reveal the hidden picture.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Yellow Orange - 11, 15, 22, 23, 24, 30, 32, 34, 36, 37, 38, 39, 40, 42, 43, 44, 46, 47, 48, 49, 56, 57, 58, 59, 63, 64, 65, 66, 67, 68, 69, 73, 75, 77, 79, 83, 85, 87, 89

Orange - 12, 13, 14, 20, 21, 25, 31, 35, 41, 45, 51, 52, 53, 54, 55

Black - 33

Draw a small black circle in 22 and 24.

Draw a smile!

Figure 10. Hundreds chart mystery picture

The next two intervention sessions held on November 29th and 30th accordingly, combined a variety of the aforementioned activities including War, Bingo, and the hundreds chart mystery picture. I was incredibly impressed with Sadie throughout these two days. She was reading the numbers more accurately and sharing insights in conversations. During War, she exclaimed that “100 is like an ace!” meaning it would automatically beat any number. Later, when she played a 16 and Braden played a 19 she noticed, “We are both teens!” At the end of one game, the boys had 19 cards and the girls had 20. Sadie said, “It’s like a Near Double!” I was proud that she was making connections to our core instruction.

The students continued to be engaged and enthusiastic during gameplay, which made intervention time seem hardly like an intervention at all. Math interventions felt so different than reading interventions. After I briefly front-loaded the content and gave a warm-up, I took a backseat and watched as the students practiced their skills through play.

On December 3rd, I felt that Sadie, Braden, and David were ready to be progress monitored again on number identification. The results were better than expected. All three surpassed the goal of naming 25 numbers in a minute. In just two weeks, each student averaged an increase of 11 numbers per minute. Figure 11 illustrates how Braden and David’s progress skyrocketed. Now that every student had met their number naming fluency goal, I had to determine our next course of action. The next logical step was to target basic facts.

Spending over a decade on the pool deck instilled in me a great number of traits, including competitiveness. Some might shy away from competition in fear of losing. I personally believe that adding contest and competition heightens an activity's importance. After witnessing how gameplay positively impacted student learning in the past few weeks, it is now my contention that competition can play a vital role in increasing engagement and authenticity within math interventions.

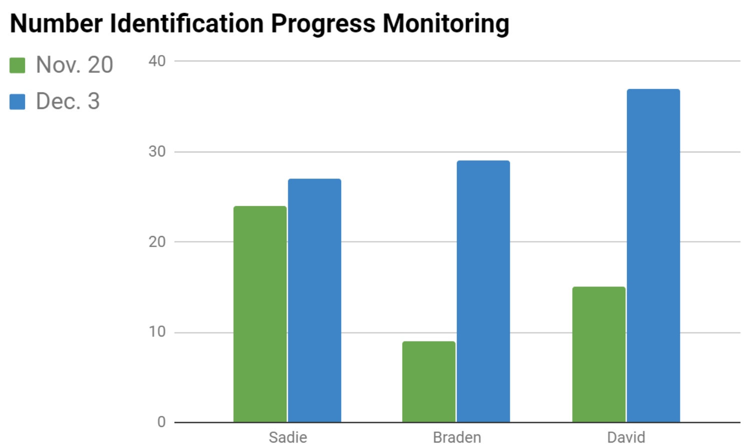


Figure 11. Number identification progress monitoring, December 3rd

Think Fast: Addition Strategies

The youngest swimmers on a team only compete in 25-yard races. Or in layman's terms, one length of the pool. Once a swimmer turns 11-years-old, they move up to a new age bracket and double the distance of their events. Swimming a 50-yard race certainly requires more strength and endurance. It also presents an interesting challenge: turning around. It can take a child years to master a strong flip turn. At first, it feels unnatural to complete a forward roll, submerged in water, inches from a wall. With time, flip turns become an automatic response, *a mindless extension of a stroke. If a swimmer's flip turn is not maneuvered quickly and forcefully, it could easily cost them the race.*

Just as a flip turn accounts for mere seconds in a swimmer's race, calculation is only a small part of solving a word problem. However, in both cases, if the minor labors are mismanaged, the greater efforts may prove to be fruitless. Take, for example, the following word problem:

> *Jake and Tim picked peaches to bake a pie. Jake picked 5 peaches and Tim picked 6 peaches. They only need 8 peaches for the pie. How many peaches will the boys have left over?*

A child would have to consider a great deal of information to solve this two-step equation correctly, including when to use two different operations. It would not be surprising if a child with poor fact fluency struggled with cognitive overload when facing a problem like this one (Woodward, 2006). It is imperative for students to acquire automaticity with their basic facts so that they can process more complex word problems.

Over the past two months, my interventions have focused on what would be considered number sense and early numeracy skills. Those are the building blocks upon which all mathematics are constituted. So far, subitizing, the count sequence, and number identification have focused on singular values. Subitizing showed students that amounts are represented by numerals. The count sequence reinforced that numbers are arranged into repeating patterns that have a sequential and specific order. Then, number identification taught students how to read individual numbers and started to impart the importance of place value. These skills were never directly taught within the first grade curriculum, but are crucial for later success. Now that the majority of students had mastered these early numeracy skills, it was time to start focusing my attention on developing fact fluency.

By early December our math series had covered addition and subtraction to 20 and exposed students to six different addition strategies. Although we had worked on these mental math strategies ad nauseum throughout core instruction, many of them had not become second nature to students. For example, many students floundered when we were working on adding three addends, like 3 + 5 + 7. I always tell my students to circle the “Make 10 Buddies” first when adding three numbers together because it makes their job easier. “Make 10 Buddies” are pairs of addends that add up to 10, such as 8 and 2. As I walked around the room, I noticed that students were circling addends that were not “Make 10 Buddies.” Later, while taking the Topic Five test on addition to 20, I saw a few of my intervention students using strategies incorrectly. I saw that Sadie was using the “Near Doubles” strategy with her “Monkey in the Middle” facts, and thus getting them all wrong. Some strategies were causing more confusion than support.

Although research does suggest that strategy-based instruction can increase fact fluency (Tournaki, 2003; Woodward, 2006), it appeared that my students needed more targeted practice with these skills. With the remaining time until winter break, I would utilize intervention time to review our addition strategies using a CRA approach.

The next question I asked myself was: Who needs help with these strategies to acquire their basic facts? On the beginning of year DIBELS Math Computation probe, only two students scored below grade level. Now that we had Rocket Math underway, I had additional data to base my grouping decisions on. There were a handful of students who were stuck on early sets of the Rocket Math program because they still did not have automaticity when solving +1 and +2 equations. It was not surprising that students like Sadie, Liz, and David, who needed extra support with number sense were failing to show progress on Rocket Math. With time, I was experiencing how weaknesses in early numeracy skills impacted computational fluency and limited student success.

On December 6th, I held my first intervention on the identity property of addition. My first graders call this strategy “Zero Mirror” because when zero is added to any number, the number remains the same, as if a reflection. When the six students joined me at the back table, I quickly explained that this group would, once again, be a little different than what we have done in math groups before. I told the students that we would be practicing our addition strategies to get better at mental math. The end goal was that these strategies would help the students move through sets in Rocket Math.

To begin, I took out three pencils and placed them on the table. I reminded them of our classroom rule: They may have three pencils in their pencil holder, and zero more. If zero means nothing, that means they can only have three pencils total in their pencil holder. I then wrote 3 + 0 = 3 on my whiteboard. I noted how the zero somewhat resembled a mirror and the three was reflected back on the other side of the equal sign. Next, I said, “There are seven Harry Potter books. The author said that there would be zero more books in that series. So, there will only ever be seven books because seven and no more, is still seven.” I wrote 7 + 0 = 7 on the whiteboard to represent this concept. To assess students’ understanding, I asked a question with a choral response: “Let’s say you have 12 Pokemon cards. You get zero more. How many Pokemon cards do you have?” Everyone responded, in sync, “Twelve!”

Next, we transitioned to the worksheet, illustrated in Figure 12, that had four part-part whole mats representing the “Zero Mirror” concept with accompanying equations. We did two equations together, and then students did two by themselves. Finally, I reminded students that we would not always have a

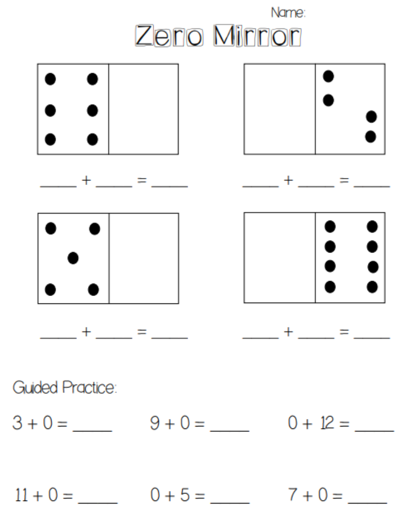


Figure 12. Addition strategies CRA worksheet

picture to help us with our facts. We solved three "Zero Mirror" equations together. They completed the back of the page independently. Every student received 100% and was able to complete nine equations within about 45 seconds. Grace looked up at me after she had finished and said, "Wow, we got those done quickly!"

I try to avoid using worksheets during interventions, but this entire activity only took us about seven minutes to complete. I developed these worksheets myself for each of our addition strategies. I designed them to follow a gradual release of responsibility that also lead from representational to abstract concepts. It was my hope that the worksheets provided a brief but effective method to reteaching these strategies.

With the remaining time left in our lesson, we played a flashcard game called Make It Take It. Make It Take It is a game in which the students competed against one other person to solve equations as quickly as possible. If they answered correctly first, they kept the flashcard. I limited the flashcards in the pile to Doubles, “Zero Mirror,” and Counting On facts within 12. I did not want students to become discouraged by facts that were too hard. At the end of the game, students counted their cards and a winner was determined. As their “ticket out the door” students read me all of the equations in their winning pile. I felt confident that students were ready to move on from the “Zero Mirror” strategy.

The following week, I called on my computation group. Braden cheered and skipped to the back table when I called his name. I reminded my group that the last time we worked together we reviewed the “Zero Mirror” strategy. In an effort to see how much they remembered, I gave each student a half sheet of paper with nine “Zero Mirror” equations on it for a warm up. On the first equation, I saw Chris writing “0 + 9 = 0” which is a common mistake for students to make. Luckily, before moving onto the next equation, he caught his error and fixed the sum. Everyone else sped through the warm up in a matter of seconds.

During this session, I reviewed Counting On as a strategy for solving +1 facts. Again, I started off by showing the students eight crayons as authentic manipulatives. I told them that most crayon boxes had eight crayons. If a friend gave them one more, they would have nine crayons in all because nine comes after eight when we count. I wrote 8 + 1 = 9 on my whiteboard. Next, I pulled out ten markers. I had students “lock” ten into their brains as I pulled another marker over to the pile. When I asked what number came after ten, they all shouted “Eleven!” That meant that there were now 11 markers altogether. I noticed how when we add one more, the answer is always the next number we say when counting.

For the rest of the intervention, we followed along with the Counting On +1 explicit instruction worksheet. Everyone scored 100% on the independent practice section except for Liz. She answered three of the nine equations as if they were “Zero Mirror” facts. For example, she wrote, “9 + 1 = 9.”

The entire worksheet only took about five minutes to complete so we were left with ample time to play a game. I saw David doodling on the sides of his worksheet and could tell that the students were getting antsy. Instead of having students play Make It Take It again while seated, I stuck three pieces of tape to the floor. Students formed two teams and stood in two lines. This time, in order to earn the flashcard for their team, they had to beat the other person three times, taking one step forward after each victory.

As we played, it was endearing to see Sadie motioning the “locking” of a number in her brain before counting on. Jade used her fingers to count on from six. I could tell that both of the girls were trying to be accurate in their calculations and apply what we learned. On the other hand, Braden sputtered out numbers as quickly as possible while playing, which made it hard for me to tell if he was self-correcting or merely guessing. I cannot say I blame him for rattling off numbers at lightning speed. When we use programs like Rocket Math and timed one-minute assessments, students start to believe that we place value on speed rather than accuracy. That can be one of the risks of using games like this one.

I have talked a lot about my efforts to make my interventions game-based by integrating games to reinforce new skills. But as soon as students lose interest or ambition in the game, all of the benefits of play are lost. This happened today when the boys' team beat the girls' team round after round after round. I could see the girls becoming less focused and giving up. At the end of the game, the boys had won 19 to 6. Although I had intended for this to be fun practice for everyone, the competition factor had actually been a deterrent for some. As I plan more activities for intervention, I need to be cognizant that games do not always equate play, or learning.

On December 13th, I only had about ten minutes to work with my computation group. Normally, I would not have bothered to gather the students for such a short period of time, but winter break was drawing closer. We warmed up by reviewing our +1 facts on a half sheet of paper. The rest of the session was spent on practicing counting on to solve +2 facts. I reminded students to look for the larger addend before counting on. For example, when solving 2 + 7, students should “lock” seven in their brain and count on, “8, 9.” This would help them to derive the answer more quickly. On the independent practice, I noticed that Grace always counted on from the first addend, regardless as to whether or not it was larger. For example, when solving 2 + 6, she said, “two, three, four, five, six.” She and Braden took the longest to complete the daily independent practice. With the exception of David, everyone scored 100%. He had 88% because he mistakenly wrote, “1 + 2 = 4.” With the last few minutes of our session, we played a game called Pop! that focused on developing basic facts to 12.

Although I did not realize it at the time, December 14th would be our final math group before winter break and the middle of year benchmark. When the students joined me at the back table, they immediately noticed an iPad propped up. On the screen was a “Doubles Rap” video that we had watched a month earlier during a whole group lesson. David blurted out, “Oh, yeah! I remember this song!” I told the group that today we would be reviewing our Doubles facts. As a refresher, we could sing and dance along to the Doubles rap video.

Once the video was over, I wrote the equation 4 + 4 on my whiteboard. I told the group that this was a Doubles equation because both addends were the same. I reminded them that each of our Doubles facts had a name to help us memorize the sums. This was our spider fact, because 4 + 4 = 8, just like a spider has eight legs. Next, I took out my Doubles poster that showed each equation with a picture as a mnemonic device. As a group, we went through each picture and read the equations. Finally, we completed the Doubles facts explicit instruction worksheet. Jade scored 88% because she wrote 7 + 7 = 12.

With our leftover time, students were invited to pick a partner for a game of Double Trouble. Each pair was given a game board, like the one shown in Figure 13, and a spinner. When it was their turn, each child flicked a paper clip and spun a number one through ten. Once a child landed on a number, they doubled it and covered the sum somewhere on their board. Their goal was to

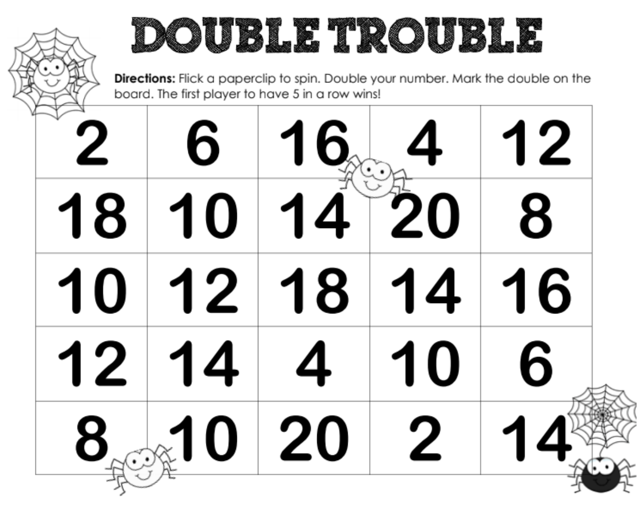


Figure 13. Double Trouble game board

connect five in a row. The partners were content and cordial as they played the game. Sometimes the players forgot to double their number. For example, Braden spun a number six, but instead of doubling it to make 12, he marked a six on his board. His partner did not seem to notice. I saw that Sadie was grinning and laughing while playing with Liz. After witnessing the girls give up while playing a game a few days ago, I was glad to see their enjoyment resurfacing. Partner play, as opposed to a whole group game, was a way to incorporate fun while minimizing the stakes.

The conclusion of Double Trouble also meant that our final intervention session had come to a close. It also symbolized that winter break was upon us. When the students returned from winter break, we scrambled to prepare for the DIBELS reading benchmark. Before I knew it, it was time to administer my post-intervention assessments. It was now time to see if the math groups and the students' successes that I had witnessed throughout the beginning of the school year would coincide with the DIBELS Math results.

The Clock: Post-Intervention Data Collection

When I walk around the pool deck while coaching, you will always find a stopwatch wrapped around my neck. I am constantly checking the time: Checking to see how long our set will take, checking to see how much rest swimmers are getting between intervals, checking to see if the sprints are fast enough.

Swimming is a sport governed by time. Ultimately, a swimmer judges their performance, not by whom they beat, but by the numbers on the clock.

Time is a dangerous concept. As a teacher, you hope that you can utilize time effectively. However, throughout my action research, time seemed to be my enemy. Unlike preparing a swim practice, I could not micromanage how long it would take my group to master a skill. At the beginning of this journey, I anticipated working through all of our early numeracy skills, finishing addition strategies, and even hoped to delve into some subtraction. But part of the complicated nature of interventions is that the pacing of a group and your day-to-day instructional goals are ever-changing and modification is needed. It was my students' daily accomplishments and setbacks that guided my decision-making. Anna Gillingham's quote about reading instruction rings true for math interventions, as well: "Go as fast as you can, and as slow as you must." Although I did not cover all of the content I had hoped that I would, I was confident that slowing down and ensuring a sound understanding of early numeracy skills would pay dividends later on. It is similar to the concept that a house is only as strong as its foundation. I knew that my students' success was dependent on this foundation.

On January 11th and 14th, with the help of my school's learning support teacher, it was time to administer the DIBELS Math middle of year benchmark assessment. On the middle of year assessment, students are only given three measures: the Advanced Quantity Discrimination, Missing Number Fluency, and Computation probes. At the beginning of the year, 29% of my class scored below benchmark (Figure 3). On the middle of year benchmark, that percentage dropped to just eight percent (Figure 14). Chris scored below benchmark, indicating that

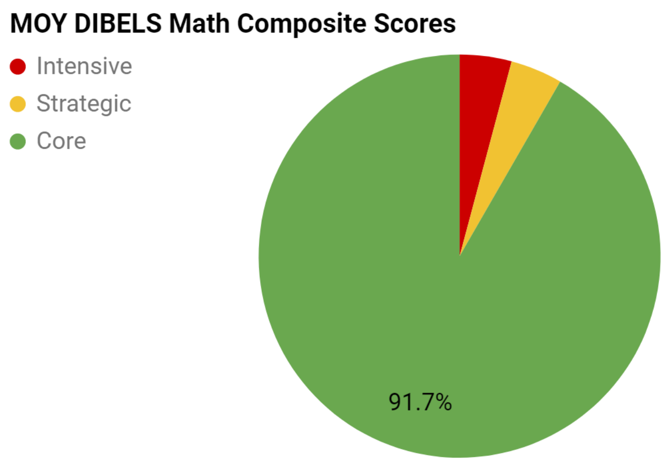


Figure 14. Middle of year DIBELS Math composite scores

he would benefit from continued strategic interventions. Braden scored well below benchmark, which suggests that he will need more intensive interventions to make the end of year goals. Overall, I was pleasantly surprised to find that 92% of my class wound up meeting the middle of year benchmark.

Table 3 gives a more detailed look at the subtest scores from the DIBELS Math benchmark. If any child failed to meet the measure's goal, I noted their name below the category where they fell out. On the Advanced Quantity

Discrimination measure, the middle of year goal was to compare 19 quantities in one minute. Ninety-two percent of students made this goal with a class average of 22.2 comparisons per minute. Braden, with 17 comparisons per minute, and David, with 15 comparisons per minute, both missed the goal slightly. As I

Table 3

Middle of Year DIBELS Math Subtest Scores, n = 24

Measure	Core	Strategic	Intensive
Advanced Quantity Discrimination	22 students 91.7%	2 students 8.3% (Braden, Chris)	0 students 0.0%
Missing Number Fluency	20 students 83.3%	3 students 12.5% (Alexandra, Chris, Grace)	1 student 4.2% (Braden)
Computation	23 students 95.8%	1 student 4.2% (Braden)	0 students 0.0%

administered this measure, I was notably impressed with how students rattled off the two-digit numbers quickly. Although number identification was not included as a part of the middle of year benchmark test, AQD inherently gauged whether or not students could read two-digit numbers. From these results, I can see that most students have a firm grasp of place value concepts and how to differentiate magnitudes.

The Missing Number Fluency probe had the most unsatisfactory results of the three subtests, although the results were still quite promising. Eighty-three percent of the class was able to complete eight number patterns within one minute. The class average was 10.3 missing numbers per minute. Alexandra, Chris, and Grace finished between five and seven number patterns. Braden was only able to identify two of the missing numbers. From these results, I can infer that some students need more practice with identifying number patterns and strategic counting.

Similar to the baseline tests, the Computation measure was the most successful measure on the middle of year assessments. Ninety-six percent of my class met the benchmark goal of solving 10 addition and subtraction equations in two minutes. In fact, students performed so well that the class average was double the benchmark goal. Braden was the only student who did not meet the goal, after only answering nine equations in two minutes. Interestingly, that was lower than his beginning of year score. This decline might have been a result of relying on unsolidified strategies instead of just using on a number line. Additionally, many of Braden's errors were from mistakenly adding when he should have subtracted.

The middle of year Rocket Math two-minute test verified these findings. Students solved an average of 21.5 addition equations in two minutes. That boils down to roughly 5.5 seconds for each equation. That is not too far off from the standard for automaticity (Woodward, 2006). Figure 15 is a graph that shows the comparison of students' beginning and middle of year Rocket Math two-minute test results. Although Braden failed to meet the benchmark goal on the DIBELS Math Computation measure, he performed much better on the Rocket Math two-minute test where he answered 17 equations in two minutes. I can understand why he, and other students, would perform better on the Rocket Math test because all of the facts were addition. The DIBELS Math Computation measure presented a challenge by mixing the operations.

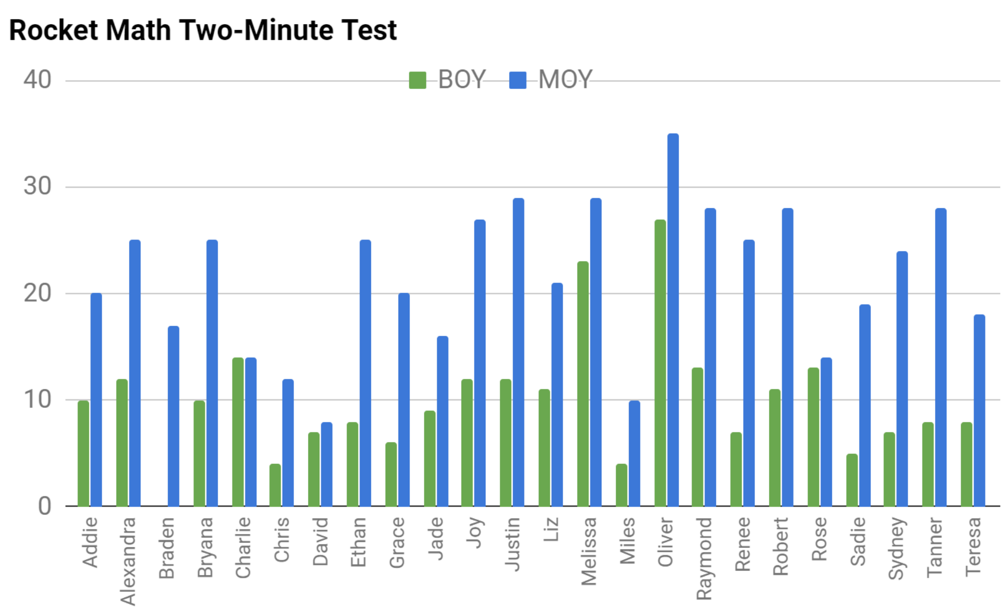


Figure 15. Rocket Math two-minute test BOY and MOY comparison

At the beginning of the school year, I felt like I was fighting an uphill battle during my math block. I was alone with 26 first graders all day, without any support. It was impossible to check in with every child during the independent practice portions of our whole group math lessons. There were simply too many students who needed reteaching and not enough time for one-on-one check-ins.

With that being said, I am happy to report that I no longer feel like this is an impossibility. Now when I scan students' responses, I see that the majority of students are grasping the concepts after a guided practice. There are still errors and I still need to support students like Braden who tend to rush ahead and work carelessly. But overall, there is a stark change in the atmosphere of our classroom. Students are able to access new content because they have a solid foundation in place. Hands raise as soon as I ask for someone to come to the board to model and explain their thinking. There is no longer a quiet minority who wait for someone else to do the work for them.

The math interventions served as an excellent vehicle to identify and strengthen individual weaknesses, but have not been a panacea that alleviates all math difficulties. During our calendar time in late December, Braden saw that we had been in school for 68 days and remarked, "Soon it will be sixty-ten." Chris also continues to grapple with two-digit numbers and identifying ten more and ten less than an amount. On a 5-a-Day warm up, he wrote that 43 + 10 = 23 and could not understand why the sum did not make sense. Now that we are getting into more advanced skills, Sadie is second-guessing herself again. She works accurately but painstakingly slow in an effort to avoid mistakes.

Looking back over the chapters of my story, I see this pattern emerge again and again: the triumphs and the obstacles, the successes intertwined with the failures. For this reason, measuring the impact of my targeted interventions is a complex job. Judging the effectiveness of these groups is not as simple as reading time on a stopwatch. Ironically, mathematical literacy cannot be summed up with numbers alone. This is precisely why as an action researcher I have gathered many different forms of data, analyzed said data, and make informed conclusions from that analysis.

Data Analysis

My practitioner action research study was conducted from September through January of the 2018 - 2019 school year. Over the course of eleven weeks, I conducted 20-minute small group math interventions two to three times a week, targeting various early numeracy skills. Throughout this process, I collected both quantitative and qualitative data in an effort to gauge the impacts of these targeted interventions on students' number sense and basic fact acquisition.

DIBELS Math

My primary tool for pre- and post-intervention data collection was the DIBELS Math measures of early mathematical skills. There were five measures used in this study: Number Identification, Next Number Fluency, Advanced Quantity Discrimination, Missing Number Fluency, and Computation. The Number Identification and Next Number Fluency probes were only administered at the beginning of the year to assess students' abilities to read two-digit numbers and their knowledge of the count sequence. On Table 2, there is a breakdown of students' performances on the baseline DIBELS Math measures and whether they were below, well below, or met the benchmark goals. Additionally, Figure 3 is a pie chart depicting the class' overall composite scores. These composite scores gave me a rough estimate of how many students would need additional math instruction to be successful. The composite scores indicated that nearly a third of my students would benefit from strategic math interventions.

When analyzing the scores from the beginning of the year, I expected to see deficiencies in basic fact fluency. I was surprised that students performed very well on the Computation measure. Ninety-two percent of students met the beginning of year goal by solving five equations in two minutes. On the other hand, students struggled with more basic skills, like number identification and the count sequence. Only around 60% of students met the goal for those subtests. At first, it seemed counterintuitive that students scored better on computation than on number identification. But in hindsight, computation only requires the manipulation of numbers smaller than 20. Both number identification and counting tasks require knowledge of numbers through 100. The DIBELS Math measures were the first step in evaluating students' strengths and weaknesses, and in planning how I could intervene.

In January, after conducting tiered interventions for over two months, I administered the middle of year DIBELS Math benchmark assessment. The second round of the DIBELS Math benchmark only assessed Advanced Quantity Discrimination, Missing Number Fluency, and Computation concepts. Table 3 illustrates the percentage of students who were below, well below, or met the goals for these measures. Figure 14 presents a pie chart with the composite score breakdown from the middle of the year. Students exhibited growth in all areas. To further illustrate this point, Table 4 compares the percentage of students at the core level in the beginning and the middle of the year. Thirty-four percent of

Table 4

Beginning of Year/Middle of Year DIBELS Math Comparisons

	Intensive	Strategic	Core	Change
BOY AQD	17%	25%	58%	↑ 34%
MOY AQD	0%	8%	**92%**	
BOY MNF	12%	17%	71%	↑ 12%
MOY MNF	4%	13%	**83%**	
BOY Computation	4%	4%	92%	↑ 4%
MOY Computation	0%	4%	**96%**	
BOY Composite Score	8%	21%	71%	↑ 21%
MOY Composite Score	4%	4%	**92%**	

students went from scoring below benchmark on Advanced Quantity Discrimination in September to meeting benchmark by the middle of the year. That growth was much smaller in the area of computation but only because of how well students performed on the baseline assessment. Perhaps the weakest performance was on Missing Number Fluency where only 83% of students made benchmark. From this information, I can surmise that quality core instruction paired with tiered interventions positively impacted students' number sense and basic fact retrieval.

Rocket Math Two-Minute Test

One of the components of the Rocket Math program is a two-minute test consisting of random addition equations to the sum of 18. I administered this test both before and after conducting small group interventions to gauge students' basic fact retrieval. At the beginning of the year, my class solved an average of 10 equations in two minutes. At the end of the data collection period, students were solving, on average, 21.5 equations in two minutes. That is an average increase of 11.5 equations over the course of four months. Some students, however, did not see such significant gains. Charlie, David, and Rose made little to no improvements from the beginning to the middle of the year, as seen in Figure 15. Unfortunately, I was unable to cover all of the addition strategies in our group before the benchmark assessment. Both David and Rose would have benefitted from a review on the more complex strategies such as "Near Doubles" and "Monkey in the Middle" facts. All things considered, this data still suggests that both math interventions and math centers promote fact fluency for most students.

Diagnostic Assessments

Although DIBELS Math comes with progress-monitoring probes, additional diagnostic assessments were needed throughout the course of this study to assess students' understanding of more nuanced competencies such as subitizing and counting to 100. Figure 16 below is an example of the subitizing and counting diagnostic assessments that were used before, during, and after instructing on these topics. If students hesitated on a number for more than three

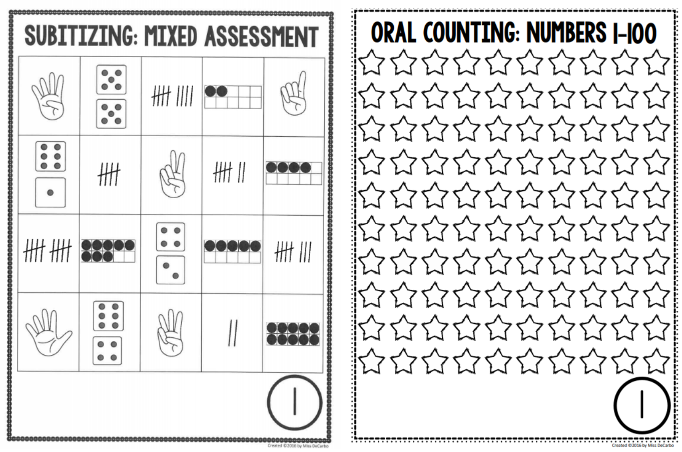


Figure 16. Sample diagnostic assessments

seconds, it was marked as incorrect. Students needed to score 95% or higher on these assessments to have mastered that skill. Figure 7 shows individual student improvement on their subitizing skills. These diagnostic assessments were quick and effective ways for me to measure students' abilities in accordance with our topics and goals.

Intervention Logs

After each intervention session, I recorded the target skill, activities, and the results of the student's daily independent practice. The intervention logs also included a section for miscellaneous notes where I recorded student quotations and when students demonstrated strategies (Figure 17). I also made note if

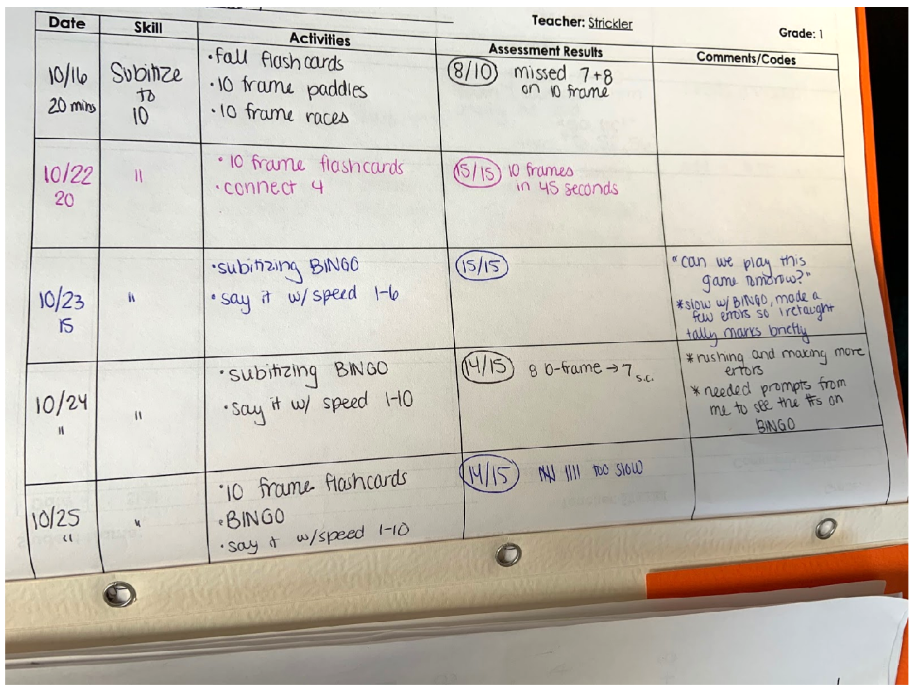


Figure 17. Student intervention log

students could articulate their reasoning and thought processes while solving the given math equations. I was sure to include when students exemplified frustration or had misconceptions so that this information could be examined and future interventions could be modified and adapted. By looking back at these entries, patterns and common mistakes that the students were making became easily detectable. The intervention logs were an invaluable roadmap that allowed me to see where each child had been and where they still needed to go. They also aided in the development of future intervention activities and modifications that would be beneficial for my students.

Student Work

Although most of the early interventions relied primarily on manipulatives and gameplay, there were a few lessons on addition strategies that incorporated paper-pencil activities. I collected these student work samples and coded the artifacts. In addition to grading these worksheets for accuracy, I analyzed each student's performance, with a focus on the following aspects: Did they attempt to apply strategies from our lesson? If there were any mistakes, were the errors minor or were they wildly off base? Were there any apparent patterns that were revealed within the student work? From there, I considered how I could address the issues in follow up lessons. Student work samples were formative in nature and helped me to target specific areas of need.

Field Log

Throughout this process, I kept a very detailed field log and teacher journal. After each intervention session, I documented which students were present and which skill was being developed that day. Furthermore, I described three crucial components of each lesson: what activities we did, how the students responded, and how students performed on the independent practice. Taking a moment to reflect on my experiences and observations helped me to gain valuable insights and, more importantly, it drove my instruction. As I cataloged our experiences, I also coded the topics of each entry. For example, when David noticed a variety of manipulatives and exclaimed, “Are we going to use *those* today?” I coded that quotation as excitement. Coding helped me to flag important moments within my field log and detect repeating trends.

Codes and Bins

At the conclusion of my data collection, I compiled a list of all of the codes from my field log and student work samples. I organized the codes and the frequency of their occurrences within a Coding Index (Appendix E). The Coding Index allowed me to identify main ideas from the data collection process, ranging from instructional strategies to student reactions. There were 21 codes in all. Each code was like a puzzle piece, a small component of the larger picture of my study.

I then sorted the codes into categories and considered how they all fit together (Figure 18). Thematically, the codes could be arranged into an equation of inputs and outputs. On the input side, there are the aspects that I added to our current curriculum. The inputs included the skills that I targeted within our groups and the instructional strategies I employed. On the output side of the equation are the outcomes from those curricular changes. Although there were ample benefits from supplementary instruction, many codes also emerged from the challenges of implementing small group interventions.

Graphic Organizer

What are the effects of targeted tier two interventions on first grade students' early numeracy skills and basic-fact retrieval?

INPUTS OUTPUTS

a + b = c - d

A

Early Numeracy Skills

- Subitizing
- Count Sequence
- Number Identification
- Quantity Discrimination
- Computation

C

Benefits

- Fluency
- Improvement
- Higher-Order Thinking
- Excitement
- Participation
- Strategy Application

B

Instructional Strategies

- Explicit Instruction
- Concrete Representational Abstract Approach
- Game-Based Learning
- Manipulatives
- Core Instruction

D

Obstacles

- Grouping
- Flexibility
- Difficulty
- Failure
- Resistance

Figure 18. Coding graphic organizer

Theme Statements

Finally, utilizing the coding graphic organizer, I developed thematic statements to summarize the central themes that emerged from my action research. The following is a list of those theme statements.

Impacts on achievement. Tier two math interventions promote number sense, basic fact retrieval, and higher-order thinking skills.

Early numeracy skills. Early numeracy skills such as subitizing, number identification, and knowledge of the count sequence, should be the primary focus of early intervention as they are the foundation upon which computation and advanced mathematics are built.

Instructional strategies. Effective interventions include brief explicit instruction, a Concrete-Representational-Abstract approach, and ample opportunities for students to engage with new content through gameplay.

Motivation and engagement. When instruction incorporates games and varied manipulatives, practice transforms into play and students become excited about attending intervention groups.

Challenges. The effectiveness of Tier Two math interventions may be diminished by student resistance and the limitations of a sole interventionist.

Findings

The original intent for this study was to explore the impacts that Tier Two interventions had on first-grade students' number sense and basic fact retrieval. As I reflected on the codes that were gathered in the data collection process, several themes emerged. More than just facts and figures about student achievement, I bore witness to the power of purposeful instructional methods and the engagement of gameplay. I encountered the obstacles of being a sole interventionist but took pleasure in seeing student growth. Throughout the following sections, I will present the themes that unfolded from conducting this action research in my classroom.

Impacts on Achievement

Tier two math interventions promote number sense, basic fact retrieval, and higher-order thinking skills.

I can recall moments from the beginning of the year when a handful of students, overwhelmed by inaccessible content, withdrew from math lessons and sat helplessly. The beginning of year DIBELS Math benchmark assessment made it very clear why: nearly a third of the students in my class were below grade level in mathematics. At the time, I was relying on only whole-class instruction to teach the content. It was apparent that core instruction was not meeting the needs of all learners. In a world where traditional whole-class instruction is failing to prepare students (OECD, 2018; Geary, 2004), it was not surprising that this method was not working in my classroom, either. After seeing the success that a RtI framework had garnered in reading, it was logical to implement a tiered approach to math instruction.

Gersten and colleagues (2009) recommended that tiered interventions be used to detect, prevent, and support students with mathematical difficulties. For eleven weeks, I conducted 20-minute Tier Two math interventions two to three times a week that targeted specific early numeracy skills. All the while I collected data from my field log, students' intervention logs, and diagnostic assessments to guide my decision-making and to determine the direction of future interventions. There were a total of 20 intervention sessions that were aimed at expanding number sense: six sessions focused on subitizing, seven focused on counting to 100, and another seven centered on number identification. The final four sessions of the study were meant to increase fact fluency through the teaching of addition strategies. In all, I held 24 intervention sessions, for a total of approximately eight hours of supplemental instruction. It is no surprise that many of the achievement gaps documented at the beginning of the year were closed by the end of the study.

When I readministered the DIBELS Math benchmark assessment, students were tested on their quantity discrimination, skip counting, and computation. Scores increased across the board. My class went from having 58% proficiency in quantity discrimination to 92% proficiency. This suggests that not only were students reading two-digit numbers fluently, but they were understanding place value. In Missing Number Fluency, my class went from 71% proficiency in September to 83% meeting the benchmark in January. This shows that students were better able to identify and extend counting patterns. Again, this would not be possible if students did not have a firm grasp of the count sequence. The results from the middle of year Quantity Discrimination and Missing Number Fluency measures indicate that students possess a stronger number sense than they did when entering first grade.

Additionally, my class went from an already impressive 92% proficiency on the Computation measure to 96% proficiency in the middle of the year. The Rocket Math two-minute test results corroborated these results, showing that students went from solving 10 equations to nearly 22 addition equations in two minutes. Taken together, these results suggest that students have better basic fact retrieval now than they did before receiving math interventions.

It is more than just the raw data that leads me to believe that students possess greater flexibility with numbers now than they did before. In the math groups, students shared insights about numbers and how they related to one another. From War to Bingo, our activities sparked countless opportunities for dialogue and discussion. As students' confidences grew, they volunteered to "be the teacher" during whole group lessons and articulate their processes and justifications to the class. To teach others required the fullest degree of understanding. Now that a strong foundation is in place, students are employing higher-order thinking skills within our math block.

It is impossible to know the full extent to which math interventions impacted students' number sense and basic fact retrieval. However, it is clear that Tier Two interventions gave students with math difficulties the much needed reteaching and guided practice necessary for them to complete grade level mathematics. Math groups acted as booster shots for the underachieving and were crucial in developing the strong mathematical foundations that all students need.

Early Numeracy Skills

Early numeracy skills such as subitizing, number identification, and knowledge of the count sequence, should be the primary focus of early intervention as they are the foundation upon which computation and advanced mathematics are built.

After reviewing the scores on the baseline DIBELS Math assessment, I was shocked to find that it was not poor fact fluency that was holding students back. It was the early numeracy skills, the "interconnected knowledge of numbers and operations" (NRC, 2009, p. 95) that were holding them back. Forty-two percent of students did not meet the goal for Number Naming Fluency. Another

38% of students struggled to identify the next number in a series. My students had become dependent on a number line but lacked a conceptual understanding of numbers.

Jordan and colleagues' (2010) found a strong correlation between first-grade students' number sense and their problem-solving abilities later in third grade. If students had gaps in their understanding now and lacked a strong number sense, it could impact their mathematical performance for years to come. Because of this, my interventions focused on early numeracy skills for the majority of this study, including subitizing, counting, and number identification.

On the middle of year benchmark, students were assessed on their Quantity Discrimination and Missing Number Fluency. None of my interventions had targeted skip counting. I had never explicitly taught greater than or less than within my small groups. Neither topic had been covered within whole group instruction, either. Despite that fact, students showed growth on each of those subtests. So how can I logically explain the growth on those measures? In part, I think that strengthening students' number sense gave them the necessary foundation for taking on more complex math tasks.

Take, for example, our focus on number identification. While we practiced reading numbers, I emphasized how the first digit represented the tens and helped us to read the number correctly. In doing so, I was inadvertently alluding to the value of that number. Although our focus was to read two-digit numbers, students gained a better understanding of place value as well. This also happened during our sessions on counting. I helped students to organize their materials into groups of ten, just in case they lost track of where they were. We often skip counted to make sure we counted the correct amount. I did not realize it at the time, but that procedure turned out to be good practice for the Missing Number Fluency probe.

I had set intentional instructional goals for each intervention session. But the beauty of our base-ten system is that it inherently builds upon itself. Students were walking away with secondhand skills that would be beneficial to them later on. When interventions focused on early numeracy skills like subitizing, counting, and number identification, students were actively building a foundation for more advanced mathematics.

Instructional Strategies

Effective interventions include brief explicit instruction, a Concrete-Representational-Abstract approach, and ample opportunities for students to engage with new content through gameplay.

I would argue that the increase in student achievement was as much of a result of the instructional strategies as it was the instructional focuses. For Tier Two math interventions to be truly effective, it is important to employ explicit instruction, a CRA approach, and promote play.

Recent research suggests that struggling students benefit from Tier Two interventions that are explicit, systematic, and hands-on (Fuchs et al., 2005; Bryant et al., 2008; Doabler et al., 2016). Every intervention session began with brief direct instruction paired with a think aloud and modeling of how to do a task. This gave my students behaviors to emulate as they tried the work for themselves. For example, while teaching the Counting On strategy to add +2 facts, I modeled how to identify the larger addend, lock it in my brain, and count on from there. Later, while observing students play a fact fluency game, I noticed Jade motioning the "locking" of a number in her brain before counting on. This was not the only time students followed my example from the direct instruction. Students often used the same vocabulary that I modeled. Sadie referred to numbers as "teens" and others identified digits as "addends." Explicit language helped my students to discuss their learning with precision and it helped them to find a confident voice to express their understanding of the concepts.

Additionally, my interventions gradually transitioned from concrete to abstract experiences to promote a conceptual understanding of numbers. Studies indicate that quality math instruction follows a CRA transition and uses concrete manipulatives and models before introducing abstract concepts (Bryant et al., 2008; Flores, 2010; Agrawal et al., 2016). When first introducing subitizing, I started off by tossing counter chips onto the table. This showed students that real values could be recognized quickly. From there, we used flashcards and pictorial representations of dot patterns to illustrate the same concept. Starting off with manipulatives shows students that math is rooted in reality. By the time children are introduced to abstract symbols, they understand the concepts that they represent.

Finally, gameplay was a central component of my instructional methods. Game-based learning provided low-stakes opportunities for students to practice and refine their new skills. In an effort to avoid drill and kill practice, gameplay was a fun way to repeat procedures but for authentic and meaningful purposes.

Motivation and Engagement

When instruction incorporates games and varied manipulatives, practice transforms into play and students become excited about attending intervention groups.

Instructional methods that included gameplay and a variety of materials were both conducive to learning and engaging for students. From Bingo to Fly Swatting, students played dozens of instructional games throughout this study to solidify new concepts. Almost every session incorporated a partner or group game based on the target skill. When games were used for independent practice instead of repetitive worksheets, students became excited about attending math groups. For the most part, students were joyous and focused during playtime. Games gave the illusion that this was not work, this was play, making the students more open to the concepts that were being instructed and reinforced.

Manipulatives had a similar appeal. Pennsylvania Common Core suggests that students demonstrate their comprehension using both models and tools (NGACBP, 2010). Students are accustomed to using counter chips and place value blocks in math. But why count with cubes when you can count crayons? Students were excited to work with new and unique materials, especially when they were empowered to choose their manipulatives.

Challenges

The effectiveness of Tier Two math interventions may be diminished by student resistance and the limitations of a sole interventionist.

There were ample benefits to conducting small group math interventions with my students. However, this does not mean the implementation of these tiered groups was without challenge. Many of the students in my math interventions were students who also struggled with reading. Students like Braden, David, and Sadie, were being pulled for phonics interventions between 30 and 60 minutes a day. On days when I held math groups, those students were receiving over an hour of intense instruction on top of the regular curriculum. It was only natural for them to become resistant to additional support. David became frustrated when our counting activities were tedious and repetitive. To combat these student frustrations I tried to incorporate fun activities and only hold interventions two to three times a week. Although most students seemed to enjoy math groups, some days it was impossible to get students to "buy in."

More so than student resistance, it was the limitations of being the sole math interventionist that was most difficult for me. It felt nearly impossible to meet the unique needs of 26 students. When Braden did not master counting to 100 after three one-on-one sessions, I was forced to move on to a new skill, for I could not neglect the other students who needed support. This could have been avoided if there was a team of interventionists in place. In an ideal RtI framework, we would have adjusted student groupings so that Braden would continue to receive instruction on counting. However, with myself as the only interventionist, my hands were tied. This might have been the reason why Braden was the only student to score well below grade level on the middle of year benchmark. With these two challenges in mind, I plan on making some key changes to my interventions in the coming months and years.

Next Steps

I will never forget the day that I officially retired from competitive swimming. I broke the news to my college coach after the first practice of my sophomore year. It would have been my 13th season. In the truest fashion of a breakup, I cited wanting to see other people. It was true; I wanted to join the clubs and campus organizations that I had never had time for. I wanted to build up a resume that would impress future employers. Although I no longer wanted to be a student athlete, swimming would always hold a piece of my heart. There were tears in my eyes when I slammed my locker for the last time. But as I walked into the bright, warm September air, I couldn't help but feel both relieved and hopeful about what was yet to come.

I have spent the past year planning, researching, enacting, and reflecting on my graduate thesis. This has been nothing short of a labor of love. Now that I am at the end of this journey, I can't help but feel relieved. The decision to conduct action research and overhaul your professional practice is risky, especially when you know that it will affect young learners. It is a relief to know that my math interventions were beneficial for both myself and my students. For my students, the additional guidance and practice solidified concepts that are instrumental in advanced mathematics. For me, I refined my pedagogy and learned how to more effectively support students in math. Although I'm grateful and pleased to have sparked this growth, I know that my job is not done yet.

After the success of the middle of year benchmark test, I decided to continue with my math interventions and have since wrapped up the addition strategies and delved into place value. I didn't want to get complacent. As this year progresses, I will continue to administer diagnostic assessments to gauge students' understanding of subtraction strategies, and then, their ability to add and subtract two-digit numbers. If time allows, I will assess students' understanding of other mathematical skills such as measurement, time, fractions, and graphing. It will take a tremendous amount of time to collect and create intervention materials for the wide-range of skills first graders need to master. But in the future, that effort will pay dividends. Next year I will be able to hit the ground running with math groups without spending time gathering resources.

One of the major challenges of this study was being the sole interventionist for my students. Unlike the school-wide RtI program set in place for supporting emergent readers, I was alone in administering Tier Two support for math. I would love for my grade-level colleagues to join me next year in implementing math groups. Even with one additional interventionist, we could further differentiate student groupings. Through sharing my successes, maybe others will consider making math groups a part of their block too.

At the district level, math has often taken a backseat to literacy. It is my sincere hope that my inquiry sparks a new conversation: How can we use what we know about data collection and tiered reading interventions and apply that to math instruction? Ultimately, I hope to see students with math difficulties given the same strategic interventions as students who struggle with reading. After all, early numeracy skills are just as important as early literacy skills in preparing students for a 21st-century world.

For the time being, I am overjoyed to work with first graders in what is arguably the most transformative school year of a child's life. Their enthusiasm for life and learning drives me to become a better educator. Someday, I might consider becoming a math or reading specialist. But for now, I am happy to be making a splash in my own classroom.

References

Agrawal, J., & Morin, L. (2016). Evidence-based practices: Applications of concrete representational abstract framework across math concepts for students with mathematics disabilities. *Learning Disabilities Research & Practice, 31*(1), 34-44.

Archer, A. L. (2011). Explicit instruction: effective and efficient teaching. New York: Guilford Press.

Bryant, D. P., Bryant, B. R., Gersten, R. M., Scammacca, N. N., Funk, C., Winter, A., ... Pool, C. (2008). The effects of tier 2 intervention on the mathematics performance of first-grade students who are at risk for mathematics difficulties. *Learning Disability Quarterly, 31*, 47-63.

Carbonneau, K., Marley, S., & Selig, J. (2013). A meta-analysis of the efficacy of teaching mathematics with concrete manipulatives. *Journal of Educational Psychology, 105*(2), 380-400.

Clarke, B., Doabler, C. T., Nelson, N. J., & Shanley, C. (2015). Effective instructional strategies for kindergarten and first-grade students at risk in mathematics. *Intervention in School and Clinic, 50*, 257-265.

Delpit, L. (2012). *"Multiplication is for white people:" Raising expectations for other people's children.* New York: The New Press.

Doabler, C. T., Clarke, B., Kosty, D. B., Kurtz-Nelson, E., Fien, H., Smolkowski, K., & Baker, S. K. (2016). Testing the efficacy of a tier 2 mathematics intervention: A conceptual replication study. *Exceptional Children, 83*, 92-110.

Flores, M. M. (2010). Using the concrete-representational-abstract sequence to teach subtraction with regrouping to students at risk for failure. *Remedial and Special Education, 31*(3), 195-207.

Foorman, B. R., Francis, D. J., & Fletcher, J. M. (1998). The role of instruction in learning to read: Preventing reading failure in at-risk children. *Journal of Educational Psychology, 90*, 37– 55.

Fuchs, L. S., Compton, D. L., Fuchs, D., Paulsen, K., Bryant, J. D., & Hamlett, C. L. (2005). The prevention, identification, and cognitive determinants of math difficulty. *Journal of Educational Psychology, 97*(3), 493.

Fuchs, L. S., Fuchs, D., Craddock, C., Hollenbeck, K. N., Hamlett, C. L., & Schatschneider, C. (2008). Effects of small-group tutoring with and without validated classroom instruction on at-risk students' math problem solving: Are two tiers of prevention better than one? *Journal of Educational Psychology, 100*, 491–509.

Geary, D. C. (2004). Mathematics and learning disabilities. *Journal of learning disabilities, 37*(1), 4-15.

Gersten, R., & Chard, D. (1999). Number sense: Rethinking arithmetic instruction for students with mathematical disabilities. *The Journal of Special Education, 33*(1), 18-28.

Gersten, R., Beckmann, S., Clarke, B., Foegen, A., Marsh, L., Star, J. R., & Witzel, B. (2009). *Assisting Students Struggling with Mathematics: Response to Intervention (RtI) for Elementary and Middle Schools*. Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://ies.ed.gov/ncee/wwc/publications/practiceguides/.

Gersten, R., Clarke, B., Jordan, N. C., Newman-Gonchar, R., Haymond, K., & Wilkins, C. (2012). Universal screening in mathematics for the primary grades: Beginnings of a research base. *Exceptional Children, 78,* 423-445.

Hasselbring, T. S., Goin, L., & Bransford, J. D. (1988). Developing math automaticity in learning handicapped children: The role of computerized drill and practice. *Focus on Exceptional Children, 20*, 1-7.

Hendricks, C. (2017). *Improving schools through action research: A comprehensive guide for educators.* (4th ed.). Boston: Pearson Education.

Howell, R., Deiotte, M., & Patton, S. (2008). *Understanding response to intervention: A practical guide for systemic implementation*. Bloomington: Solution Tree.

Jordan, N. C., Glutting, J., & Ramineni, C. (2010). The importance of number sense to mathematics achievement in first and third grades. *Learning and Individual Differences, 20*, 82–88.

Jordan, N., & Dyson, N. (2014). *Number sense intervention*s. Baltimore, Maryland: Paul H. Brookes Publishing.

Lipton, J. S., & Spelke, E. S. (2003). Origins of number sense: Large-number discrimination in human infants. *Psychological Science, 14*(5), 396-401.

McNiff, J. (2017). *Action research: All you need to know*. Los Angeles: Sage.

Morgan, P. L., Farkas, G., & Maczuga, S. (2015). Which instructional practices most help first grade students with and without mathematics difficulties? *Educational Evaluation and Policy Analysis, 37*(2), 184–205. doi:10.3102/0162373714536608

National Center for Educational Statistics. (2017). *National assessment of education progress*. Washington, DC: U.S. Department of Education.

National Governors Association Center for Best Practices, & Council of Chief State School Officers. (2010). Common core state standards for mathematics: Grade 1 introduction. Retrieved from http://www.corestandards.org/Math/Content/1/introduction/

National Mathematics Advisory Panel. (2008). *Foundations for success: The final* *report of the national mathematics advisory panel*. Washington, DC: U.S. Department of Education.

National Research Council. (2001). Adding it up: Helping children learn mathematics. Washington, DC: The National Academies Press. doi:10.17226/9822.

National Research Council. (2009). *Mathematics learning in early childhood: Paths toward excellence and equity*. Washington, DC: National Academies Press.

Núñez, R. (2017). *How much mathematics is "hardwired," if any at all: Biological evolution, development, and the essential role of culture*. Hoboken, NJ, USA: John Wiley & Sons, Inc..

OECD. (2018). *Mathematics performance (PISA) (indicator)*. doi:10.1787/04711c74-en

Parsons, J. (n.d.) *An introduction/review of action research and its ethical practices.* Retrieved from https://www.academia.edu/19869893/An_Introduction_Review_of_Action_Research_and_Its_Ethical_Practices

Powell, S. R., Fuchs, L. S., Cirino, P. T., Fuchs, D., Compton, D. L., & Changas,

P. C. (2015). Effects of a multitier support system on calculation, word problem, and prealgebraic performance among at-risk learners. *Exceptional Children, 81*, 443-470.

Powell, S., & Fuchs, L. (2015). Intensive intervention in mathematics. *Learning Disabilities Research & Practice, 30*(4), 182-192. doi:10.1111/ldrp.12087

Purpura, D. J., Baroody, A. J., Eiland, M. D., & Reid, E. E. (2016). Fostering first graders' reasoning strategies with basic sums: The value of guided instruction. *Elementary School Journal, 117*, 72-100.

Stickney, E. M., Sharp, L. B., & Kenyon, A. S. (2012). Technology-enhanced assessment of math fact automaticity: Patterns of performance for low- and typically achieving students. *Assessment for Effective Intervention, 37*(2), 84-94. doi:10.1177/1534508411430321

VanDevender, E. M. (1988). Problems in teaching mathematics in the elementary classroom. *School Science and Mathematics, 88*(1), 65-71.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA:Harvard University Press.

Woodward, J. (2006). Developing automaticity in multiplication facts: Integrating strategy instruction with timed practice drills. *Learning Disability Quarterly, 29*(4), 269289.

Appendices

Appendix A: HSIRB Approval Letter

Dear Samantha,

The HSIRB has completed its final review of your proposal and is granting **approval** of this proposal.

Please note that if you intend on venturing into topics other than the ones indicated in your proposal, you must inform the HSIRB about what those topics will be. Should any other aspect of your research change or extend past one year of the date of this email notification, you will need to file those changes or extensions with the HSIRB and receive approval of the changes before implementation. If you need a hard copy letter indicating your approval status for record keeping purposes, please let me know.

One last step. We need to collect your electronic signature(s). If (each of) you could respond to this email with your own name and the project title in the subject line, that will serve as your electronic signatures. Please do not hesitate to contact me if you have any questions.

Good luck with your exciting and important research!

Take care,
Dr. DesJardin

Appendix B: Principal Consent Form

Dear Mr. Steidle,

As you know, I am a graduate student at Moravian College and am working towards my Master's Degree in Curriculum and Instruction. A central philosophy of Moravian's program calls upon practitioners to conduct action research into their own teaching practice. For my culminating thesis, I would like to conduct a study on mathematics intervention. I will examine the effects of tiered and targeted interventions on students' number sense and basic fact retrieval. I believe that by providing additional support to students with mathematical difficulties, those students will develop a more sound understanding of our base-ten numeration system. I will be conducting this research during my math block in the fall of 2018.

During this study, I will collect diagnostic screeners, topic tests, student work, intervention logs, and observational notes, to determine if the interventions are effective. All of the students in my class will be given parental consent forms to participate in this study. Participation is optional and any student may withdraw from the study at any time without being penalized. I will only use data from students who have been granted permission by their legal guardian. All students will be provided with pseudonyms. The only other person who will have access to my data will be my graduate professor. Research materials will be kept in a secure location in my classroom and all data that was collected throughout the study will be destroyed at the end of the study.

If you should have any questions or concerns about my research at any time, please feel free to contact me. Questions may also be directed towards my professor, Dr. Joseph Shosh, at 610-861-1482 or by email at shoshj@moravian.edu.

I want to thank you for your time and consideration in this matter. As always, I appreciate your support as I refine my practice to better help our students.

Please check the appropriate box below and sign the form:

[ ] I give permission to the researcher to conduct the above named research in my school as described in the proposal.

[ ] I do not give permission to the researcher to conduct the above named research in my school as described in the proposal.

______________________________________ ______________

Signature of Principal Date

Thank you,
Samantha Strickler

Appendix C: Parent Consent Form

Dear First Grade Families,

As I tell my students, even teachers go to school! Currently, I am a graduate student at Moravian College and am working towards my Master's Degree in Curriculum and Instruction. This semester, I'll be conducting action research into my own teaching practice. I will examine the effects of mathematics interventions on students' number sense and basic fact retrieval. I believe that providing additional support to students will help develop a more sound understanding of our base-ten number system. I will be conducting this research during our math lessons this fall.

Here's where you come into play! While all of my students will be involved in the activities as a part of our regular class time, I will only use data from students who have been granted permission by their legal guardian. During this study, I will collect universal screeners, diagnostic assessments, student work, intervention logs, and observational notes, to determine if the interventions are effective. Participation is optional and any student may withdraw from the study at any time without being penalized. All students will be provided with pseudonyms. The only other person who will have access to my data will be my graduate professor. Research materials will be kept in a secure location in my classroom and all data that was collected will be destroyed at the end of the study.

There is little to no risk for students involved with this research. However, if your child experiences any adverse effects, please contact the school nurse. If you should have any questions or concerns about my research or your child's rights, please feel free to contact me. Questions may also be directed towards my professor, Dr. Joe Shosh, by email at jshosh@moravian.edu

I want to thank you for your time and consideration in this matter. I appreciate your support as I refine my practice to better help my students.

Sincerely,
Ms. Samantha Strickler

I attest that I am the subject's legally authorized guardian, that I read and understand this consent form, and that I received a copy.

Child's name (printed): ___________________________

Legal representative signature: __________________________

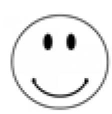
Date: ____________

Appendix D: Student Assent Form

Dear First Grade Friends,

As you already know, even teachers go to school! I am a student at Moravian College where I am learning to be a better teacher. This fall, I am going to do research on our math groups. I hope that math groups help us with our topic tests and Rocket Math. I need your help! I would like to show off your progress at my college. Do not worry. I will not share your real name. Can I use your work in my study? I will not be mad if you say no. You can change your mind anytime. Let me know if you have questions.

Thank you for your help, mathematicians!



YES! Miss Strickler can use my work in her study.

NO. Miss Strickler **cannot** use my work in her study.

Name: ______________________________________

Coding Index

Codes	Page Numbers	Related Codes
Computation	FL 4, 6, 7, 9, 28, 29, SW 42-48	Fluency, Strategy Application
Concrete Representational Abstract (CRA) Approach	FL 29, SW 42-48	Instructional Strategy, Manipulatives, Subitizing, Number Identification
Count Sequence	FL 3, 5, 8, 14, 15, 17, 18, 27, SW 18-38	Number Identification, Quantity Discrimination, Manipulatives
Core Instruction	FL 5, 6, 13, 25, 26, 27, 28	Explicit Instruction, Grouping, Instructional Strategy
Difficulty	FL 3, 4, 5, 6, 7, 11, 16, 21, 22, 24	Failure, Resistance
Excitement	FL 2, 11, 14, 15, 18, 19, 21, 22, 23, 24, D4, MS 8	Participation, Improvement, Game-Based Learning
Explicit Instruction	FL 5, 12, 20, 23, V3	Instructional Strategy, Core Instruction, CRA Approach
Failure	FL 13, 14, SW 18, 19, 20, 24, 26, 30, 39	Difficulty, Resistance
Fluency	FL 8, 9, 13, 21, 22	Computation, Subitizing, Number Identification, Quantity Discrimination
Flexibility	FL 14, 16	Grouping, Instructional Strategy
Game-Based Learning	FL 12, 13, 22, 23, 24, 25, MS 5, V5	Instructional Strategy, Explicit Instruction, Strategy Application, Participation, Subitizing, Number Identification
Grouping	FL 12, 18, 20, 22, 28, MS 7, V1, 4	Flexibility, Instructional Strategy

Higher-Order Thinking	FL 19, 21, 24, 26, MS 8	Strategy Application, Improvement, CRA Approach, Game-Based Learning
Improvement	FL 13, 15, 16, 17, 18, 23, 24, 26, 27 SW 13-17, 31, 32, 33, 35-38	Fluency, Excitement, Participation
Instructional Strategy	FL 12, 13, 14, 19, 22, 23, 24, 30, MS 7	Explicit Instruction, CRA Approach, Game-Based Learning, Manipulatives, Grouping
Manipulatives	FL 14, 15, 16, 18, 19, 29, D4	CRA Approach, Explicit Instruction, Count Sequence, Subitizing
Number Identification	FL 5, 8, 20, 21, 23, 25, 27, SW 39-41	Count Sequence, Subitizing, Quantity Discrimination, Game-Based Learning
Participation	FL 13, 15, 17, 26, D1	Fluency, Excitement, Improvement, Game-Based Learning
Quantity Discrimination	FL5, 8, 22, 24, MS 8	Number Identification, Count Sequence, Fluency
Resistance	FL 16, 23, MS 7	Failure, Difficulty
Strategy Application	FL 2, 11, 12, 13, 15, 28, 29	Explicit Instruction, Higher-Order Thinking, Subitizing, Computation
Subitizing	FL 3, 10, 12, 27, SW 1-17	CRA Approach, Number Identification, Quantity Discrimination, Fluency

Key:
FL = field log; MS = mid-study memo; D = Delpit memo; V = Vygotsky memo; SW = student work