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The Impact of Number Talks on Kindergarten Math Growth in a Large Private Independent School

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THE IMPACT OF NUMBER TALKS ON KINDERGARTEN MATH GROWTH IN A LARGE PRIVATE INDEPENDENT SCHOOL

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This dissertation was submitted by Rebecca Marie Knight under the direction of the persons listed below. It was submitted to the Gardner-Webb University School of Education and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Gardner-Webb University.

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Abstract

THE IMPACT OF NUMBER TALKS ON KINDERGARTEN MATH GROWTH IN A LARGE PRIVATE INDEPENDENT SCHOOL. Knight, Rebecca Marie, 2020: Dissertation, Gardner-Webb University.

This mixed methods action research study examined the implementation process and impact of a 9-week Number Talk intervention to build number sense in kindergarten students. Fifty-eight kindergarten students engaged in daily Number Talk lessons for 9 weeks. Qualitative data were collected to evaluate the strengths and challenges of the implementation process with the teacher participants through a twice weekly observation tool and through bi-weekly math professional learning community discussions. The qualitative data gathered were coded for themes using Tesch's Eight Steps for coding information. The data allowed me to evaluate the implementation process to determine if Number Talks were implemented with fidelity during the implementation process. Quantitative data were collected with the Number Sense Screener (NSS) assessment instrument. The students were given the NSS as a pretest before Number Talk implementation and as a posttest after the 9 weeks of implementation. A paired sample *t* test was utilized to analyze the pre and posttest results. The *t* test was completed using the results of the pre- and post-NSS, and analysis showed a significant gain in the mean score for the targeted group. The qualitative and quantitative data were utilized by the participating teachers and me to create an action plan for future Number Talk implementation within the school. The action plan includes four steps for implementation to support lesson planning, implementation reflection, implementation walk-throughs, and formative assessment of number sense.

Keywords: elementary school mathematics, mathematics curriculum, numeracy, action research, mixed methods research

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Chapter 1: Introduction

Calculating the tip at a restaurant, completing fractions to double a recipe, or knowing how many quarters and dimes a cashier should return in change are all simple tasks; however, recent studies have found about one in five adults in the United States lack the math competencies required of a student at the middle school level or the mathematical competencies needed for many modern jobs (Geary et al., 2013; Neergaard, 2013). Young children report not only enjoying math but feeling confident in their ability and success in mathematics. Unfortunately, by seventh grade, students in the United States statistically do not perform well on standardized tests, score well below their international peers, and have negative attitudes towards math classes and their personal abilities to perform well in those classes (Best et al., 2011; National Assessment of Educational Progress [NAEP], n.d.).

Scientific evidence supports early reading instruction with preschoolers because of the strong connection between a young student's ability to name letters and their later ability to distinguish the sounds of letters and learn to read more easily. Scientists are now showing research to support the early development of number system knowledge and number words to ease a student's development of number sense. Dr. David Geary, a cognitive psychologist, found when tracking students from kindergarten through high school, students who developed a gap in number sense early in their education maintained or widened that gap as the students aged through middle and high school (Neergaard, 2013). Current research shows an early proficiency in mathematics is a more reliable predictor of long-term success of students than any other childhood skill, including literacy. Additionally, research has found early proficiency in mathematics is a more accurate predictor of later reading achievement than early literacy competency (Duncan & Magnusson, 2011).

While researchers do not fully understand why mathematics proficiency is an early predictor of future success for students in school, research demonstrates that mathematics learning is closely tied to a student's executive functioning skills such as problem-solving, reasoning, working memory, and task flexibility. These skills strongly support student achievement across all academic subjects (Best et al., 2011). Young children have significant and often untapped potential to grasp math concepts and skills, including skills of magnitude, patterns, shapes, and measurement. Most current mathematical standards utilized by schools underestimate a child's innate ability to understand mathematics. Furthermore, educators are not utilizing emerging research to ensure mathematics education is age appropriate (Clements et al., 2013).

High-quality early math instruction supports later learning of science, technology, engineering, and mathematics skills, which are essential for college and career readiness and are skills that employers are demanding of newly hired employees (Szekely, 2014). Maintaining the productivity of the nation requires the United States to continue to develop and produce highly qualified scientists, engineers, entrepreneurs, and other professionals. Therefore, advanced math and science skills must be taught and achieved in American schools. The American Diploma Project estimates that 62% of American jobs over the next 10 years will require entry-level workers to be proficient in algebra, geometry, data interpretation, probability, and statistics (Hanushek et al., 2011).

In order to provide high-quality early math instruction for students, educators must be equipped to understand why it is essential for students. Educators must participate in regular staff development and training to ensure instruction is appropriate and effectively supports the needs of students (Brenneman et al., 2009; Engel et al., 2013; Szekely, 2014).

Background

When followed over time, students who lagged behind peers in middle school in an assessment of core math skills needed to function as an adult were the same students who had the least amount of number sense or fluency when they began first grade (Neergaard, 2013). A student's success in kindergarten is associated with attendance in college, along with earning potential and financial management ability, even when background characteristics are held constant. Independent of cognitive ability and social class, success or struggle with kindergarten math concepts is a powerful predictor of adolescent learning outcomes across content areas (Jordan, 2013). Persistent problems in math at the ages of six, eight, and 10 made students 13% less likely to graduate from high school and 34% less likely to enroll in college (Duncan & Magnusson, 2011).

The National Research Council's (2009) Committee on Early Childhood Mathematics found that despite research showing its importance, most early childhood programs do not spend enough focused time or high-quality instruction on mathematics and number sense development. Prekindergarten programs allocate, on average, 8% of learning activity time to mathematics while allotting 20% of learning activity time to literacy-based activities. Once in elementary school, more time is allotted to math at 3 hours per week, but this still trails behind literacy instruction by 2 hours per week. Additionally, math instruction is often integrated into other learning goals and activities like playing with blocks or counting during snack time (Szekely, 2014). This is a missed mathematical opportunity at an early age that has the potential to impact students far beyond the primary years. A student's number sense development is heavily impacted by experience and instruction. Efforts to teach number sense have been shown to result in significant gains in number sense for students (Jordan, 2013).

Research shows high-quality early mathematics instruction includes several nonnegotiables. First, math curriculum must be research based with an intentional sequence that allows students to master one skill and then build on that skill. Second, there should be a blend of teacher-led instruction and student-centered exploration and practice that is focused on building an understanding of concepts and skills, along with a focus on engaging play-based activities that stop for teachable moments. Last, high-quality early mathematics instruction promotes family engagement with math when educators can support parents to help their students at home (Clements et al., 2013).

Early number sense predicts mathematics success more than other measures of cognition, such as verbal, spatial, or memory skills (Jordan et al., 2007; Locuniak & Jordan, 2008; Mazzocco & Thompson, 2005; Siegler et al., 2012). The Committee on Early Childhood Mathematics from the National Research Council (2009) found that mathematics experiences for early childhood should focus on number, geometry, spatial relations, and measurement. The recommendation is for the majority of instruction to be focused on number, which includes whole number, operations, and relations.

Mathematical knowledge developed in primary grades is related to mathematics learning for years thereafter; and if not solidified, the gap continues to widen as students continue through school (National Mathematics Advisory Panel [NMAP], 2008). The National Report Card reveals 40% of fourth graders in 2017 were at or above the proficient level as reported by NAEP (n.d.), with only 34% of eighth graders at or above the proficient level. Between the years of 2005 to 2015, there have been no significant change in scores reported, which reveals students are not improving with current instruction.

Statement of the Problem

Ritchhart (2015) often asks stakeholders around the world, “What do you want the children you teach to be like as adults” (p. 16)? The answers are always similar, whether speaking to a room full of parents in a high-income area, teachers from a Title I school, or stakeholders in suburban America. The attributes described are consistent with those that are precursors for learning, like curiosity, inquisitiveness, and questioning. Answers also always consist of skills individuals need such as collaboration and strong listening skills. Additionally, the ability to analyze, make connections, and think critically are also included. Research supports the effectiveness of high-quality math instruction to support the development of a student’s executive functioning skills such as problem-solving, reasoning, working memory, and task flexibility, which strongly support student achievement across all academic subjects (Best et al., 2011).

Americans consistently score low on international mathematics assessments compared to peers in other countries. This trend can be seen as early as age three to five and widens by high school. In 2012, 15-year-olds in the United States ranked 26 of 34 countries when assessed by the Organization for Economic Cooperation and Development on the math portion of the Program for International Student Assessment (PISA). The Organization for Economic Cooperation and Development also completed a study on adults ages 16-25 where Americans fell behind the international average in both numeracy and problem-solving skills (Szekely, 2014).

A survey of 400 businesses across the United States conducted by a consortium of human resource, education, and corporate entities (Conference Board, Partnership for 21st Century Skills, Corporate Voices for Working Families, & Society for Human Resource Management, 2006) had employers rank skills they were looking for, both academic and applied. Critical thinking and problem-solving were at the top of the list over academic skills. While deficiencies in written communication were at the top of employer concerns academically, mathematics was the second academic skill employers listed as deficient in applicants (Ritchhart, 2015). Currently, there are half a million open computer science jobs in the United States and new ones are being created at nearly four times the rate of other jobs. Microsoft has 4,000 current job openings as of March 2019 (Hartman & Kuzmarov, 2019).

The National Council of Teachers of Mathematics (NCTM, 2014) published Principles to Action outlining guiding principles for mathematics instruction. One highlight of Principles to Action stated the importance of a balanced pedagogy where instruction goes beyond being heavily reliant on rote learning and memorization to developing conceptualizations of mathematics combined with operational and higher order thinking skills. This shift in instruction is connected to the constructivist theory that a teacher is meant to guide and support their students in the development of a conceptual understanding of math, rather than simply communicating procedural knowledge for students to memorize. Instructing from a constructivist point of theory requires a much deeper knowledge of mathematical content in order to assign appropriate tasks, explain models, and ask effective questions to stimulate student discovery (Reid & Reid, 2017).

However, research supports most teachers "hold oversimplified beliefs about classroom practice and pre-existing ideas of how to teach math based on their own experiences in traditional math classrooms" (Reid & Reid, 2017, p. 854).

When students are given high-quality, research-based instruction at an appropriate level that supports their constructing of meaning and relationships numerically, students develop a strong number sense that allows the development of mathematical thinking and reasoning ability. To raise the achievement level of American students in mathematics in a way that allows students to develop number sense and build on what is known and therefore maintain high levels of achievement throughout schooling, researchers must support teachers with high-quality research and instructional pedagogy (NCTM, 2014; Reid & Reid, 2017; Van de Walle et al., 2018). "Teachers must be focused on the mathematics they want children to learn–not on whether they are able to get right answers" (Richardson, 2012, p. xvi).

Purpose of the Study

The purpose of this study was to examine the implementation process and impact of a 9-week Number Talk intervention to build number sense in kindergarten students. Number Talks are 5- to 10-minute conversations around purposefully crafted computation problems utilized to equip students to communicate thinking and justify solutions to problems mentally. Classroom teachers focus on facilitation and relationship building to support student development of efficient, flexible, and accurate mathematical strategies by asking, "Does it make sense" and "How do you know" (Humphreys & Parker, 2015; Meli & North, 2018; Parrish, 2010, 2014). "The five key components of Number Talks are classroom environment and community, classroom discussions, the teacher's role as facilitator, the role of mental math, and purposeful computation problems" (Parrish, 2014, p. 10). The classroom environment developed should support collaboration and risk-taking for students so they are comfortable sharing the learning process. Classroom discussion is facilitated by the classroom teacher to support students sharing problem solutions and processes as the classroom teacher acts as a facilitator, questioner, listener, and learner. As students solve purposeful computation problems mentally, students are encouraged and supported to build number relationships and strengthen understanding of place value (Parrish, 2014). Table 1 outlines the seven steps of a Number Talk that encompasses the five key Number Talk components.

Table 1

Steps of a Number Talk

Steps	Description of steps
1	Purposeful computation problem written on board for students
2	Students solve problem mentally
3	Students put thumb up in front of chest when an answer is determined (can add fingers as discover more solutions)
4	Teacher calls on students for answers when most have thumb up
5	Teacher records all answers on board – correct and incorrect
6	Students share strategies and justify answers for peers
7	Teacher facilitates discussion and justification by asking, "What did you see," "How do you see it," and "How do you know" and records thinking on the board

(Parrish, 2014)

High-quality mathematics instruction provided by properly trained classroom teachers has the ability to equip students to construct a deep understanding of number sense (Reid & Reid, 2017). This study was aimed at determining if daily Number Talk instruction in kindergarten classrooms in a private, independent elementary school can improve the number sense proficiency of kindergarten students. The four main goals of a number talk with primary age students is to develop number sense, build fluency with small numbers, support a student's ability to subitize numbers, and equip students to make 10s (Parrish, 2014).

Significance of the Study

Number sense development is one of the overarching goals of mathematics learning (Leinwand, 2009). "Number sense performance and growth in kindergarten and first grade is highly predictive of mathematics achievement through at least third grade, even when adjusting for reading, age, and general cognitive factors" (Jordan et al., 2012, p. 3). Children who leave kindergarten with low number sense enter their primary years of elementary school disadvantaged, and research shows it is difficult for students to catch up.

From an early age, students need to develop a firm mathematical understanding and number sense. Mastery of foundational concepts of numbers equips students to develop a stronger number sense and to be more flexible with their problem-solving skills (Duncan et al., 2007). Early math skills and achievement have appeared to matter most to future learning and achievement in a meta-analysis of six longitudinal studies of school readiness. While early reading skills are a factor for later success of students, they are by less than half of those of early math skills. Students who have difficulty with mathematics at age seven tend to continue with this difficulty at the age of 11, more so in mathematics than in literacy (Gross, 2009). Finally, a strong foundation of basic number concepts becomes essential for students as they move to complex mathematical concepts that require conceptual flexibility (Duncan & Magnuson, 2011).

Equipping students with a firm mathematical understanding requires elementary teachers to grasp mathematical content and appropriate pedagogy. “Mathematics teaching involves building students’ trust, managing behavior, and structuring time and space in ways that are conducive to learning. This requires both pedagogical know-how and interpersonal skills” (Thames & Ball, 2010, p. 222). Number Talks develop a classroom environment and community that is safe for discussion and risk free for students when answering is important. Number Talks also build sensemaking skills in students that allow students and educators to explore and confront misconceptions within a community of learners (Parrish, 2014).

Beyond conventional content knowledge, educators need support in developing their ability to evaluate the appropriateness of mathematical strategies and manipulatives, the ability to determine what mathematics is at the heart of the lessons taught, and to know how to teach strategies that are able to increase student flexibility with computation skills (Thames & Ball, 2010). Having access to a specific number sense assessment to inform and support teachers provides educators with the data needed to modify and adjust instruction to improve student learning (Hunsader et al., 2015). Mathematics “teachers need significant mathematical skill, perspective, and judgement” (Thames & Ball, 2010, p. 223) to be able to answer the why questions behind each lesson and those asked by students to build a confident conceptual number sense.

Research to develop foundational mathematics skills in students that support their learning longitudinally has the potential to impact individuals in college and career, along with positively supporting the American economy to fill needed professional positions. Weak mathematical foundations are linked to “costly special education needs provision, to truancy, exclusion from school, greatly reduced employment opportunities, increased health risks, and an increased risk of involvement with the criminal justice system” (Gross, 2009, p. 4). Children with persistent math problems are much less likely to graduate from high school or attend college (Duncan & Magnuson, 2011). Costs to the educational system when students have a weak number sense are greater in the secondary areas than primary grades, and it is fiscally more responsible to provide intervention and support for the early primary grades than to try and support students once they have fallen behind in the secondary grades (Gross, 2009).

Research Questions

To determine if a 9-week Number Talk intervention has an impact on the number sense of kindergarten students, I conducted a mixed methods action research study. I am a lower school principal at a private, independent school where Number Talks are not currently being used with kindergarten students. The following questions enabled me to collect both qualitative and quantitative data:

1. To what extent are Number Talks being implemented with fidelity in kindergarten classrooms?
2. What do teachers perceive are the strengths and challenges of implementing Number Talks in the kindergarten classroom?
3. To what extent does a 9-week implementation of Number Talks impact number sense in students as measured by scores on the Number Sense Screener (NSS)?

Theoretical Framework

Utilizing Number Talks to develop number sense can be examined through a constructivist theoretical framework. Constructivism states that learners are not a blank slate but are creators and constructors of learning (Piaget, 1976; Van de Walle et al., 2018; Von Glasersfeld, 1995). Through the guidance and support of classroom teachers, students are able to actively create knowledge (Reid & Reid, 2017). Individuals connect existing ideas to new information and then modify existing knowledge to incorporate the new ideas. This happens through assimilation, where a new concept learned fits in with prior knowledge and then expands an individual's existing understanding, or through accommodation, where a new concept does not fit with prior knowledge, so individuals work to create new meaning and connections (Van de Walle et al., 2018).

Additionally, utilizing Number Talks to develop number sense can be examined through the sociocultural theory. In addition to the learner being able to actively create knowledge, the sociocultural theory positions the learner to learn from those they are working with who are more knowledgeable (Van de Walle et al., 2018). Learners have their own learning zone called the zone of proximal development. Within their zone of proximal development, individuals are able to learn with the support of their peers (Vygotsky, 1978). Effective learning occurs when classroom activities are within a person's zone of proximal development. Classroom discussions, when based on a child's ideas and solutions, support student learning (Wood & Turner-Vorbeck, 2001).

> Dewey (1916), Vygotsky (1978), Bruner (1996), Henry (1963), Glasser (1968), and Rogers (Rogers & Freiberg, 1994) all stressed that learning is a social endeavor in which our interactions with others not only support the learning

> process but are inseparable from it. At the heart of much of this theoretical work is the belief that transformative learning-that is, learning that cultivates the development of the whole person and strives for more than the simple transmission of information, is more likely to happen in community than in isolation. (Ritchhart, 2015, p. 203)

Vygotsky (1978) believed “children grow into the intellectual life of those around them” (p. 88). When children are surrounded with the kind of intellectual life, mental activity, and processes of learning that reflect desired learning outcomes, children are set up to become enculturated to the dispositions needed to be successful (Ritchhart, 2015).

Students are very grade and achievement focused, so students can often enter the classroom with an underlying assumption that the teacher should provide the information needed and students should just sit and receive the information. The traditional sit and get format can make students very passive and dependent, rather than being actively engaged in seeking meaning. Teachers must develop trust in the classroom and develop new patterns of student-to-student interaction. The qualities of critical thinking and problem-solving, which are needed by students to be sense-makers in mathematics are only developed over time and must be learned through immersion in a culture that values and teaches critical thinking and problem-solving (Ritchhart, 2015).

Assumptions

The trustworthiness of this study was based on a set of assumptions made by me and are therefore important to disclose (Calabrese, 2012). The participants in the study were exposed to daily Number Talks within a 9-week period. It was assumed that students enrolled in kindergarten during the 9-week study would be present at school, actively participate in the Number Talks, and communicate what they know on the pre- and post-assessment given.

It was also assumed that the teachers of these students would implement the daily Number Talks as planned with me and would provide truthful feedback when meeting in professional learning communities (PLCs) with me. It was assumed that students, when exposed to high-quality Number Talks would increase their number sense because young children have significant and often untapped potential to learn and understand math concepts and skills (Clements et al., 2013). Additionally, because assessment bridges teaching and learning and allows the classroom teacher to collect evidence on each student to inform their future instruction, it was assumed students would show increases in mathematical knowledge (William, 2007). This mathematical knowledge was measured by the NSS (Jordan et al., 2012).

Limitations

Limitations were conditions beyond my control that identified potential weaknesses in the research design and could limit the study's scope (Calabrese, 2012). The limitations of this study involved the limited involvement of participants in theory development. While I equipped the classroom teachers with the information needed to complete the daily Number Talks, classroom teachers were not involved in the bulk of the research leading up to implementation of the action research.

Classroom teachers who were most familiar with implementing math strategies as they were taught and learned in their teacher training program were most challenged with learning new ways of thinking and instructing students so students can construct meaning (Reid & Reid, 2017). Along with this limitation, teacher quality is a limitation. When compared with other commonly measured factors such as technology, curriculum, class size, and school climate, teacher quality has been found to be the most influential factor in educational outcomes (Hanushek & Rivkin, 2006; Lee, 2018). Because the teachers selected to participate in the study were selected based on being in kindergarten, rather than level of teacher quality, it was a potential to limit the study's scope.

Connected to both teacher understanding of theory and teacher quality is the limitation of implementation fidelity. Implementing with fidelity means implementation is completed directly as instructed by the researchers who validated the practices (McMaster et al., 2014). Poor implementation fidelity would weaken the effectiveness of Number Talks and thus impact positive student learning outcomes. Implementation fidelity was addressed by a twice weekly evaluation during the 9-week study utilizing a checklist of the five key components of Number Talks.

Because I was the supervisor of the teachers, this is a limitation of the study. Implementation of Number Talks was a decision made by the shared leadership team, and all team members have buy-in to the program and curricular work. The action research framework of the study focused on the team of teachers and me examining the implementation of Number Talks, along with how to improve this process for the entire school's implementation. Therefore, the focus was moved from evaluative of the teachers to improvement of Number Talk implementation for student achievement, but my role within the school community is a weakness of the study.

Additionally, the element of time was a limitation of the study as students were assessed on 9 weeks of Number Talks completed during the first semester of instruction of their kindergarten year. Finally, student attendance was out of my control and limited the learning of each student based on their ability to be at school each day to receive the Number Talk instruction.

Delimitations

Delimitations are boundaries that narrow the scope the study will impact based on what has been included or excluded from the study (Calabrese, 2012). Delimitations exist by specifying 58 kindergarteners and three classroom teachers from three classrooms within a private, independent elementary school. The results of this study will not necessarily generalize to other populations from other types of schools or grade levels. This population was a convenience sample because I had access to the classrooms and the teachers within these classrooms. The classroom teachers were under my direction, as I was also the lower school principal. These students were selected for the research study because numeracy difficulties traced back to the first year of formal schooling are connected to the development of fundamental weaknesses in number sense (Gersten et al., 2005), and number sense performance and growth in primary grades is a strong predictor of math achievement through at least the third-grade year (Jordan, Glutting et al., 2009; Jordan, Kaplan et al., 2009).

Deficiencies in the Literature

Mathematics education for the primary age student matters for long-term achievement outcomes. Primary math concepts are strong predictors of "learning outcomes across content areas, independent of cognitive ability or social class" (Duncan et al., 2007, p. 1443). There have been experiments that show early intervention for students to support cognitive and academic achievement gains, but these have been based on broad curriculum design, not targeted to building just number sense (Duncan &

Magnuson, 2011; Duncan et al., 2007).

Number Talks engage students in thinking about numbers through meaningful mathematics, rather than focusing on procedures. Understanding is the basis for developing procedural fluency, and instructional programs that emphasize understanding algorithms before applying them have shown to lead to increases in both conceptual and procedural knowledge (Mathematics Learning Study Committee et al., 2001). Number Talks to build number sense were developed in the 1990s by Ruth Parker and Kathy Richardson to address these needs, but few research studies on the effectiveness of their implementation are available. One study focused on utilizing Number Talks with kindergarten students with autism and another study focused on utilizing Number Talks in combination with other mathematics curriculums to examine social justice and equity through the implementation process. Other research studies found utilizing Number Talks focused on older students.

Additionally, while recent research on number sense is accessible, especially research showing there is a need for more support of teachers to know how to implement instruction that supports students deepening mathematical understanding, most national research ended with the Final Report of NMAP (2008) when then President George W. Bush gave an executive order to “foster greater knowledge of and improved performance in mathematics among American students” (p. xiii). NMAP recognized the importance of students having a “strong start” and for educators to use the research known about how children learn, while reinforcing the benefits of conceptual understanding, procedural understanding, and automaticity to improve mathematical achievement. Little federal funding for research has been allocated since the Final Report was presented.

NMAP (2008) saw a need for coherence across American curriculum when compared to those like Singapore who are regularly outperforming American students, but educators are still currently expressing a need for more support on the development of mathematical skills, perspective, and judgement to be able to coherently build a conceptual number sense in students (Reid & Reid, 2017; Thames & Ball, 2010). While no one would argue that teachers should have a strong grasp of mathematical knowledge, there is not a clear description of what this knowledge should look like and how mathematical knowledge should support teachers to develop mathematically prepared students. Beyond conventional content knowledge, educators need support in developing their ability to evaluate the appropriateness of mathematical strategies and manipulatives, the ability to determine what mathematics are at the heart of the lessons taught, and to know how to teach strategies that are able to increase student flexibility with computation skills (Thames & Ball, 2010). Number Talks build these skills in teachers (Parrish, 2014).

While the 2008 Final Report gave input on how to increase American student achievement, American fourth graders in 2015 still scored lower than the educational systems of 10 developed countries. Additionally, students performing in the 25th percentile and the 10th percentile actually performed lower in 2015 than in 2011. Students who are struggling the most with fourth-grade math concepts have decreased their scores within the past two test administrations.

Likewise, eighth-grade students in the United States scored lower than eight educational systems. Eighth graders performing in the 10th percentile, those scoring the lowest of United States eighth graders, also performed lower in 2015 than in 2011. Although the scores of American students have increased over the 20 years the test has been given, when American students are compared internationally, American students continue to trail behind many other industrial and competitive nations (Provasnik et al., 2016). Research needs to continue to close the gap between the knowledge of strong mathematics foundations being important and the actual development of these strong foundations in students to ensure American students are individually successful and internationally competitive.

Audience

The audience for this study includes educators interested in Number Talks in the mathematics classroom and how Number Talks impact the development of number sense. The research is especially relevant to classroom teachers, curriculum coordinators, principals, and other stakeholders who reach students in the primary grades of education who wish to understand more about how primary grade students learn mathematics. Administrators, curriculum developers, and others in positions of decision-making would be interested in the results of the study to determine whether money should be allocated for staff development, materials, and curriculum for the implementation of Number Talks. Professors in higher education supporting those going into education, especially in the primary grades, would be interested in the findings of the action research as they seek to equip students with the skills needed to develop number sense in school age students.

Research Design

The research design for this study was a convergent, embedded mixed methods action research model. The students involved in the study were 58 kindergarten students who attended a private, independent lower school in a suburban community located five miles from a southeastern coastal port city in the United States. The students were exposed to the treatment of daily Number Talks in the regular education classroom provided by the homeroom teacher for 9 weeks. The population consisted of students at the school where I worked as the lower school principal.

The first and second research questions addressing fidelity of implementation of Number Talks, along with what teachers perceived to be strengths and challenges of implementation, were qualitative in nature. Both were addressed using data collected from an observation checklist I utilized during the twice weekly observations, along with bi-weekly focus groups I held with the teachers implementing the daily Number Talks.

I created the observation checklist (see Appendix A) utilizing the seven steps of Number Talks and the five key components of Number Talks. The seven steps of Number Talks were evaluated on a 0-3 Likert scale and were evaluated during each observation. The five key components were then addressed in an open-ended question at the end of every second observation.

To better understand perceived strengths and challenges of implementation from the teachers implementing Number Talks, the kindergarten teachers engaged with me in bi-weekly focus groups during their PLC time (Eaker et al., 2002). A Math Talk PLC Agenda (see Appendix B) was kept during each meeting guiding the discussion to strengths and concerns of implementation, next steps for upcoming lessons, and questions about future implementation. Additionally, the team frequently referenced the steps and key components of Number Talks. The data of both the observation checklist and the focus group meetings were analyzed for trends and patterns in responses.

The quantitative information to address Research Question 3 included analysis of a pre- and post-administration of the NSS to the heterogeneous groups of kindergarten students. Students were individually given a pretest prior to their experience with Number Talks and then a posttest after the experience. The data were analyzed using a paired sample *t* test to look at the differences between the pre- and post-assessment scores. Additionally, the paired sample *t* test was used to analyze the scores within the three different classrooms, along with scores for students performing below (less than 50^{th} percentile), at (less than 75^{th} percentile but greater than 49^{th} percentile), or above (greater than 74^{th} percentile) average based on pretest scores.

The Trends in International Mathematics and Science Study (TIMSS) found fourth and eighth graders scoring in the 25^{th} percentile and below have decreased scores over the past two administrations (Provasnik et al., 2016). Early intervention and development of number competencies have been found to have a strong relationship to a student's school achievement during the first 4 years of elementary education (Cerda et al., 2015). The paired sample *t* test analysis provided insight into the ability of Number Talks to impact mathematical achievement for students performing below, at, or above average.

With a goal to create a Number Talk action plan for more successful school-wide implementation, the PLC (Eaker et al., 2002) team utilized trends and patterns of implementation feedback from the qualitative data, along with the support of the quantitative data analysis to inform next steps in the action research plan for Number Talk implementation.

Definition of Terms

Accuracy

Ability to produce a correct answer (Parrish, 2011).

Algorithm

"Procedures that can be executed in the same way to solve a variety of problems arising from different situations and involving different numbers" (Mathematics Learning Study Committee et al., 2001, p. 103).

Assessment of Mathematical Understanding

The process of gathering evidence of a student's knowledge of, ability to use, and dispositions toward mathematics and making inferences from that evidence for a variety of purposes (NCTM, 2000).

Conceptual Fluency

Efficient and accurate methods for computing through demonstration of flexibility in the computational methods chosen, along with an ability to understand and explain those methods, while producing accurate answers efficiently (NCTM, 2000).

Conservation of Numbers

Understanding the quantity of a given number of objects remains the same no matter their spacing (Parrish, 2014).

Dot Images

Organized arrangement of dots utilized to build a visual link to composing and decomposing small numbers (Parrish, 2014).

Efficiency

"Ability to choose an appropriate, expedient strategy for a specific computation problem" (Parrish, 2011, pp. 199-200).

Five- and Ten-Frames

Grid of five and grid of 10 with two rows of five utilized to foster fluency, subitize, work with place value, and compute with addition and subtraction. Organized to support subitizing to 5 as half of 10 (Parrish, 2014).

Flexibility

"Ability to use number relationships with ease in computation" (Parrish, 2011, p. 200).

Fluency with Numbers

Ability to not only recall facts but being able to compose and decompose numbers in different ways (Parrish, 2014).

Making 10

Ability to count objects, organize, or group numbers into groups of 10 different ways. Understanding how many more will be needed to build a 10 (Parrish, 2014).

Mathematical Proficiency

"Conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition" (Mathematics Learning Study Committee et al., 2001, p. 116).

Number Competencies

"Ability to apprehend the value of small quantities immediately, make judgements about numbers and their magnitudes, grasp counting principles, and join and separate sets" (Jordan, Kaplan et al., 2009, p. 850).

Number Sense

"A comfort with numbers that includes estimation, mental math, numerical equivalents, a use of references like 1⁄2 and 50%, a sense of order and magnitude, and a well-developed understanding of place value" (Leinwand, 2009, p. 35).

NSS

A research-based tool utilized in kindergarten and first grade for screening early numerical competencies to predict achievement level and growth in elementary school students (Jordan et al., 2012).

Number System Knowledge

Understanding that numbers represent different quantities, numbers can be broken into parts, and the ability to utilize a number line to show the differences between numbers (Neergaard, 2013).

Number Talk

An approach to developing facility with computation that engages children in thinking about numbers and allows them to add, subtract, multiply, and divide using the mathematics that is meaningful to them, rather than using procedures that do not create connection (Parrish, 2014).

One-to-One Correspondence

Understanding how a quantity relates to a specific number (Parrish, 2014).

Pedagogical Content Knowledge

The role of content when teachers select a method or practice of teaching (Reid & Reid, 2017).

Procedural Knowledge

"A sequence of actions, or the computational skills needed to negotiate set methods" (Kajander, 2010, p. 233).

Proficiency

"A solid understanding of key concepts, able to achieve automaticity as appropriate, develop flexible, accurate, and automatic execution of the standard algorithms, and use these competencies to solve problems" (NMAP, 2008, p. xvii).

Rekenreks

Two rows of stringed beads with five beads of one color and five beads of another color on each row to help students reason about numbers, subitize, build fluency, and compute using number relationships (Fosnot & Dolk, 2001).

Rote Counting

Counting a set of numbers by assigning a number name to each object in the set (Parrish, 2014).

Subitizing

Ability to immediately recognize a collection of objects is a single unit, even when the collection is rearranged (Parrish, 2014).

Summary

Chapter 1 was an overview of the study. It began with background information on the importance of early numeracy development and its connection to future academic success, along with college and career preparedness (Duncan & Magnusson, 2011). The problem this study was designed to address is the concept that many American adults do not possess the mathematical competencies needed for routine mathematics tasks, much less those needed for many modern careers (Geary et al., 2013). Furthermore, many educators are not trained on current research and pedagogy to support students to prevent this problem (Thames & Ball, 2010).

The purpose of this study was to examine the implementation process and impact of a 9-week Number Talks intervention to number sense in primary students. The research questions written to address this purpose were shared, along with the assumptions, limitations, and delimitations of the research study. Additionally, the deficiencies in the literature, along with a brief description of the research design and definitions of key terms, were provided.

The literature review, Chapter 2, follows and presents many of the key ideas in current research that led me to develop this action research study. Current trends in standardized testing of elementary age students, middle school students, and those in more advanced math classes through TIMSS, our Nation's Report Card, and PISA show American students are consistently falling behind international peers (NAEP, n.d.; Provasnik et al., 2016). The literature review examines a balanced mathematical framework (Richardson, 2012), along with the definition of mathematical proficiency (Mathematics Learning Study Committee et al., 2001; NMAP, 2008) and the theory to support number sense work (Rouder & Geary, 2014; Humphreys & Parker, 2015; Richardson, 2012). Finally, the literature review addresses the definition of number sense (Lago & DiPerna, 2010), along with the importance of number sense and early intervention (Jordan, 2013), and the definition and components of Number Talks (Humphreys & Parker, 2015).

Chapter 3, methodology, follows Chapter 2 and explains the embedded mixed methods action research approach used in the study. Chapter 3 includes a description of the research design and approach, the population utilized in the study, and an in-depth description of the data collection instruments and materials.

Chapter 4 includes the results of the action research study and an analysis of the research gathered. The focus of Chapter 5 is on conclusions from the study, along with interpretations of the findings, implications for practice, and recommendations for future study.

Chapter 2: Literature Review

Overview

There is a growing consensus that math difficulties from later elementary years to high school years can be connected to a weak understanding of basic whole number competencies, along with number relationships (Jordan, Kaplan et al., 2009; NMAP, 2008; Siegler et al., 2012). In order to be prepared for advanced math high school courses, students must have a firm foundation in early mathematics, or they may not be successful in those advanced math courses because math difficulties are cumulative and worsen with time. Understanding of numbers and number relationships makes formal mathematics more accessible. When a student enters first grade with a weak number competency compared to other first-grade peers, the student is at a disadvantage for future learning. The constant search to catch up creates a cycle, if not interrupted, that could result in permanent gaps (Jordan, Kaplan et al., 2009). Children who fall behind in math instruction are at risk for future unemployment and will face obstacles meeting everyday demands of our modern world (Geary et al., 2012; Gross, 2009).

Students lacking a firm foundation in mathematics are at risk after graduation because of limited college and career options. Success in high school mathematics through Algebra II correlates with access to college and earning in the top quartile of income from employment (Lago & DiPerna, 2010; NMAP, 2008). Advanced study of math in a student's high school years is a precursor for success in college math and science and prepares students for vocations in fields that require science, technology, engineering, and math, but many students are lacking even basic mathematics competencies to succeed in typical jobs in our modern economy (Jordan, Glutting et al., 2009; Siegler et al., 2012). Individuals must be prepared to enter jobs requiring advanced math and science because the National Science Board indicates growth of jobs in the science and engineering workforce is outpacing overall job growth three to one (NMAP, 2008).

Students who are unable to enter college and career areas equipped with strong math skills put the United States at risk because it limits an individual's ability to adapt and change within a changing global society. The United States faces a future of accelerating retirements that will impact a large section of the current science and engineering workforce. The growth of the science and engineering workforce is expected to outpace job growth in the economy at large. As stated in *Foundations for Success* by NMAP (2008), "in the contemporary world, an educated technical workforce undergirds national leadership" (p. xi). Additionally, the United States used to attract more individuals from a talented worldwide pool, but now many developed countries are utilizing their own workforce (NMAP, 2008).

Maintaining the productivity of the nation requires the United States to continue to develop and produce highly qualified scientists, engineers, entrepreneurs, and other professionals, which requires advanced math and science skills to be taught and achieved in American schools. The American Diploma Project estimates that 62% of American jobs over the next 10 years will require entry-level workers to be proficient in algebra, geometry, data interpretation, probability, and statistics (Hanushek et al., 2011).

While deficiencies in number competencies can be supported through targeted instruction, mathematical difficulties have been largely overlooked in primary grades and have in the past received far less interventions and interest (Booth & Siegler, 2008;

Jordan, Kaplan et al., 2009). *Principles and Standards for School Mathematics* (NCTM 2000) and the Mathematics Learning Study Committee et al.'s (2001) Strands of Mathematical Proficiency's *Adding It Up* have discussed the importance of math instruction moving beyond rote and procedural knowledge, but these instructional shifts have not been consistently embraced and are not reflected in current student performance nationally (NAEP, n.d.; Provasnik et al., 2016).

The literature review will begin by examining the concerning state of math achievement. Next, the components of a balanced mathematical framework along with the theory to support number sense work are reviewed. Then, number sense and its connection to early intervention are examined. Finally, a Number Talk and its components are defined and explained, along with the four goals of Number Talks in primary grades.

Concerning State of Math Achievement

TIMSS

TIMSS is an international study that allows countries to measure and compare trends in mathematics and science achievement at the fourth- and eighth-grade levels. Starting in 1995, it has been administered every 4 years, to provide a 20-year trendline, with the last assessment being in 2015. The assessment is currently being given around the world for the latest 2019 administration. The United States has participated in every administration of TIMSS except for 1999 when it was not administered to fourth graders. It is designed to broadly align with mathematics and science curricula to reflect school-based learning for all students in educational systems that participate. The international assessment allows for comparison of students in the United States to students in other participating countries.

While American fourth graders have shown an increase from 1995 to 2015, there has been no measurable difference between 2011 and 2015. American fourth graders are scoring lower than 10 education systems including Singapore, Hong Kong, Chinese Taipei, Northern Ireland, Russian Federation, Norway, Ireland, England, Belgium, and Portugal. Additionally, students performing in the 25th percentile and the 10th percentile actually performed lower in 2015 than in 2011. Scores of low-performing fourth-grade students have regressed over the past two administrations.

Eighth-grade students in the United States also have shown an increase in scores from 1995 to 2015, but also score lower than seven educational systems including Singapore, Korea, Chinese Taipei, Hong Kong, Quebec, Canada, and Ireland. Just as with fourth graders, students performing in the 10th percentile, those scoring the lowest of United States eighth graders, also performed lower in 2015 than in 2011. While the scores of American students have increased over the 20 years, when scores are compared internationally, American students are continuing to trail behind many other industrial and competitive nations.

TIMSS Advanced is an international comparative study given by the TIMMS group that measures the advanced mathematics and physics achievement of students who are taking advanced courses and are in their last year of high school. It has been administered in 1995, 2008, and 2015. In the 2015 school year, students enrolled in advanced mathematics and taking this exam, which included students in geometry, algebra, and calculus, only accounted for 11.4% of students in this cohort. In 2015, advanced 12th graders in the United States scored higher than the average scores of students in five educational systems and lower than the average scores of students in two educational systems, the Russian Federation and Lebanon. When students are assessed, scores place them in the advanced, high, or intermediate benchmark. In 2015, 7% of American students taking the assessment were in the advanced benchmark, 26% reached the high benchmark, and 56% reached the intermediate benchmark.

Students taking the physics portion of the exam only accounted for 4.8% of the 2015 cohort, with 61% being male and 39% being female. Males outnumbered and outscored females. The average scores of American advanced 12th graders were higher than three educational systems taking the test and lower than the average scores of five educational systems: Sweden, Portugal, Norway, Russian Federation, and Slovenia. Five percent of American students reached the advanced benchmark, 18% reached the high benchmark, and 39% reached the intermediate benchmark. Students in Norway, the Russian Federation, and Slovenia reached higher percentages than American students on each of the three benchmarks.

TIMSS Advanced can be utilized to inform all stakeholders in the United States the extent to which American students excel in advanced mathematics and physics, which will ultimately prepare them to specialize in degrees and careers in the areas of science, technology, engineering, and mathematics compared to their international peers (Provasnik et al., 2016).

The Nation's Report Card

NAEP (n.d.) was first administered in 1969. It is the largest continuing and nationally representative assessment of what students in the United States know and can do in certain subjects. NAEP results are used by stakeholders to assess progress and are released as The Nation's Report Card. NAEP is a congressionally mandated project that is administered by the National Center for Educational Statistics. The mathematics assessment measures student skills in mathematics, along with student capability to apply their knowledge in problem-solving situations.

NAEP administers the assessments every 2 years to students in fourth and eighth grade and every 4 years to students in 12^{th} grade. In 2017, 149,400 fourth graders and 144,900 eighth graders participated. In 2015, 13,200 12^{th} graders participated. In 2017, only 40% of fourth graders were at or above the proficient level, and students in the 10^{th} and 25^{th} percentile scored lower than in 2015. In 2017, only 34% of eighth graders were at or above the proficient level. From 2013 to 2015, scores for fourth and eighth graders decreased, with no significant change from 2015 to 2017. In 2015, the average score for 12^{th} graders was 152 within a range of 0-300. Twenty-five percent of students were at or above the proficient level, with no significant change in scores reported from 2005 to 2015 (NAEP, n.d.).

PISA

The PISA math test was given in 2009. Thirty of the 56 countries that participated had a larger percentage of students who scored at the international equivalent of the advanced level on our Nation's Report Card (NAEP, n.d.). While just 6% of the students taking the assessment in the United States earned at least 617l.1 on the PISA 2006 exam, 28% of Taiwanese students did; at least 20% of students in Hong Kong, Korea, and Finland did; and 12 other countries had more than twice the percentage of advanced students as the U.S. (Switzerland, Belgium, the Netherlands, Liechtenstein, New Zealand, the Czech Republic, Japan, Canada, Macao-China, Australia, Germany, and Austria).

National Research Concerns

Maintaining our productivity as a nation requires us to continue to develop and produce highly qualified scientists, engineers, entrepreneurs, and other professionals. In order to enter these professions and to be competitive with other nations, advanced math and science skills need to be taught and achieved in our schools (Hanushek et al., 2011). One in five adults in the United States lack the math competence expected of a middle school student, much less the qualifications needed for many of today's jobs (Neergaard, 2013). Steinke (2017) asked students from three math levels within a community college developmental math program to place five whole numbers on a line that had only endpoints 0 and 20. Twenty-three percent of the students showed a lack of the concept of part-whole coexistence in the task. The students were unable to reasonably place the whole numbers on the number line using their existing understanding of number relationships. In two of the three levels of classes, this lack of concept had a significant relation to student success in the developmental math class (grades of an A, B, or C). This concept is assumed to be understood and foundational by students in most math programs and textbooks by fourth grade.

Richardson (2012) shared,

> If we are going to raise achievement in mathematics in ways that allow children to build on what they know, and thus maintain high levels of achievement throughout their schooling, teachers must focus on the mathematics they want children to learn, not on whether they are able to get right answers. (p. xvi)

The Committee on Early Childhood Mathematics from the National Research Council (2009) found that while research shows how young children should develop and learn key mathematical concepts and practices, these findings are not widely known or implemented. The Final Report of NMAP (2008) encouraged educational experts to make use of the rigorous research that shows how students learn and the advantages of having a strong early start for mathematical success. These instructional practices should be informed by high-quality research. The ability to identify numbers, discriminate between quantities, and identify missing numbers in sequences at the end of kindergarten is a strong predictor of mathematics outcomes at the end of first grade (Jordan, Glutting et al., 2009). Mathematical knowledge developed in kindergarten is related to mathematics learning for years thereafter; and if not solid, the gap continues to widen as students continue through school (NMAP, 2008). Robert Moses believed algebra, always known as a gatekeeper of sorts to higher mathematics, is now actually a gatekeeper for citizenship; and students who do not have an understanding of it are now like Americans who did not know how to read and write in the industrial age (Moses & Cobb, 2001).

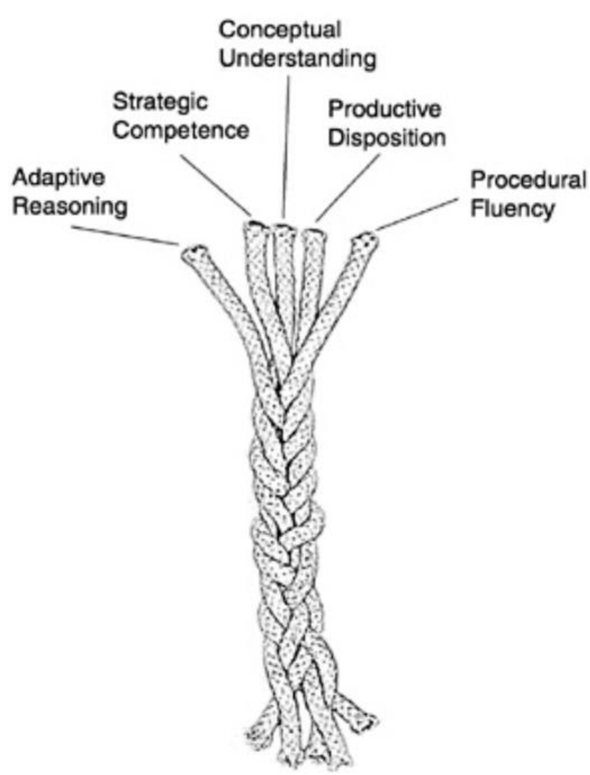
A Balanced Math Framework

Many students and adults view math as rules and procedures to memorize, while lacking the understanding that numerical relationships actually provide a foundation to provide the context needed to comprehend these rules and procedures. As students enter more complex algebra classes, a mathematical foundation based on memorization crumbles when asked to generalize arithmetic relationships (Parrish, 2014).

Only looking at a student's ability to get a correct answer means educators might not be gathering the information needed to understand what the student knows and still needs to learn. Instructional time spent on memorizing what might not conceptually make sense to a student rather than developing the understanding they need for future math concepts limits student understanding and ability to be successful in future mathematics (Richardson, 2012). The Mathematics Learning Study Committee et al. (2001) described mathematical proficiency as including "conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition" (p. 116). These components, while individual, are not separate but are intertwined when evaluating a student's number sense (Bass, 2003). These intertwined strands of proficiency are represented in Figure 1.

Figure 1

Intertwined Strands of Proficiency (Mathematics Learning Study Committee et al., 2001)



Conceptual understanding is the comprehension of mathematical concepts, operations, and relations (Mathematics Learning Study Committee et al., 2001). Students must have instruction focused on meaning and relationships. These relationships enable students to connect numbers to be able to describe quantities and relationships. With this foundation, students are able to take numbers apart and put them back together with counting one by one. Students are able to relate an answer to what is reasonable and demonstrate proficiency with computations (Richardson, 2012). Developing a conceptual understanding means developing a deeper understanding of mathematical concepts by connecting the relationships and patterns among the different pieces (Miller & Hudson, 2007). NMAP (2008) stated three foundational skills are necessary for conceptual understanding: fluency with whole numbers, fluency with fractions, and fluency with geometry and measurement. Fluency with whole numbers is important for primary grades and includes developing number sense, grasping basic mathematical operations, and having the ability to problem solve. Conceptual understanding allows students to utilize an integrated and functional grasp of math ideas rather than isolated facts and methods. A student's degree of conceptual understanding is directly related to the student's ability to make connections (Mathematics Learning Study Committee et al., 2001).

Procedural fluency is the skill of carrying out procedures flexibly, accurately, efficiently, and appropriately (Mathematics Learning Study Committee et al., 2001). As defined by the *Principles and Standards for School Mathematics,* procedural fluency refers to being efficient and accurate, with the ability to apply algorithms for computing that are based on an understanding of the properties and number relationships (NCTM, 2000). It is different from procedural knowledge, which only involves being able to follow step-by-step procedures to follow a math problem (Miller & Hudson, 2007). Students with developed procedural fluency are able to analyze similarities and differences between methods of calculations and are able to estimate the results of procedures accurately. This fluency supports conceptual understanding (Mathematics Learning Study Committee et al., 2001).

Strategic competence is the ability to formulate, represent, and solve mathematical problems (Mathematics Learning Study Committee et al., 2001). While drill and practice may equip students to memorize place value columns and names, using manipulatives and representational strategies allows students to develop an understanding of the number relationships that are important to completing place value tasks with accuracy and sensemaking (Miller & Hudson, 2007). Beyond solving the problem, strategic competence allows a student the ability to know how to set up the problem to be solved, along with the ability to utilize different and flexible approaches to solving problems (Mathematics Learning Study Committee et al., 2001).

Adaptive reasoning is the capacity for a student to bring logical thought, reflection, explanation, and justification to mathematical operations and problem-solving (Mathematics Learning Study Committee et al., 2001). Students equipped with adaptive reasoning are able to explain how they arrived at an answer, are able to justify the answer, and are able to provide sufficient reasoning to support the explanation (Mathematics Learning Study Committee et al., 2001).

Productive disposition (Mathematics Learning Study Committee et al., 2001) is the habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy. Productive disposition is needed for students to develop perseverance towards and a perceived benefit from mathematical challenge. Once students experience the rewards of sensemaking, productive disposition begins to develop. The classroom teacher plays a large role in the development of productive disposition (Mathematics Learning Study Committee et al., 2001).

Theory to Support Number Sense Work

According to Richardson (2012),

> What children know and understand about number and number relationships impacts every other area of mathematical study. Students cannot analyze data, determine functional relationships, compare measures of area and volume, or describe relative lengths of sides unless they can use numbers in meaningful ways. Number concepts are the foundation that children must have in order to achieve high standards in mathematics as a whole. (p. xiii)

Early number sense predicts math school success more than other measures of cognition, such as verbal, spatial, or memory skills (Jordan et al., 2007; Locuniak & Jordan, 2008; Mazzocco & Thompson, 2005; Watts et al., 2014). The Committee on Early Childhood Mathematics from the National Research Council (2009) found that mathematics experiences for early childhood should focus on number (whole number, operations, and relations), geometry, spatial relations, and measurement, with most of the focus on number.

Early theorist Piaget (1976) expressed a mature number sense with whole numbers was thought to appear around the age of seven or eight, with more recent research showing age nine (Houde et al., 2011). Additional research shows math achievement is related to a strong nonverbal number sense (Libertus et al., 2018) and an individual's ability to place whole numbers on an empty number line (Booth & Siegler, 2008: Eleanor & Gilmore, 2009; Rouder & Geary, 2014). These findings align with Siegler et al.'s (2011) development of the Integrated Theory of Numerical Development.

This theory states that number sense involves understanding that all real numbers have magnitudes and can be assigned a specific location on a number line. NMAP (2008) stated one of their major research findings as what is developmentally appropriate in regard to number sense instruction and development is largely contingent on prior opportunities to learn, not on a particular age or stage.

Research shows our traditional curriculum and instructional methods in the United States have left American students with fragile skills and shallow understanding of number sense and more advanced mathematical concepts (Hiebert 1999; Humphreys & Parker, 2015). Students are dependent on rote procedures that they apply mindlessly. For example, when a student completes the algorithm for 15-7, they will immediately cross out the one and borrow to make it 15 again, rather than completing the subtraction problem understanding 14-7 is 7, so 15-7 is 8.

When students rely on a set of rules and procedures, known as an algorithm, without understanding what is happening as the algorithm is completed, students are limited from developing a deeper number sense of why the algorithm works every time they apply it. “Arithmetic algorithms are important tools for students because they are reliable and efficient and work with all numbers, but they can mask the meaning and complexity of the steps involved each time you complete the algorithm” (Bass, 2003, p. 323). For example, the subtraction algorithm replaces the understanding of subtraction for the efficiency of completing the procedural steps quickly. Students can get the right answer by treating numbers as columns of place value-neutral digits. When the instruction is focused on completing the procedural steps rather than the value of what is being subtracted, the relationship between the quantities being subtracted is lost

(Humphreys & Parker, 2015).

In 54-36, the 5 represents 50, but students do not need to understand the value of 5 in the 10s place to get the correct answer when completing the algorithm. Students are told to simply “Make 5 into a 4.” It is misleading to let students think that students can simply “change” numbers when the focus is on the procedure instead of the value of the 5 when in the 10s place. Rather than changing the number, students are actually substituting ten 1s for the one 10. As a continuation of the problem, students are not taught that 40 + 14 is equal to 54, which is what has been borrowed, to continue the connection to the value of borrowing one 10.

Another misconception also developed in primary grades to help students “borrow” is teachers often say, “you cannot take 7 from 3.” When, actually 7 can be taken from 3 with the result being a negative number, -4. When students learn this in first or second grade, that it cannot be done, and then get to seventh grade and learn it is true, mathematical rules seem arbitrary and the concrete idea that numbers have magnitude is lost (Humphreys & Parker, 2015). There is a missed opportunity to connect this procedural problem to number sense building using a number line.

This type of teacher instruction in the primary grades, instruction completed without connecting for students that numbers having magnitude as stated in The Integrated Theory of Numerical Development, begins to develop misconceptions for students that ultimately impacts later math instruction (Siegler et al., 2011). Success in algebra and beyond depends on understanding the concepts that educators often conceal in the learning of algorithms with only procedures in mind, rather than including an understanding of numbers, number values, and number magnitudes (Humphreys &

Parker, 2015).

The arguments of researchers above can be summarized as students needing to understand that numbers have magnitude and meaning and students must interact with numbers in purposeful ways in order to develop a conceptual understanding of mathematics (Hiebert 1999; Humphreys & Parker, 2015; Richardson, 2012; Siegler et al., 2011), but traditional education has continued to focus on steps and procedures, which lacks meaning and a connection to what numbers on a page represent.

The constructivist theory supports students developing a meaningful understanding of numbers as they explore and construct meaning in student work (Piaget, 1976; Reid & Reid, 2017; Van de Walle et al., 2018; Von Glasersfeld, 1995). As a student learns something new through guidance of a teacher and through the social interaction of peers, students are able to connect new learning to existing learning or realize there is not existing knowledge, and the mind continues to explore and construct meaning. As this learning is constructed within the context of a community of learners, including the classroom teacher who acts as a guide, peers are utilized to affirm or disaffirm new learning through the sociocultural theory (Van de Walle et al., 2018; Wood & Turner-Vonbeck, 2001). If the goal of mathematics instruction is to teach for understanding, students must be equipped to construct their own knowledge through connecting new ideas to prior knowledge (Dance & Kaplan, 2018).

Defining Number Sense

Researchers and educators agree number sense is an important prerequisite to later math achievement, but it is often defined in slightly differing ways (Lago & DiPerna, 2010). Lago and DiPerna (2010) and Gersten and Chard (1999) defined number sense conceptually as a student’s ability to be fluid and flexible with numbers, an ability to understand what numbers mean, and then perform mental math using what these numbers mean to make realistic comparisons. NCTM (2000) defined number sense as the ability to understand the meaning of numbers, define different relationships among numbers, recognize the relative size of numbers, use references for measuring objects and events, and think of numbers in a flexible manner. Baroody and Wilkins (1999) defined number sense as a concrete understanding of numerical relationships. Baglici et al. (2010) concluded number sense must mean students have an understanding of what numbers mean, fluency and flexibility when using numbers, and an ability to make quantity comparisons and perform mental mathematics. Fennell and Landis (1994) found number sense to include an awareness of what numbers are, their value, and how they relate to others. Additionally, a strong number sense includes an understanding of what happens when performing operations, including mental mathematics and estimations. NMAP (2008) defined proficiency as understanding key concepts, achieving automaticity, and developing flexible and accurate skills to use these competencies to solve problems. Leinwand (2009) described number sense as having a comfort with numbers, an ability to estimate with reason, and a well-developed understanding of place value.

At every stage of development of number sense, the size of numbers, the size of the differences between the numbers, and the level of abstractness impacts a student’s ability to understand and use numbers. For example, a student might understand that 6 is contained within 8 but not yet understand the relationship between 16 and 18. Students must be supported to start their learning and sensemaking with concrete representation of numbers before moving to a more abstract symbolic representation (Richardson, 2012).

Richardson (2012) also noted that each stage of mathematical learning is much more complex than educators generally realize, and the work to support students in number sense development is more complex than teachers connect for students. A firm understanding of number competencies, which is the ability to apprehend the value of small quantities immediately and understand a number's magnitude, supports students as students learn to make connections among mathematical relationships, principles, and procedures (Jordan, Kaplan et al., 2009). Jordan, Kaplan et al. (2009) reported,

> While students who are fluid with fact retrieval are more successful in math classrooms, a student will have difficulty memorizing arithmetic facts by rote without understanding how combinations of numbers relate to one another on a number line (e.g., 3 + 2, 2 + 3, 5 - 2, and 5 - 3). (p. 851)

Accurate and efficient counting supports a student to develop strong number relationships, which supports a student's ability to connect a problem and its solution, which in turn reduces the need for rote memorization (Bryant & Nunes, 2009; Jordan, Kaplan et al., 2009). A misconception of instructors is a child who has learned to answer questions and follow procedures might not have a deep awareness that gives true meaning to math. For example, if a primary student knows the teacher has 11 counters, but when the teacher lays them out on the desk or adds more space between them and asks how many the teacher has, the student has to recount to know there are 11, this student lacks a developed adaptive reasoning to think logically about the number of counters based on the movement of the counters. Or, if a student has memorized that 6 + 6 is 12 but does not know how to use this memorized fact to answer 6 + 7, the student's procedural fluency is underdeveloped (Richardson, 2012).

Number Sense and Early Intervention

A student's success in kindergarten has been found to be associated with college attendance, earning potential, and financial management, even when background characteristics are held constant (Jordan, 2013). The ability to identify numbers, discriminate between quantities, and identify missing numbers in sequences at the end of kindergarten is a strong predictor of mathematics outcomes at the end of first grade and a significant predictor of the rate at which a student achieves between first and third grades. Studies have shown that having a strong foundation in number competency early on is a stronger predictor of success in math over verbal, spatial, and memory skill competencies (Jordan, Kaplan et al., 2009; Locuniak & Jordan, 2008), independent of cognitive ability and social class (Jordan, 2013). Mathematical knowledge developed in kindergarten is related to a student's mathematics learning for years thereafter; and if not solid, the gap continues to widen as the student continues through school (NMAP, 2008). Higher levels of kindergarten number competence predict a statistically significant difference in a child's ability to achieve at the end of third grade (Jordan, Kaplan et al., 2009).

Early mathematical competencies, especially achievement in counting and numerical tasks, have been found to have a strong relationship to a student's school achievement during a student's first 4 years of elementary education (Cerda et al., 2015). Weak general number sense shows in a student through poorly developed counting procedures, slow fact retrieval, and inaccurate computation (Jordan, Kaplan et al., 2009). Siegler et al. (2012) analyzed nationally representative, longitudinal data sets from the United States and United Kingdom. These longitudinal data sets showed elementary school student knowledge of whole number division and fractions were predictors of knowledge of algebra and overall math achievement in high school. These results were true even after they statistically controlled for general intellectual ability, working memory, and family income and education. NMAP (2008) stated that proficiency with fractions should be a major goal of all kindergarten through eighth-grade mathematical programs because it is foundational for success in algebra programs.

Work to support high-risk kindergarten students with specific interventions focused on building number competencies has resulted in significant gains on first-grade mathematics outcomes compared to control groups (Jordan, Kaplan et al., 2009). A study by Baglici et al. (2010) tracking students from kindergarten to first grade found that oral counting and number identification are gateway skills that enable students to then participate in more math activities, while missing number activities appear to assess a student’s understanding of number sense, which is directly tied to school success. Kindergarten performance on the missing number measure was a significant predictor of first-grade computation success, while oral counting has been found to be a preschool indicator of later success.

Early understanding of number relationships and operations provides a student with support for learning complex calculation procedures involving larger numbers as well as supporting problem-solving abilities in a variety of contexts (Jordan, Kaplan et al., 2009), which supports data showing that a strong conceptual knowledge and a firm understanding of procedural skills are interrelated and support the learning of each other (NMAP, 2008). University of Missouri researchers followed 180 seventh-grade students (Neergaard, 2013). Those who were below average compared to peers in seventh grade were also those who struggled with number sense and number fluency in first grade

(Neergaard, 2013).

Each stage of learning number sense is much more complex than we generally recognize (Richardson, 2012). Just as parents have been encouraged to practice letter names with their preschoolers so the preschoolers can better distinguish letter sounds to make reading easier, children need to know number words and have numbers attached to nouns, like "five crayons" to help develop an understanding of the magnitude of numbers (Neergaard, 2013). NMAP (2008) has found "encouraging results" from instructional programs designed to intervene at an early age with supporting number sense in students, but tests of short- and long-term effects need to be completed with more populations and more education and implementation of these findings communicated to all stakeholders.

Number Talks Defined and Components

Number Talks can change a student's view of mathematics by teaching them number sense; developing their mental math skills; and engaging them in creative, open mathematics. Number Talks shift student experiences with math to see that problems can be solved in different ways, math is open and a visual subject, and all math problems can be solved using different methods and pathways. In contrast to traditional algorithms, Number Talks depend on a student's sensemaking abilities while allowing a student to construct their understanding of the problem and concept being discussed (Humphreys & Parker, 2015). Number Talks are a purposeful vehicle to make sense of math, develop efficient computation strategies, communicate mathematically, and reason through and prove solutions (Parrish, 2014).

Classroom Number Talks involve 5- to 10-minute conversations around purposefully crafted computation problems. By combining essential mathematical processes and habits of mind, students learn to communicate thinking and justify solutions to problems solved mentally. The teacher focuses on facilitating discussion; number relationships; and the use of these relationships to develop efficient, flexible strategies with accuracy. Focus moves from getting the correct answer to the teacher asking, “Does it make sense” and “How do you know” to facilitate sensemaking (Humphreys & Parker, 2015; Meli & North, 2018; Parrish, 2010, 2014).

There are five key components of Number Talks. These five components are developing a safe classroom environment and community, holding classroom discussions, the teacher’s role becomes facilitator, students are equipped to utilize mental math, and computation problems are introduced purposefully to support learning and internalizing strategies that can be applied to future mathematics (Parrish, 2014).

Classroom Environment and Community

Developing a classroom environment and community that is safe for discussion and risk free for students when answering is important. In the sociocultural theory, students can construct meaning within relationships and work with other students (Van de Walle et al., 2018). In order for this to be successful, the acceptance of all ideas and answers is key because wrong answers are often rooted in misconceptions and allow the community to explore and confront the misconceptions. Teachers record all answers without verbal or physical expressions that indicate agreement or disagreement onto the board or other surface, which allows students to defend their thinking behind the solution, again building sensemaking for students (Humphreys & Parker, 2015; Meli & North, 2018; Parrish, 2010, 2014). NMAP (2008) stated that a child’s goals and beliefs about their learning are related to the student’s performance. When shifts are made from ability to effort within math talk work, this is related to improved mathematics performance.

Classroom Discussions

Classroom discussions are another component of Number Talks. Building communication skills within and among students supports sensemaking. Students can indicate an answer with a thumb up in front of their chest and continue looking for answers, while everyone has a chance to think. After adequate wait time, students share individual answers, all answers are recorded, and students are given a chance to explain the thinking used to get to their answer.

Teacher as Facilitator

The teacher's role shifts from being the sole authority of imparting information and confirming correct answers to assuming the roles of facilitator, questioner, listener, and learner. By keeping the focus on math and helping students structure their comments and wonderings, teachers facilitate the development of communication skills while listening in for misconceptions and number sense strengths to inform future Number Talks. Listening to student thinking rather than focusing on the final or correct answer is a part of Number Talks. Students are also listening to the explanations of other students. Teachers shift their question from "What answer did you get" to "How did you solve the problem" and "How do you know" (Humphreys & Parker, 2015; Parrish, 2010, 2014).

The Role of Mental Math

Another component of Number Talks is mental math, which encourages students away from traditional algorithms and relying on memorized procedures to building on number relationships and problem-solving. Building on number relationships, problem-solving, and sensemaking strengthens understanding of place value and student ability to view numbers as whole quantities, instead of discrete columns of digits or as columns of place value-neutral digits.

Purposeful Computation Problems

Computation problems selected for students must be purposefully planned to develop patterns. This careful design develops computational strategies that equip students in sensemaking and builds skills to notice the reasonableness of the answers constructed (Humphreys & Parker, 2015).

There are several benefits of sharing and discussing computation strategies. Sharing purposeful strategies challenges students to clarify thinking, investigate and apply mathematical relationships, build a repertoire of efficient strategies, and make decisions about choosing efficient strategies for specific problems; and equips students to consider and test other strategies to see if the strategies are mathematically logical (Parrish, 2010, p. 203). Number Talks lead to the development of more accurate, efficient, and flexible strategies. Accuracy is the ability to produce a correct answer; efficiency is the ability to choose an appropriate and expedient strategy for specific computation problems; and flexibility is the ability to use number relationships with ease in computation (Parrish, 2010, 2014).

Four Goals of Number Talks in Primary Grades

Parrish (2014) stated four goals for Number Talks in primary grades. These goals are to develop number sense, to build fluency with small numbers, to equip students to subitize numbers, and to support making 10s.

Developing Number Sense

Number Talks in primary classrooms should develop number sense. Every answer is elicited to a problem in a Number Talk, and students are asked to share whether the proposed solutions are reasonable. The connection built to an answer and its reasonableness builds number sense. When teachers ask students to give an estimate before the students begin thinking about a specific strategy, teachers foster number sense. Discerning or justifying whether a solution is reasonable must be developed in students. If a teacher asks a student to estimate and provide evidence to prove the answer is reasonable without focusing on the correctness of the answer, the teacher is building number sense.

Conversations around numbers and one-to-one correspondence are essential to number sense building. Students with a developing number sense understand the quantity of a given number of objects remains the same no matter how they are spatially arranged. If a student is asked to count a group of objects and then this group of objects is moved around in front of the student and the student is asked again to state how many of the objects are seen, the student will then know the value is the same. If the student recounts, the student is unable to conserve the number and is lacking number sense. Additionally, Number Talks in primary grades develop one-to-one correspondence, which is a student's ability to count a set of objectives while understanding how a given quantity correlates to a specific number. This is different from rote counting and matching a number name to an object. For example, if a student knows two socks match the student's two feet, they are developing one-to-one correspondence.

Building Fluency

Another goal of Number Talks in the primary grades must be developing fluency with small numbers. Fluency is much more than fact recall. Number fluency is knowing how a number can be composed and decomposed and using that information to be flexible and efficient with solving problems (Parrish, 2010, 2014). Richardson (2002) stated that students in primary grades should first work towards fluency with numbers 1 through 6 and then with numbers 7 through 10. Fluency means a student could decompose a 7 into 5 and 2, so the 5 could be combined with another 5 to make a 10. Therefore 5 + 7 is the same as 5 + 5 + 2 (Parrish, 2010, 2014).

Subitizing

Students in primary grades must also develop the skill of subitizing in Number Talks. Subitizing means a student can immediately recognize a collection of objects as a single unit, like seeing and knowing the number of pips on a die without counting them. Number Talks using dot images, five- and ten-frames, or rekenreks builds recognition of numbers and the number’s parts. The ability to subitize is a critical component of computation in lower grades.

Making 10s

Supporting the ability of students to make 10s is an important piece of Number Talks in primary grades. Making 10s provides a link to developing and understanding place value and the American base system of 10s. Understanding that ten 1s is also a single entity of one 10 is a critical understanding to develop in primary grades. Students need many opportunities to count objects and organize the objects into groups of 10 to begin constructing their understanding of place value that can then be applied when completing procedural computation problems with the ability to reason through an appropriate answer. Presenting questions that ask students to consider how many more are needed to have a group of 10 builds an understanding of how to compose and decompose 10. This ability continues to build number fluency (Parrish, 2010, 2014).

Beyond the power of knowing that there are many ways to solve a problem, educators have to help students develop flexibility and confidence in working with numbers. Building sensemaking within a community of risk-taking and problem-solving supports not only the building of number sense but also confidence as a student of mathematics. Number Talks support students believing in themselves mathematically, support students becoming more willing to persevere when solving complex problems, build confidence when the student realizes the ideas the student constructs are worth listening to, and transform the culture of the math class (Humphreys & Parker, 2015).

Summary

The teaching of mathematics has long been focused on learning a discrete set of rules and procedures students must implement with speed and accuracy, but these two pieces have been implemented without a necessary understanding of mathematical logic, or number sense. For some students and adults, learning mathematics as simple procedures has been successful; but for the majority of individuals, knowledge of rules and algorithms has not allowed them to use math confidently in their daily lives within school and beyond. Approximately two thirds of our nation’s adult population identify as being fearful of mathematics; and many have simply said no to classes, courses, degrees, and careers that require higher math (Burns, 1998; Parrish, 2014). Many students choose not to pursue college degrees and careers that require more complex math courses because of previous negative experiences with mathematics (Parrish, 2014). America needs students who are able to reason about quantitative information, possess number sense, and check for reasonableness of solutions and answers within the context of math classrooms and real-life applications. Parrish (2014) stated, “Math curriculums must focus on preparing students to be mathematically proficient and compute accurately, efficiently, and flexibly” (p. 5).

Chapter 3 introduces the methodology of the study, including the purpose for the study and description of the research design and approach. Chapter 3 discusses the research questions, population included in the study, variables that were studied, and the study’s validity and reliability. Finally, Chapter 3 explains how data were collected and analyzed.

An analysis and report of the results of the action research study are found in Chapter 4. Chapter 5 includes interpretations of the findings, implications for practice, and conclusions from the study, along with recommendations for future study.

Chapter 3: Methodology

This chapter includes a review of the methodology of the study. I describe the purpose of the study, the research design, the research questions that were addressed, and information about the population included in the action research study. Additionally, this chapter addresses the variables in the research study, the qualitative and quantitative data that were gathered, and how the data collection and analysis were completed.

Purpose

This action research study examined the implementation process and impact of a 9-week Number Talk intervention to build number sense in kindergarten students. For the purposes of this study, the school site is not named to protect the confidentiality of the study participants. The study took place during the first semester of the 2019-2020 school year with kindergarten students in a private, independent lower school located in the coastal area of a state in the southeastern United States. Students participated in daily Number Talks as a part of their daily math instruction for 9 weeks.

To plan and prepare for Number Talks, we utilized Parrish's (2014) text, *Number Talks: Whole Number Computation*. This text provided teachers with the concept of Number Talks, how to prepare for Number Talks, how to utilize Number Talks to develop strategies in students, and how to purposefully design Number Talks for kindergarten students. In addition to reading the text together within their PLC, teachers received professional development twice throughout the fall semester by a staff developer brought into the school (Eaker et al., 2002).

During the 2018-2019 school year, the lower school staff of the school where the research took place began an evaluation of current student performance in math. The math committee, consisting of a representative from each grade level and the administration, noted current strengths in students as mathematicians, along with areas for growth. Teachers in first and second grade began to experiment with Number Talks during that school year and noted an improvement in student ability to talk about math and hold conversations around math. This was noted as a strength. Within areas of growth, teachers noted students struggled to explain their answers and how to know if the answer was correct. Fourth- and fifth-grade team members noted an extreme difficulty with fractions; and the entire team noted negative attitudes toward math, a need to get the right answer, and difficulties with word problems. These perceived difficulties are reinforced by standardized testing data when students at the school are compared to students in the same age cohort at other independent schools as seen by the testing data in Table 2.

Table 2

2018 Math and Quantitative Reasoning Mean Scale Scores

	Math mean scale score			Quantitative reasoning mean scale score		
Grade level	Site level norm	Independent school norm	Scale score range	Site level norm	Independent school norm	Scale score range
2	277	322	152-434	n/a	n/a	n/a
3	379	441	229-690	n/a	n/a	n/a
4	398	484	305-392	361	425	272-476
5	454	565	342-816	436	487	300-612

Students in second through eighth grade participate in the Comprehensive Testing

Program 5 (CTP 5) developed by the Educational Records Bureau (ERB, 2019). ERB is a not-for-profit organization utilized by independent and public schools for admissions and achievement assessments and instructional services for students PK through Grade 12. The CTP 5 provides assessments in reading, listening, vocabulary, writing, and math, along with verbal and quantitative reasoning, beginning in fourth grade. The CTP 5 allows schools to "compare content specific and curriculum-based performance to more conceptual knowledge base found in reasoning tests" (ERB, 2019, p. 1). Students at the school where the research study took place participate in the fall administration, which utilizes fall normative data, so testing data can be received during the current school year to allow for more directed support of individual students, along with instructional and curriculum decisions to be made with the current student cohort.

Table 2 indicates every grade's site level math norm is lower than the overall independent school math norm mean scale scores, with a difference ranging from 34 scale score points in second grade to 111 scale score points in fifth grade. Additionally, both norms for quantitative reasoning at the site level are at least 50 scale score points lower than the independent school norms.

A student's knowledge of whole numbers, division, and fractions in elementary school has been found to be a long-term predictor of the student's knowledge of algebra and overall math achievement in high school (Siegler et al., 2012). This knowledge begins in kindergarten with a kindergarten student's ability to identify numbers, discriminate between quantities, and identifying missing numbers. The ability to identify numbers, discriminate between quantities, and identify missing numbers is a strong predictor of a student's math outcomes at the end of first grade and a significant predictor of a student’s rate of achievement between first and third grade (Jordan, Glutting et al., 2009; Locuniak & Jordan, 2008).

Because of what the data in Table 2 indicated, the math committee, along with the lower school shared leadership team, decided to make Number Talks a focus of the 2019-2020 school year, along with a rolling implementation of model drawing in first through fifth grades and staff development focused on developing students who are confident mathematicians. The math committee also reviewed math curriculums to ensure the lower school has selected the correct materials to support these areas of growth.

The kindergarten team, along with other teachers, received preplanning staff development around number sense and Number Talks. This was delivered by a staff developer brought on to campus to work in small groups with each grade level. The staff developer focused on the five key components of Number Talks: classroom environment and community, classroom discussions, the teacher’s role as facilitator, the role of mental math, and the importance of purposeful computation problems.

Training with the staff developer also occurred one additional time during the fall semester. In order to build a strong foundation in mathematics, students must be able to make sense of numbers and number relationships (Parrish, 2014). Number Talks build both of these in students in primary grades by focusing on the four goals of primary grade Number Talks: developing number sense, developing fluency with small numbers, equipping students to subitize, and teaching students how to make ten.

Staff development supports teacher understanding of how to utilize Number Talks to investigate different strategies, test if these strategies will work with any set of numbers, and build an understanding of efficient strategies. I worked with the kindergarten team during PLCs to design purposeful Number Talks. A PLC is a collaborative team that partners to achieve common goals (Eaker et al., 2002). Appendix C contains the first week of Number Talks that were implemented by teachers utilizing the seven steps of a Number Talk listed in Table 1.

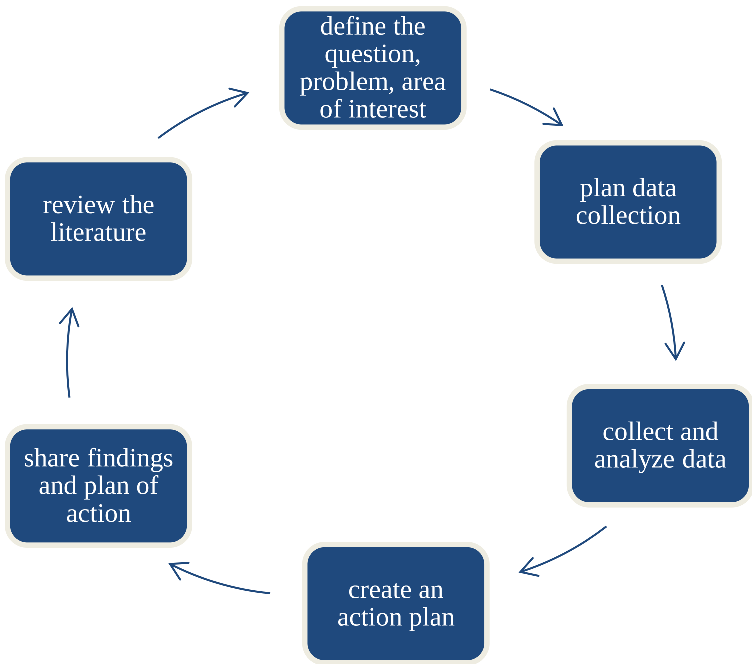
Description of Research Design and Approach

The study is a convergent parallel mixed methods action research design. A convergent parallel mixed methods design allows researchers to collect "both quantitative and qualitative data, analyze them separately, and then compare the results to see if the findings confirm or disconfirm each other" (Creswell, 2014, p. 219).

Action research is a systematic process of studying a real situation to understand and improve the quality of actions or instruction. Action research provides researchers with a standard way to explore a problem against a possible cause of action (Johnson, 2012). While action research is not always linear and steps may need to be repeated or put in a different order, Johnson (2012) defined five essential steps to utilize in the circular process of action research after the researcher has reviewed the literature connected to the area of interest. Figure 2 represents these five steps.

Figure 2

Action Research Steps (Johnson, 2012)



After completing the literature review around mathematics achievement of students, I completed Step 1 defined by Johnson (2012) and defined the problem and area of interest. The area of interest is how to improve number sense and mathematical fluency in students, specifically kindergarten students because of the impact of early numeracy success (Jordan, Kaplan et al., 2009; Locuniak & Jordan, 2008; Parrish, 2014). Step 2 of the process is to plan for data collection. The study is a convergent parallel mixed methods action research design. I collected one set of quantitative data of a pre- and post-assessment utilizing the NSS (Jordan et al., 2012). Throughout the implementation of the Number Talks, I completed twice weekly walk-through observations to support fidelity of implementation of Number Talks utilizing a checklist of the seven steps of a Number Talk listed in Table 1. Additionally, once each week, I reflected on the teacher’s development of the five key components of Number Talks in their classroom environment. I also collected qualitative data through bi-weekly PLC meetings with the kindergarten team. Step 3 of collecting and analyzing the data is shared in detail in Chapter 4 of the study. I collected and analyzed the data. The quantitative data were analyzed by utilizing the pre and posttest data to perform a statistical analysis of the NSS data using a paired sample *t* test to determine if there is a statistical difference between the pre- and post-assessment scores. Additionally, paired sample *t* tests were completed for each subsection of the test to analyze student performance on each subtest as compared to the four goals of Number Talks in primary grades. The qualitative data were analyzed by coding for themes utilizing Tesch’s eight steps in the coding process, along with descriptive analysis (Creswell, 2014). Table 3 aligns the data sources described with the research question they supported.

Table 3

Research Question and Data Source Alignment

Research question	Data source
1	Number Talk observation checklist
2	Bi-weekly Number Talk PLC
3	NSS pre and posttest

After the data were analyzed, I worked with the kindergarten team to create an action plan to improve the implementation of Number Talks and presented this back to the math committee, the shared leadership team, and other stakeholders. This information is reported in Chapter 5 of the study.

Research Questions

I investigated three questions. The first two questions were evaluated qualitatively. The third was evaluated quantitatively.

1. To what extent are Number Talks being implemented with fidelity in kindergarten classrooms?
2. What do teachers perceive are the strengths and challenges of implementing Number Talks in the kindergarten classroom?
3. To what extent does a 9-week implementation of Number Talks impact number sense in students as measured by scores on the NSS?

Population

The participants in the study included 58 kindergarten students ranging in age from 5-6 as the sample population that received the treatment of daily Number Talks. The ages of the sample population at the start of the study are shown in Table 4.

Table 4

Sample Population of Kindergarten Students by Age

Classroom	Age 5 #	Age 5 %	Age 6 #	Age 6 %	Total
1	15	78.9	4	21	19
2	17	89.4	1	5	19
3	17	85	3	15	20

The students were heterogeneously grouped in three homeroom classes. Table 5 shows the races for the sample population. The students who attend the private, independent school where the study took place range from prekindergarten to 12th grade. The location was a suburban community located 5 miles from a southeastern coastal port city in the United States. The school was an independent school dually accredited by the Council on Educational Standards and Accountability and AdvancED Cognia. Students attending the school have completed an application, acceptance, and enrollment process;

and families pay a yearly tuition fee. Students in kindergarten can attend the morning program, which costs $6,340 for the 2019-2020 school year or the full-day program, which costs $10,655 for the 2019-2020 school year. Students are able to apply for need-based financial assistance.

Table 5

Sample Population of Kindergarten Students by Race

Classroom	White #	White %	Black #	Black %	Asian #	Asian %	Multi-Racial #	Multi-Racial %	Total
1	15	78.9	1	5.2	1	5.2	2	10.5	19
2	12	63.2	2	10.5	4	21.1	1	5.2	19
3	16	.8	2	.1	1	.05	1	.05	20

Kindergarten classroom teachers were also included in the study. I observed the classroom teachers twice weekly to observe for fidelity of implementation of Number Talks. I also met with the classroom teachers in a bi-weekly PLC during the 9 weeks to reflect on the implementation. Both of these data points are included in the qualitative data analysis. Demographics represented by the teachers who participated in the study are in Table 6.

Table 6

Kindergarten Teacher Information

Teacher	Gender	Race	Years of experience	Years teaching kindergarten	Advanced degree Y/N	Number of students
1	F	W	24	3	N	19
2	F	W	18	18	N	19
3	F	W	28	12	N	20

The lower school classrooms are self-contained with the same teacher and teacher assistant for instruction of the core subjects: reading, writing, mathematics, science, social studies, and Bible. The school schedule provides time outside of the regular classroom to participate in daily, 40-minute enrichment classes including art, media, music, technology, STEAM, and physical education on a 6-day rotating schedule.

I selected kindergarten students for the action research because independent of cognitive ability and social class, the development of a primary age student's number sense is a strong predictor of the student's outcomes across content area. Research completed by Jordan (2013) connected to the NSS found that a student's ability to solve simple combinations at the beginning of kindergarten was most strongly predictive of the student's math achievement from first through third grade with a correlation of 0.7. Additionally, a student's early ability to compare numbers and solve addition and subtraction number combinations uniquely predicted calculation fluency of students in second grade over working memory, spatial ability, and language. Because the students were able to apply what the students knew about numbers to compare, add, and subtract, this meant students were not memorizing number facts but were able to transform the numbers with which they were working.

Once a student accesses first-grade curriculum and is struggling with number sense development, research has shown these to be the same students who lagged behind peers in middle school in an assessment of core math skills needed to function as an adult (Neergaard, 2013). A student's success in primary grades is associated with attendance in college, along with earning potential and financial management ability, even when background characteristics are held constant. While deficiencies in number competencies can be supported through targeted instruction, mathematical difficulties have been largely overlooked in kindergarten and have in the past received far less interventions and interest (Booth & Siegler, 2008; Jordan, Kaplan et al., 2009).

In this action research study, I was the lower school principal. The student sample selected is a convenience sample consisting of all kindergarten students in the school. Urdan (2010) defined a convenience sample as one where a researcher selects participants based on the proximity and ease of access and is an acceptable way to sample when the sample does not differ from the population of interest. The teacher sample population consists of each teacher assigned to a kindergarten class. There are three kindergarten classes in the school.

Independent Variable

According to Urdan (2010), the independent variable is often the variable manipulated by the researcher. The independent variable affects the outcome and is often called the treatment (Creswell, 2014). The treatment, or independent variable, in this action research was exposure to daily Number Talks because there was a potential for them to influence the outcomes of number sense in the participants. Number Talks were a part of the daily routine for students and continued for the duration of the study. Students participated in the daily Number Talks as a part of their daily math lesson, which occurred for 1 hour a day.

Dependent Variable

Urdan (2010) described the dependent variable as “hypothesized to depend on the values of the independent variable” (p. 10). The quantitative scores from the NSS were a dependent variable. The qualitative observations from the observation tool I utilized to better understand implementation fidelity and the bi-weekly PLC meetings with the kindergarten teachers utilized to understand teacher perceptions of the strengths and challenges of implementation of Number Talks were also dependent variables, or outcomes of the treatment. As a mixed methods study, both quantitative and qualitative outcomes were considered.

Data Collection Instrumentation and Materials

Both quantitative and qualitative data were collected in the study. Qualitative data were gathered in two different ways. I completed twice weekly observations utilizing the observation tool in each classroom. Additionally, the participating kindergarten teachers and I met bi-weekly in a PLC group to discuss implementation strengths and challenges based on the seven steps of a Number Talk and the five key components of Number Talks. Both the observation tool and the PLC agenda were piloted with the first-grade team of teachers who were already practicing with Number Talk implementation to establish validity. After piloting with the first-grade team, the team provided feedback on the observation tool and the PLC agenda and the usability of both for implementation support. Both the observation tool and the recordings of the PLC meetings were coded for themes utilizing Tesch's eight steps in the coding process (Creswell, 2014).

The second data point for this study is quantitative. The quantitative data collected were gathered using the NSS, which is a research-based tool for screening early numerical competencies for students in kindergarten and first grade. The NSS aligns with the Kindergarten Focal Points of the NCTM in the areas of numbers and operations. The NSS is a standardized measure designed to be used by teachers or other school-related personnel (Jordan et al., 2012). The test was administered to individual students by the classroom teacher and me. The NSS quick script (Appendix D) was utilized to ensure clear and consistent presentation of the questions for each student participant.

The test is organized by the number topics of counting skills, number recognition, number comparison, nonverbal calculations, story problems, and number combinations. The test was developed by Dr. Nancy Jordan and Dr. Joseph Glutting with Dr. Nancy Dyson. Dr. Jordan received her doctoral degree in education from Harvard University and has served on the Committee on Early Childhood Mathematics of the National Research Council of the National Academies. Dr. Glutting is a professor in the School of Education at the University of Delaware, specializes in applied multivariate statistics and test construction, and is a quantitative psychologist. Dr. Nancy Dyson has been in education for more than 30 years as a teacher and director of a parent cooperative school and completed her doctoral degree in education at the University of Delaware, with a focus on students with mathematical struggles.

The test was given to students as a pre- and post-assessment before and after their exposure to daily Number Talks for a period of 9 weeks. The NSS, published by Paul H. Brookes, stated no permission was needed to utilize the NSS as long as no modifications were made to the instrument (Appendix E)**.**

Qualitative Data

I utilized a twice weekly observational tool to evaluate implementation fidelity within each kindergarten classroom. The observational tool was based on Parrish's (2014) seven steps of a Number Talk and the five key components of a Number Talk. The observation tool was developed into a Google form, which I completed twice a week on all three teachers. At each observation, I completed a Likert scale of 0 to 3 (see

Appendix A), ranging from the step not demonstrated to the step being appropriately demonstrated. Then, once a week, I made notes about the teacher's achievement of the five key components of Number Talks (see Appendix A).

On a bi-weekly basis, I met with the kindergarten teacher team in a PLC meeting. Each meeting was recorded, and notes were kept on the discussion of the strengths and challenges of implementation based on the seven steps of a Number Talk and the five key components of Number Talks. A final meeting was held at the end of the 9 weeks and the posttest was completed on each student to discuss the entire implementation process, along with future implementation for kindergarten and all grade levels.

Quantitative Data

NSS

The NSS is available through Paul H. Brookes Publishing. The NSS is a research-based tool for screening kindergarten and early first-grade students to assess their early numeracy competencies that can be used to predict growth in mathematics at the elementary level and achievement level (Jordan et al., 2012). The NSS includes 29 items and provides norms for the fall and spring of kindergarten and the fall of first grade. It was developed from a longer research instrument, and a Rasch item analyses and a more subjective review of issues related to item bias were utilized to select the assessment items in the final NSS (Jordan et al., 2008).

The test was administered individually by the classroom teacher who is thoroughly familiar with the assessment tool and the student. Table 7 displays the materials needed for the test administration.

Table 7

NSS Administration Materials

NSS material	NSS material description
NSS Stimulus Book, K-1, Research Edition	Spiral-bound book containing visual stimuli
NSS Record Sheet, K-1, Research Edition	Recording and Scoring Form
NSS Quick Script, K-1, Research Edition	Explicit, verbatim instructions for each item and subarea
NSS Appendix A	Box with 10 black tokens, white foam mat
NSS Appendix B	Story Problems and Number Combinations Worksheet
NSS Appendix C	Master Number List for Story Problems and Number Combinations Subareas
Pencil	

The NSS data were collected from the administration of the pre- and post-assessment individually to each kindergarten student by their classroom teacher. Prior to the start of the study, teachers of the kindergarten students in the study were briefed on the purpose and details of the study, along with their role in the study and how to administer the NSS. The adoption of Number Talks and the NSS was a part of new curriculum adoption for the 2019-2020 school year as decided upon by the lower school shared leadership team and lower school math committee. With this adoption came an expectation that all kindergarten teachers would administer the NSS as a part of formative data collection. Additionally, all lower school teachers were expected to implement daily Number Talks with the support of provided staff development and PLC book studies. Each teacher was presented with the assent form (Appendix D) outlining the study and their role, along with their participation recording of the bi-weekly PLC meetings being voluntary.

The new curriculum adoption of Number Talks and the NSS assessment tool was also shared at the August 2019 lower school curriculum night with each of the kindergarten families. As a new curriculum adoption, all students participated in the NSS assessment tool and the daily Number Talks as a part of daily formative assessment and instruction. The Number Talks adoption was a part of regular classroom instruction. The administration of the NSS informed this instruction as results were utilized to improve instruction and to meet the individual curricular needs of students. As a result, Number Talks and the NSS were a part of regular classroom instruction and were not research requiring consent.

The pretest was given the third week in September before the classroom teachers begin daily Number Talks. Test materials and data were kept secure in the locked testing cabinet located in the lower school counselor's office. Students did not have access to the test before the administration. The classroom teachers administered the assessment individually to students utilizing the NSS quick script to maintain consistency. Each assessment took approximately 10 minutes per student, with teachers completing four tests a day during their math center time, to complete 20 students in the week.

The students sit around the corner at a table from the teacher so the child can see the NSS stimulus book and hear the teacher, while the teacher has plenty of room to record on the recording sheet for test administration (Jordan et al., 2012). The examiner places the NSS stimulus book in front of the student and turns the pages from top to bottom. The examiner does not give any hints in the form of gestures, expressions, or indications that answers given are right or wrong. The teacher who administers the assessment can encourage the student to listen and to work hard (Jordan et al., 2012). The teacher reads the question slowly and may repeat the question once if needed by the student. While the assessment is not timed, a student should answer each question within 10 seconds. If the student does not respond to a question, it is marked incorrect.

At the start of the assessment, the teacher says, “We are going to play some number games. It is important that you listen carefully and do your best. Are you ready to play” (Jordan et al., 2012, p. 8). The examiner follows the NSS quick script between each subsection and subarea and should be sure to utilize its transitional phrases, along with the transitional blank pages so students are not looking at previous material when the teacher introduces the next subarea. The subareas include counting skills, number recognition, number comparisons, nonverbal calculation, story problems, and number combinations.

In examining the six subareas, the tasks asked of students can help teachers understand student progress on achieving the four goals of Number Talks in primary grades. Table 8 shows which of the four goals of Number Talks in primary grades students are using when assessed on each of the six subareas.

Table 8

NSS Subareas Compared with Goals of Primary Number Talks

NSS subareas	Build fluency	Subitizing	Making 10	Develop number sense
Counting skills			X	X
Number recognition	X			X
Number comparisons	X			X
Nonverbal calculations	X	X	X	X
Story problems	X	X	X	X
Number combinations	X		X	X

After completing the pretest, the students participated in 9 weeks of daily Number Talks as the treatment phase of the study. I designed and mapped daily Number Talks with the kindergarten PLC after preplanning staff development was completed. Additionally, reflections from the kindergarten PLC bi-weekly meetings were utilized to develop the weekly lesson plans. The team utilized Parrish's (2014) design for purposeful Number Talks for kindergarteners as a resource. For primary age students, these Number Talks are designed to give students opportunities for counting, building fluency with small numbers, and developing the concepts of one-to-one correspondence and conservation of numbers. Teachers utilized dot images and five- and ten-frames as resources during the Number Talks. In order to facilitate a connection between these geometric models and the numerical models, the teachers recorded corresponding number sentences for students to match their thinking. Additionally, to build quick recognition of groupings of numbers on the dot images, they practiced showing them for 2 to 3 seconds to foster unitizing so students began to see them as groups rather than counting them individually. At the end of the 9-week period of daily Number Talks, the teachers spent a week completing the posttest just as they completed the pretest.

Validity and Reliability

Qualitative

Qualitative data were collected in two different forms. I observed each teacher participant twice a week and completed an observational tool that observed for the seven steps of a Number Talk, along with once weekly making notes about the presence of the five key elements of Number Talks within each classroom. These observations allowed me to observe for fidelity of implementation of Number Talks. Qualitative data were also gathered in bi-weekly PLC meetings that were recorded with the kindergarten team to discuss strengths and challenges of implementation. Both the observational tool and the PLC meetings allowed me to collect descriptive data that were coded for themes of implementation fidelity and the perceptions teachers hold towards the strengths and challenges of implementation of Number Talks. The qualitative data provide the first and second data points, which were compared to the quantitative analysis completed. By utilizing three data points, two qualitative and one quantitative, the triangulation of different data points allows analysis for themes, which adds validity to the study (Creswell, 2014).

After I coded the qualitative data for themes, I conducted a follow-up interview with the kindergarten teachers to allow them to comment on the findings of the themes and to ensure the participants felt the findings were accurate. Utilizing member checking is a strategy utilized to support the validity of qualitative findings (Creswell, 2014).

The observational tool was piloted with a group of teachers in first grade who already have been exposed to implementing Number Talks. After using the observational tool several times with the first-grade team, I discussed the tool with the first-grade team in a PLC meeting. This supported me to determine inter-rater reliability, or the similarity of the rater responses (Creswell, 2014).

Quantitative

Creswell (2014) noted proposal developers must take steps to be sure the studies are completed and their findings are checked for accuracy and credibility to ensure they are both valid and reliable. The instrument selected to gather the quantitative data in the study, the NSS, was found to be both reliable and valid by the authors and other independent researchers. A tool has reliability if it shows a consistency of measured scores across items and across time (Salvia et al., 2009). The NSS was found to have an item-reliability index of .99 and a person-reliability index of .84, "providing evidence of reliability (person index) and validity (item index) of the scale" (Jordan et al., 2012, p. 24). A differential item functioning analysis was performed to determine if there was gender bias utilizing the Mantel-Haenszel methodology and only one item of 26 was found to show bias; therefore, "it is fair to infer that the NSS is essentially free of gender bias" (Jordan et al., 2012, p. 25).

Cronbach's coefficient alpha was utilized to determine internal-consistency reliability. Table 9 shows alpha coefficients for each of the NSS's three norm groups, has them separated by males and females, and presents averaged values. Reliability was found to increase with the age of the children; and Table 9 shows the scores demonstrate high levels of internal-consistency reliability, so the NSS can be utilized by examiners with confidence.

Table 9

Internal-Consistency Reliability for the NSS

	Demographic cohort		
Norm group	Total sample[a]	Males	Females
Fall of kindergarten	.82	.83	.82
Spring of kindergarten	.86	.89	.85
Fall of first grade	.87	.87	.87
Average[b]	.85	.87	.85

[a]N = 425.

[b]Average coefficients were calculated with Fisher's *z'* transformation (Jordan et al., 2012, p. 26).

The assessment was found to have reliability across norm groups and was also found to have test-retest reliability across six time periods. The NSS test-retest reliability coefficients can be found in Table 10. Stability coefficients were found to be higher for shorter intervals. Twelve of the 15 reliability coefficients were at or about the .70 criterion recommended in assessment textbooks (Gregory, 2007; Reynolds et al., 2006). The three coefficients that dipped below the .70 criterion occurred when the testing period exceeded 1 year; therefore, the data show a need for annual retesting.

Table 10

NSS Test-retest Reliability Coefficients

Time of administration	September K	November K	February K	April K	November Gr. 1	February Gr. 1
September K	-	.81	.80	.78	.69	.61
November K		-	.82	.81	.70	.61
February K			-	.86	.77	.70
April K				-	.81	.75
November Gr. 1					-	.80
February Gr. 1						-

Note. K = kindergarten; Gr. 1 = Grade 1. N = 378 (Jordan et al., 2012, p. 27).

A test is thought to be valid to the extent to which it measures what it is designed to measure (Salvia et al., 2009). The NSS has been examined both internally to itself and externally to criterion variables, which is a consistent validation strategy with the substantive-construct model of test development (Jordan et al., 2012). The NSS was found to be valid in the areas of developmental changes, content-related validity, discriminant (contrasted-groups) validity, predictive validity, and construct validity. “Because mathematics knowledge is expected to increase with age during childhood, it is argued that valid tests show raw scores that increase with age” (Jordan et al., 2012, p. 28). The raw scores from NSS’s three norm groups exhibited consistent age changes; therefore, NSS possesses considerable developmental validity. It also exhibits content-related validity as it aligns with the Kindergarten Focal Points of the NCTM (2006) and is well established by research (Jordan et al., 2010).

The developers completed a study to measure for discriminant validity by comparing student achievement on the NSS to student success on the Delaware Student Testing Program in third grade. Students meeting proficiency on the Delaware Student Testing Program in third grade had higher NSS scores across the three time periods of assessment. The main effect for the group represented a very large effect size; therefore, it is reasonable to infer that the NSS shows discriminant validity (Jordan et al., 2012). The NSS was found to have predictive validity. Children who had been given the NSS at the beginning of first grade were evaluated through a multi-year longitudinal investigation of math development through the evaluation of cognitive measures and math achievement measures in the spring of first grade and the spring of third grade. Performance on the NSS in early first grade was found to be a significant predictor of performance in the spring of first and third grade (Jordan et al., 2012).

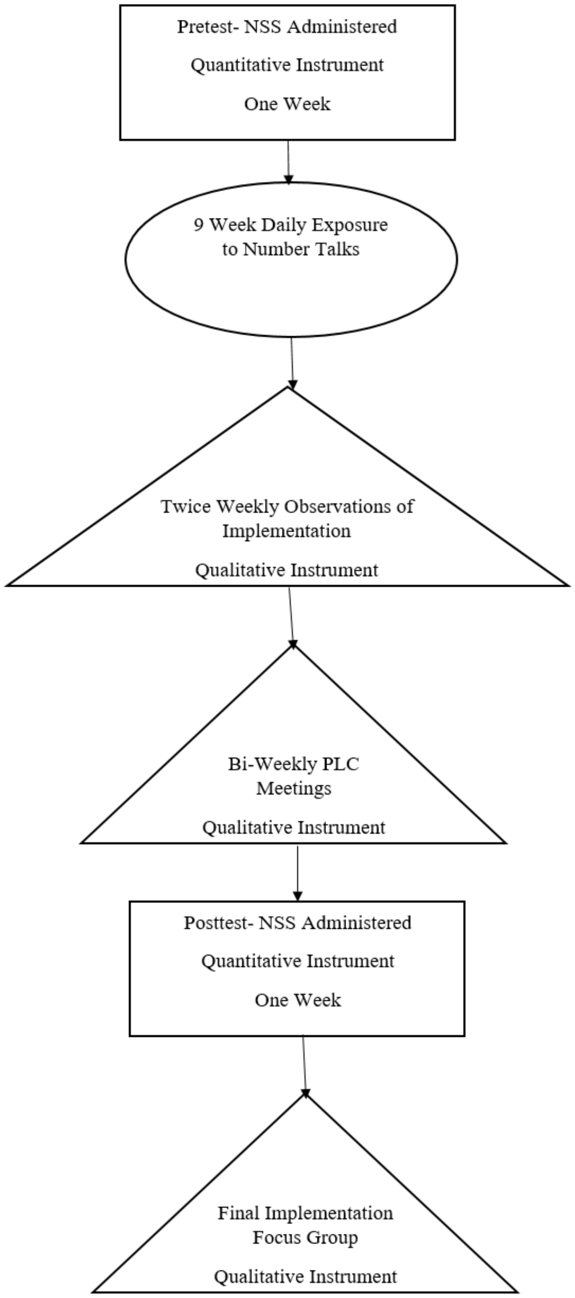
Outcomes of the NSS given at the end of first grade showed high correlations, or convergent validity, with mathematics scales from the Woodcock-Johnson designed to measure similar attributes. When compared to the DIBELS reading measure, no scale showed a high correlation; this supports a divergent association. Therefore, it can be reasonably inferred the NSS "shows substantial construct validity" (Jordan et al., 2012, p. 36).

Data Collection

I utilized a convergent parallel mixed methods action research design. Both quantitative data and qualitative data were collected. Both sets of data were analyzed separately, and the results of both were compared to see if the findings confirmed or disconfirmed each other (Creswell, 2014). Figure 3 shows the sequence of data collection for the study.

Figure 3

Sequence of Data Collection.



The quantitative data were collected with the pre and posttest scores using the NSS. Before the sample population was exposed to the Number Talks, the classroom teachers and I administered the NSS. After the pretesting was completed, the students participated in 9 weeks of daily Number Talks in homerooms with the classroom teacher. After the 9 weeks were completed, students were administered the NSS for the posttest.

The qualitative data were collected in two ways. I completed twice weekly observations using the observation tool that noted Parrish's (2014) seven steps of a Number Talk and the five key components of a Number Talk. The observational tool was completed utilizing a Google form. Additionally, I met with the kindergarten team in bi-weekly PLC meetings to discuss the strengths and challenges of implementation based on the same two lists utilized in the observational tool.

Data Analysis

After the completion of the pre and posttest and the results from the individual assessments were scored, the pretest and posttest data were utilized to perform a statistical analysis of the NSS data using a paired sample *t* test to determine if there is a statistical difference between the pre- and post-assessment scores. The purpose of this paired sample *t* test was to determine if there is a statistical difference in the means of the pretest and posttest data when students were exposed to daily Number Talks. A paired sample *t* test was utilized because I was comparing average scores of a single sample (the independent variable of Number Talks) on two dependent variables' (the pre and posttest) means (Urdan, 2010).

Additionally, the pre and posttest assessment data were broken down by subtest within the NSS to compare the statistical growth of students on each subtest. The subtests were counting skills, number recognition, number comparisons, nonverbal calculations, story problems, and number combinations. A paired sample *t* test was utilized to determine if there was a statistical difference between the pre and posttest for each subtest.

In the paired sample *t* test, the significance level was specified as $p < .05$. Where the data collected have a *p* value of $p < .05$, the data have rejected the null hypothesis and show a statistically significant difference. Where the data collected have a *p* value of $p > .05$, the data fail to reject the null hypothesis and have no statistically significant difference.

The observational tool data and the PLC meeting notes were coded for themes. These findings were compared to the quantitative findings after the research was completed. Predetermined codes, along with codes that developed during the collection of teacher open-ended responses, were utilized. Creswell (2014) noted the importance of looking for three types of themes: themes a reader would expect based on the findings of the literature review, codes that are surprising and not anticipated, and codes that are uniquely conceptual to themselves. I utilized Tesch's Eight Steps in the Coding Process found in Table 11 to code and analyze the questionnaire responses (Creswell, 2014, p. 198).

Table 11

Tesch's Eight Steps in the Coding Process

Steps	Description of Steps
1	Get a sense of the whole. Read all the transcriptions carefully. Perhaps jot down some ideas as they come to mind as you read.
2	Pick one document (i.e., one interview)- the most interesting one, the shortest, the one on the top of the pile. Go through it, asking yourself, "What is this about?" Do not think about the substance of the information but its underlying meaning. Write thoughts in the margin.
3	When you have completed this task for several participants, make a list of all topics. Cluster together similar topics. Form these topics into columns, perhaps arrayed as major, unique, and leftover topics.
4	Now take this list and go back to your data. Abbreviate the topics as codes and write the codes next to the appropriate segments of the text. Try this preliminary organizing scheme to see if new categories and codes emerge.
5	Find the most descriptive wording for your topics and turn them into categories. Look for ways of reducing your total list of categories by grouping topics that relate to each other. Perhaps draw lines between your categories to show interrelationships.
6	Make a final decision on the abbreviation for each category and alphabetize these codes.
7	Assemble the data material belonging to each category in one place and perform a preliminary analysis.
8	If necessary, recode your existing data.

(Creswell, 2014, p. 198)

I examined the coding data to determine if the themes coded affirm or disaffirm the findings of the quantitative analysis results when compared.

Measures for Ethical Protection

Creswell (2014) defined ethical issues researchers and proposal writers need to anticipate and address prior to research beginning in order to protect the research participants, build confidence among participants, elevate the importance of integrity, and guard against improper behavior that would reflect poorly on the organizations and institutions involved. Prior to the beginning of the study, I submitted an application to the university's Institutional Review Board for approval and to ensure standards for professionalism and ethics were followed. I reviewed the Institutional Review Board standards with the school headmaster to ensure all school expectations were followed.

Additionally, in order to respect the site and cause as little disruption as possible (Creswell, 2014), I gained prior approval from the headmaster to use the site for research (Appendix F). The research is beneficial (Creswell, 2014) as it aligns with identified needs and areas of growth as defined by the lower school's math committee and shared leadership team. The research took place during the regular school year and day, and all students received the benefits from the action research as the curriculum adoption and implementation is a part of the regular school curriculum.

It is important to obtain necessary permissions from participants and ensure the purpose and plan for the study are clearly communicated (Creswell, 2014). Teachers involved in the study were fully informed of the purpose and procedures of the study, along with plans for the outcomes of the research. Teachers were informed that all personal identifying information would be removed from data collection and would remain confidential. Teachers involved signed letters of assent (see Appendix G) to ensure all participants were willing, informed, and free from pressures to participate. Students and parents were informed of the implementation of new curriculum and assessment pieces as a part of back to school communication. Letters of assent were not needed from students or parents because the use of Number Talks and the NSS are a part of lower school curriculum.

Summary

The mixed methods action research study described above examined the implementation process and impact of a 9-week Number Talk intervention. The participants in the study included 58 kindergarten students as the sample population that would receive the treatment of daily Number Talks, along with three kindergarten teachers who implemented the 9 weeks of Number Talks. The students and teachers are a part of a private, independent school located in a suburban community outside of a southeastern coastal port city in the United States.

The qualitative data gathered through the observational tool and bi-weekly PLC meetings were coded for themes and analyzed to better understand implementation fidelity and teacher perceived strengths and challenges of implementation. The data from the NSS quantitative instrument were analyzed to see to what extent the implementation of Number Talks impacted number sense development in the participating population. These data are presented in Chapter 4 of the study. The kindergarten team and I utilized the analyzed data to make recommendations for improvement to the implementation of Number Talks in the lower school as a part of the analysis of the research findings and action research study.

Chapter 4: Results

Introduction

The ability to identify numbers, discriminate between quantities, and identify missing numbers in sequence at the end of kindergarten is a significant predictor of the rate at which a student achieves between first and third grade. Having a strong foundation in number competency in the primary grades is a stronger predictor of success in math over verbal, spatial, and memory skill competencies independent of cognitive ability and social class (Jordan, Kaplan et al., 2009; Jordan, 2013; Locuniak & Jordan, 2008). Research has suggested Number Talks can change a student's view of mathematics by teaching number sense, developing mental math skills, and providing opportunities for creative and open mathematics (Humphreys & Parker 2015).

The purpose of this study was to determine if a 9-week Number Talk intervention had an impact on the number sense of kindergarten students. I conducted a mixed methods action research study. I was a lower school principal at a private, independent school where Number Talks were not currently being used with kindergarten students. The following questions enabled me to collect both qualitative and quantitative data:

1. To what extent are Number Talks being implemented with fidelity in kindergarten classrooms?
2. What do teachers perceive are the strengths and challenges of implementing Number Talks in the kindergarten classroom?
3. To what extent does a 9-week implementation of Number Talks impact number sense in students as measured by scores on the NSS?

This chapter describes the results of the study. This mixed method study utilized a convergent parallel design where both qualitative and quantitative data were collected and analyzed separately and then compared to see if the results confirmed or disconfirmed each other (Creswell, 2014). The qualitative data provided a detailed view of the implementation process of the participants, with the quantitative data providing scores on the NSS instrument administered to the students.

Data Analysis Strategy

The strategy for data analysis utilized both qualitative and quantitative data points to determine if Number Talks had any or all positive results in terms of the effectiveness of Number Talks when implemented with fidelity as well as participant feedback on the strengths and challenges of implementation. The end goal of the data analysis was to influence, through action research, the school-wide implementation of Number Talks.

Utilizing a convergent parallel mixed methods design allowed for an in-depth perspective of the implementation process through qualitative descriptive data that were compared side by side to the quantitative results (Creswell, 2014). The qualitative descriptive data described the implementation process by the teachers, along with the reflection on the implementation process gathered by the action researcher. As an action researcher, I collaborated with the participants to review data and determine recommended action steps throughout the process and at the end of the research process. The quantitative results focused on the growth of student number sense as reported by the NSS pre and posttest data, along with pre and posttest data on subtests within the NSS. Microsoft Excel spreadsheets were utilized to complete calculations and statistically analyze the data for the paired sample *t* tests.

Findings of the Study

Each data point was analyzed and applied to each of the three research questions used to frame the study. Each data point aligned with one of the research questions. This alignment is referenced in Table 3. Using the convergent parallel mixed methods research design allowed for qualitative and quantitative data to be collected to provide different types of information through detailed views of the participants (qualitative) and scores on the NSS instrument (quantitative) that were then able to be compared to see if the results confirm or disconfirm each other (Creswell, 2014). The research questions and the analysis of results are presented in the following section.

Research Question 1: To What Extent Are Number Talks Being Implemented with Fidelity in Kindergarten Classrooms?

The three kindergarten teachers participating were observed twice weekly during the 9 weeks of Number Talk implementation. I utilized qualitative observation as a complete observer, as I observed without participating, to record in a semi-structured approach each teacher's fidelity of Number Talk implementation (Creswell, 2014). During the observation, I rated the teachers on a scale of 0-3 for each step of the seven steps of a Number Talk. Appendix A provides the details of the observation tool utilized, along with an explanation of the scale of 0-3. Table 12 provides the mean for each Number Talk step for each teacher, along with the overall mean for each step.

Table 12

Observational Tool Number Talk Steps Mean Data

Number Talk steps	Teacher A mean (18)	Teacher B mean (18)	Teacher C mean (18)	Overall mean (18)
1	3.00	3.00	2.89	2.96
2	2.94	3.00	2.78	2.91
3	2.94	3.00	2.78	2.91
4	2.89	2.94	2.61	2.81
5	2.94	2.56	2.22	2.57
6	3.00	2.89	2.89	2.93
7	2.89	2.94	2.56	2.80
Overall	2.94	2.90	2.68	2.84

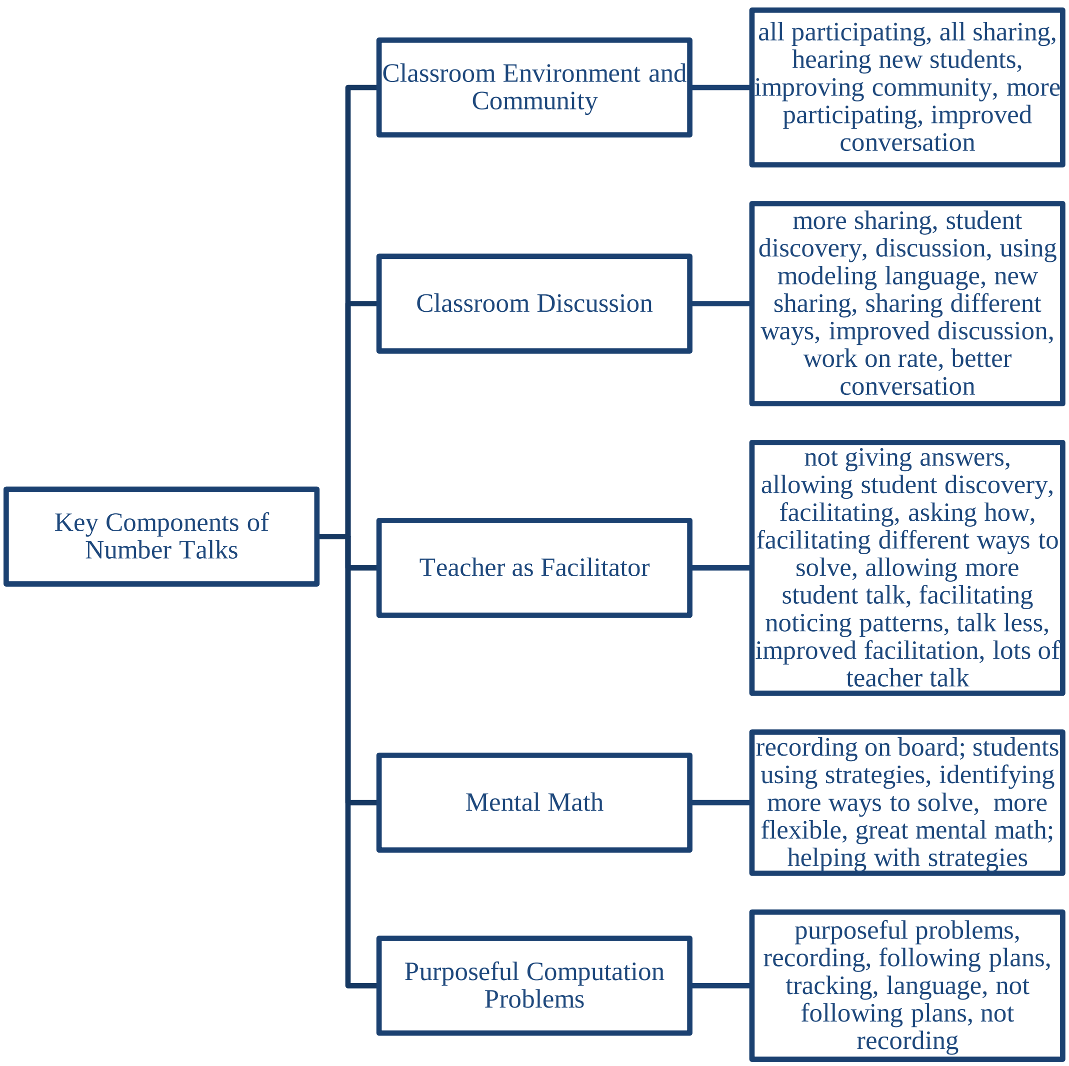
Teacher A scored the highest mean on Step 1 (writing a purposeful computation problem on the board) and Step 6 (allowing students to share strategies and justify answers). Teacher A scored the lowest mean on Step 4 (calling on students for answers when most students have a thumb up). Teacher B also scored the highest mean on Step 1, along with Step 2 (students solve the problem mentally) and Step 3 (students put a thumb up in front of their chest to indicate they have an answer). Teacher B scored the lowest mean on Step 5 (teacher records all answers on the board). Teacher C scored the highest means on Step 1 and Step 6, and the lowest on Step 5. Overall, Step 1 had the highest mean, while Step 5 had the lowest mean.

Despite Step 5 having the lowest mean, it still averaged a mean of 2.57. On the observational tool found in Appendix A, a 2 equates to the "step somewhat appropriately implemented" and a 3 equates to the "step appropriately implemented." Therefore, with all of the means ranging from 2.50 to 3 as a mean, it can be said that all seven steps were implemented with fidelity.

Additionally, each week, I reflected once on how each teacher was meeting the five key components of Number Talks. The observational checklist reflection portion was coded for themes using predetermined categories as the five key components of Number Talks. Figure 4 shows these major themes.

Figure 4

Coded Themes for Weekly Observation Reflection



The five coded themes of Number Talk Key Components and corresponding data are aligned for each teacher, along with the number of times they were referenced as observed correctly, observed as an area of noticed improvement, or observed as not correct in Table 13.

Table 13

Weekly Reflection Aligned to Five Key Components of Number Talks for Each Teacher

	Class environment and community			Classroom discussion			Teacher as facilitator			Mental math			Purposeful computation		
Teacher	C	I	N	C	I	N	C	I	N	C	I	N	C	I	N
A	3	0	0	3	1	0	6	0	0	1	3	0	4	0	0
B	2	1	0	3	1	0	4	1	2	0	4	0	3	0	0
C	0	4	0	0	2	2	2	3	3	0	3	0	1	1	2
Total	5	5	0	6	4	2	12	4	5	1	10	0	8	1	2

Note. C = observed implemented correctly; I = noticed implementation improvement; N = observed not implemented correctly.

As seen in Table 12, all five key components were observed more often as implemented correctly or with improved implementation than observed implemented incorrectly. While the Number Talk curriculum was new to the teachers participating, all three utilized the training they received prior to implementation, the lesson plans I provided, and the bi-weekly PLC meetings to correctly implement the five key components. Where implementation needed improvement, the participants utilized feedback I provided, feedback from each other, and feedback from the curriculum resources to also improve implementation throughout the 9-week implementation. This is evident especially in the area of mental math. It is evident by the descriptive data in Tables 11 and 12 that teachers were implementing Number Talks with fidelity and that implementation fidelity improved throughout the 9 weeks of observation.

Research Question 2: What Do Teachers Perceive Are the Strengths and Challenges of Implementing Number Talks in the Kindergarten Classroom?

The kindergarten teachers participating in the implementation of Number Talks met every other week during the implementation process in a PLC to discuss the strengths and challenges of the process. Appendix B shows the PLC agenda utilized during the Math Talk PLC. I facilitated the PLC meetings. The meetings were recorded with the permission of the participants. As the action researcher, I utilized the transcripts from the meetings to code for themes relating to strengths and challenges during the implementation process. The transcripts were coded using predetermined categories of the five key components of Number Talks. Strengths and challenges of students and teachers were identified throughout the implementation process and are shown below in Tables 14-18.

Table 14

Week 2 Math PLC Implementation Transcript Coding

Number Talk key components	Strengths	Challenges
Classroom environment and community	Transfer to textbook lesson	Time management Need timer to manage time How and when to utilize dot cards
Classroom discussion		More student driven Utilizing correct questions Struggle to know how to much to guide
Teacher facilitation	Some improvement in writing responses Connecting number sense in textbook lesson	More student driven Utilizing correct questions Forgetting to write responses on the board Forgetting to use multiple modalities Connecting all of the pieces Unsure of myself Attached to my lesson plans
Mental math	Understanding number sense more	Struggle with subtraction Need firmer understanding of addition first Struggle to make things concrete
Purposeful computation	More focus on 0 to 5 See need for slower movement through smaller numbers Reflection – have only touched the surface with past cohorts	More organized to be more purposeful Scrambling to get materials

After 2 weeks of implementation, the team met for the first PLC meeting to discuss strengths and weaknesses of the implementation thus far. The team immediately shared the success of seeing students already connecting what is being discussed in Number Talks with the textbook lessons being taught both whole group and small group. The growth in students was evident already as students were utilizing the number sense skills already developing within other areas. Additionally, the growth in teacher understanding was noted as the team reflected on the amount of time being spent with what had been traditionally known as the easy numbers from 0 to 5. The team reflected on this change and looked forward to seeing if this change would have a greater impact later in student understanding.

Participants noted two common areas of challenge: time management and student-centered facilitation. In the area of time management, the participants reflected on still feeling uncomfortable with the new curriculum and the flow of the lesson, while also still feeling very tied to the lesson plans. The participants agreed to set a timer for the 10 minutes and maximize that time, while also agreeing to be sure all materials were prepared and ready to use at the carpet before starting. In addition to time management, working to facilitate more and control less was a struggle for the participants. Learning the new way of asking questions to facilitate discussion and the need to allow students to speak while feeling uncomfortable when student talk is not focused on the learning objective of the lesson were difficult challenges for the participants.

Table 15

Week 4 Math PLC Implementation Transcript Coding

Number Talk key components	Strengths	Challenges
Classroom environment and community	Students making connections Students using Number Talk terms	Need more student input on how they know their answer
Classroom discussion		Knowing when we ask Number Talk questions as follow-up Students need to share the why more
Teacher facilitation	Waiting for student thumbs up – all participating	Knowing when we ask Number Talk questions as follow-up Facilitating most efficient way to achieve answers Too much teacher talk
Mental math	Improvement on story problems Increasing flexibility with numbers	Facilitating most efficient way to achieve answers
Purposeful computation	Students making connections I understand number sense more	

At the end of Week 4 of implementation, the team met again as a PLC to discuss strengths and challenges of implementation. The strength of continued student connections was highlighted multiple times. Beyond simply using strategies within other math lessons, students were beginning to show more flexibility with numbers as was evident in story problems. The teachers also reflected on improvement in the area of waiting for all students to participate and share, especially students who often try to blend into the crowd to not be noticed.

As students began to share more, the team reflected on the challenge of supporting students to share more of the why behind answers and understanding, without having too much teacher talk and control over explaining answers and why answers make sense. The team reviewed the important questions all should be using to guide students to respond like, “What do you see,” “How do you see it,” and “How do you know?” Keeping these the same will support students to know what to expect as students continue to build more confidence in sharing thinking.

Table 16

Week 6 Math PLC Implementation Transcript Coding

Number Talk key components	Strengths	Challenges
Classroom environment and community	Students who struggle to engage and showing increased participation and number sense	
Classroom discussion	Using plans but responding to student needs	Building student conversation skills to talk about math the way we talk about sight words
Teacher facilitation	Improving my timing	Direct students to patterns, doubles, strategies
Mental math	Increased transfer of skills Increased ability to see number combinations several ways	Struggle with two more and two less Select
Purposeful computation	Connections outside of Number Talks Changing end goal to building flexibility with numbers	

At the end of Week 6, the participants continued to notice students becoming more comfortable with sharing and engaging in discussion around numbers. More than one participant had a specific story of a struggling student beginning to shine in surprising ways. As a team, the participants and I reflected on the time we need to give all students to learn something new and the strength of giving them a tool that can be transferred to all new math learning. The participants noted the level of comfort increasing with the lesson plans so that they were able to be more flexible to respond to the needs of their specific students during the Number Talks, along with improving lesson timing. Most importantly, the teacher participants discussed a shift in understanding what the end goal of kindergarten math should be; from attaining a specific amount of curriculum taught to an end goal of students being flexible with numbers so they can utilize the strategies they have learned as they advance to different levels of mathematics instruction.

Along with this reflection, a challenge emerged as the participants discussed the difficulty with helping students to connect the patterns and strategies they are learning so they can apply them to new learning. The question became, “How do you do this with students so young?” One reflection surrounded making math discussion more prominent in daily lessons; just as we often connect sight word learning across curriculum for kindergarten students, we must be as focused on supporting students to identify where they are using math strategies throughout curriculum.

Table 17

Week 8 Math PLC Implementation Transcript Coding

Number Talk key components	Strengths	Challenges
Classroom environment and community	Student discussion becoming second nature Students discussing numbers more with peers	
Classroom discussion	Student transfer to other lessons Less use of fingers	
Teacher facilitation	Understanding more how to use discussion to facilitate deeper thinking	Identifying 10s and 1s in numbers
Mental math	Naturally breaking numbers apart Before and after digits clicking	
Purposeful computation	Better at using multiple modalities to show computation	Always showing concrete and abstract representations

Week 8's discussion centered around many strengths for students. Perhaps the lack of discussion of strengths for the teachers is also a strength, as Number Talk work is becoming second nature to the participants and the conversation began to shift away from the how and more to the importance and the why. As for students, the teachers commented on students beginning to use the strategies they were learning in discussions with their peers without teacher initiation. The participants noted more automaticity of student math facts and students using multiple modalities to express understanding of problems.

I noted in discussion of challenges for participants to not become overconfident in student ability and to continue to share concrete models of problems, along with multiple representations. The participants agreed that it can be easy to stop modeling and showing student answers on the board because of the focus on discussion, but the visuals are important for students to make connections.

Table 18

Post-Implementation Math PLC Implementation Transcript Coding

Number Talk key components	Strengths	Challenges
Classroom environment and community	Increased focus on number strategies and flexibility rather than isolated skills Increased confidence in students and teachers	
Classroom discussion	Student struggle is not a bad thing	
Teacher facilitation	Sometimes less teacher talk is better to facilitate classroom and student discussion	Concerned about creating own plans after 9 weeks end
Mental math	All students showed growth Even students of concern showed growth	
Purposeful computation	Realized some resources look pretty but are not as purposeful as what we created	Scope and sequence needed

After the 9 weeks of Number Talk implementation, the PLC met for a final discussion of strengths and concerns observed during the implementation process. For both students and teachers, the team agreed an increase in mathematical confidence was a strength. All students showed growth on the posttest, which affirmed for the participants that the observations they were making in class were accurate: All students were increasing their ability to think flexibly about numbers, even the students of concern. The teachers recognized that student struggle is not a negative thing, but rather an important part of the facilitation process to new understanding and a builder of student confidence as they make those new discoveries. The participants agreed that less teacher talk allowed them as the teacher to hear and understand student thinking more, which informed daily instruction. Finally, the team agreed that purposeful problems and planning played a large role in student success because the lesson plans were created based on student needs from the assessment and were influenced by the bi-weekly PLC meeting discussions of student needs.

As for concerns, the team agreed they were fearful of what to do after the 9 weeks ended and desired support to create a lesson plan system for continued strong implementation. The participants agreed that a focused scope and sequence for Number Talks for not only kindergarten students but also for the other grades would be important for continuity and for increased success through purposeful design.

Research Question 3: To What Extent Does a 9-Week Implementation of Number Talks Impact Number Sense in Students as Measured by Scores on the NSS?

The NSS was administered to each kindergarten student at the beginning of the study and at the end of the study after the 9-week implementation of Number Talks. The pre- and post-percentile rankings for kindergarten students in the fall were utilized in the statistical analysis. Table 19 shows the results of paired sample *t* tests for differences in student percentile rankings in Classroom A, Classroom B, Classroom C, and the entire cohort of kindergarten students on the pre- and post-NSS assessment.

Table 19

Paired t Test for Differences in Student Scores on the Pre- and Post-NSS

Student population	Pretest percentile rank mean	Posttest percentile rank mean	Degrees of freedom (*df*)	P(T<=t) two-tail
Classroom A	64.85	88.18	19	<.001
Classroom B	66.78	90.33	18	<.001
Classroom C	64.94	92.87	18	<.001
Kindergarten cohort	65.51	90.42	57	<.001

The statistical analysis of the data for each class and for the total cohort scored a higher mean on the post-NSS than the pre-NSS. Additionally, for all four groups of data, the p value was less than an alpha value of .05. The analysis for Classroom A produced a significant t value ($t_{(19)} = 7.21$, $p < .001$), the analysis for Classroom B produced a significant t value ($t_{(18)} = 5.94$, $p < .001$), the analysis for Classroom C produced a significant t value ($t_{(18)} = 5.09$, $p < .001$), and the analysis for the kindergarten cohort produced a significant t value ($t_{(57)} = 10.15$, $p < .001$). Therefore, the data for each classroom and for the kindergarten cohort reject the null hypothesis and show a statistically significant difference.

Within the NSS, each student was assessed on six subareas including counting skills, number recognition, number comparison, nonverbal calculations, story problems, and number combinations. Assessing these six areas of number sense allows insight into the development of understanding of the four goals of Number Talks in primary grades as compared in Chapter 3.

Table 20 shows the results of a paired sample *t* test for differences in student percentile rankings of the entire kindergarten cohort on each subarea within students on the pre- and post-NSS assessment.

Table 20

Paired t Test for Differences in Student Scores on the NSS Subtests

NSS subtests	Pretest percentile rank mean	Posttest percentile rank mean	Degrees of freedom (*df*)	P(T<=t) two-tail
Counting skills	2.97	3	57	.159
Number recognition	1.60	2.48	57	<.001
Number comparisons	5.26	6.22	57	<.001
Nonverbal calculations	3.21	3.66	57	.003
Story problems	2.17	3.52	57	<.001
Number combinations	2.21	4.36	57	<.001

The statistical analysis of the data for each subarea of the NSS pretest and posttest resulted in *p* values less than an alpha value of .05 for all of the subareas except for counting skills. Therefore, for the subareas of number recognition ($t_{(57)} = 7.44$, $p < .001$), number comparisons ($t_{(57)} = 5.39$, $p < .001$), nonverbal calculations ($t_{(57)} = 3.12$, $p = .003$), story problems ($t_{(57)} = 6.13$, $p < .001$), and number combinations ($t_{(57)} = 8.01$, $p < .001$), all produced a significant *t* value. The data for each of these subareas reject the null hypothesis and show a statistically significant difference. For the subarea of counting skills ($t_{(57)} = 1.43$, $p = .159$), the *p* value is more than an alpha value of .05, and the data fail to reject the null hypothesis and show no significant statistical difference.

As noted in the review of literature, the gap in mathematical knowledge that can develop in primary grades continues to widen as students age. Therefore, Table 21 shows the results of paired sample *t* tests when pretest scores were separated into three levels of achievement.

Table 21

Paired t Test for Differences on the Pre- and Post-NSS by Pretest Score Achievement

Student population	Pretest percentile rank mean	Posttest percentile rank mean	Degrees of freedom (*df*)	P(T<=t) two-tail
Pretest < 50th percentile	32.41	75.74	16	<.001
Pretest < 75th percentile ≥ 50th percentile	63.45	93.25	10	<.001
Pretest ≥ 75th percentile	87.03	98.71	26	<.001

The statistical analysis of the data for each student population of pretest assessment scores scored a higher mean on the post-NSS than the pre-NSS. Additionally, for all three groups of data, the *p* value was less than an alpha value of .05. The analysis for students who scored below the 50th percentile on the pretest produced a significant *t* value ($t_{(16)} = 8.83$, $p < .001$), the analysis for students who scored between the 74th percentile and the 50th percentile produced a significant *t* value ($t_{(12)} = 10.45$, $p < .001$), and the analysis for students who scored at the 75th percentile or above produced a significant *t* value ($t_{(29)} = 8.18$, $p < .001$). Therefore, the data for each cohort, no matter what they scored on the pretest, reject the null hypothesis and show a statistically significant difference.

Summary

Action research data were collected to determine if Number Talk interventions had an impact on number sense development in kindergarten students. The implementation process and the impact were measured utilizing a mixed methods approach. Qualitative research was utilized to analyze the implementation process of Number Talks. The first qualitative instrument was an observation tool I completed to determine the fidelity of implementation by each participating kindergarten teacher. The data from this observational tool was coded for themes. The second qualitative instrument was bi-weekly meetings with the teachers implementing the Number Talks to discuss strengths and challenges with the implementation process. These PLC discussions were also coded for themes.

The impact of the implementation process on number sense development was analyzed through a quantitative pre and posttest tool. For all four groups of data, the cohort as a whole, and each of the three classroom cohorts, a *p* value of less than an alpha value of .05 occurred. Therefore, the data for each classroom and for the kindergarten cohort rejected the null hypothesis and showed a statistically significant difference after implementation of the 9-week Number Talk intervention.

A convergent parallel mixed methods design was utilized to allow for an in-depth perspective of the implementation process so the work of the action researcher can continue after the study. This design also allowed me to evaluate the quantitative data alongside the qualitative research. Further reflection on the findings of these data points and the implications of the findings on further steps of the action research, along with recommendations for future research, are discussed in Chapter 5.

Chapter 5: Discussion

Introduction

When tracking students from kindergarten through high school, Dr. David Geary, a cognitive psychologist, found students who developed a gap in number sense early in their education maintained or widened that gap as they aged through middle and high school (Neergaard, 2013). Early proficiency in mathematics is a stronger predictor of long-term success of students than any other childhood skills, including literacy (Duncan & Magnusson, 2011). Even at an early age, as children construct new meaning by modifying their existing knowledge to incorporate new ideas through assimilation or accommodation, students become “sense-makers” in mathematics (Van de Walle et al., 2018; Ritchhart, 2015). Classrooms that utilize student interaction within learning opportunities support students to be enculturated to the dispositions needed to be actively engaged as they seek meaning and learn from each other (Ritchhart, 2015).

The purpose of this chapter is to discuss the results of an action research study completed to examine the implementation process and impact of a 9-week Number Talk intervention to build number sense in kindergarten students. Number Talks are 5- to 10-minute conversations around purposefully crafted computation problems utilized to equip students to communicate thinking and justify solutions to problems mentally (Parrish, 2014). Number sense development is one of the overarching goals of mathematics learning (Leinwand, 2009). Through the guidance and support of classrooms teachers, students actively create knowledge (Reid & Reid, 2017), which supports the constructivist theoretical framework that learners are not blank slates, but rather creators and constructors of learning (Piaget, 1976; Van de Walle et al., 2018; Von Glasersfeld, 1995). The study involved 58 kindergarten students who were exposed to daily Number Talk instruction over 9 weeks. I utilized a mixed methods action research model to investigate the implementation process of Number Talk instruction and evaluate the impact of the intervention with three data points: two qualitative and one quantitative.

The first section of this chapter includes limitations of the study, followed by a discussion of Steps 5 and 6 of the action research process, creating the action plan, and sharing findings and the plan of action with stakeholders (Johnson, 2012). Next, implications and recommendations for future research are discussed, along with my reflections of the implementation and action research process and key findings that define the work completed in the study.

Limitations of the Study

Delimitations of the study included (a) participant selection and sample size, (b) the limited bounds of the study, (c) the focus on action research, and (d) insider research. The action research study was limited to the participants who teach kindergarten and the students in that grade during the study. The school represents a population of students who attend a private school where parents pay tuition. As a result of these choices, the results may not be generalizable to other kindergarten cohorts or lower schools.

The focus of the study was action research to assist the team and me in improving and refining math instruction in the lower school. The purpose was to evaluate Number Talks and the implementation of the program to influence future actions. The goals of the school and me impacted the research questions selected and the balance of qualitative and quantitative research collected.

Finally, a delimitation of the study was insider research. My decision to investigate within the school where I work could have disadvantages, as I was the supervisor of those observed. With the goal on action research to determine how to improve implementation of Number Talks and to increase student achievement and understanding, the focus was removed from evaluation of the participants to one of collaboration and site-based growth. Additionally, the need to make curricular mathematical changes was a determination of the Lower School Mathematics Committee and the Lower School Shared Leadership Team.

In addition to expected delimitations, an additional limitation from those discussed in Chapter 1 was noted. Data for Research Question 2 were gathered from PLC discussions held bi-weekly. Participants may have withheld statements pertinent to the discussion if the participants felt the responses were not valid, seemed unflattering, or could be incorrect. On the other hand, participants could have provided information based on what participants believed I wanted to hear or to please me as the supervisor. Although the information participants shared required self-reporting, I believe the impact of this limitation is lessened because the data were triangulated. Additionally, the data collected from the participants were collected over multiple touch points throughout the study, which also lessens the impact of the limitation.

Summary of Action Research

Action research was selected for this study because it enabled the participants and me to engage in the process of inquiry that was relevant to the needs of me as the researcher, participants, students, and the research location (Sagor, 2000). After the initial review of the literature and defining of the problem, Steps 1 and 2 of the action research as defined by Johnson (2012), the bi-weekly PLC meetings of the teachers and researcher allowed for four cycles of collecting and analyzing data as the team reviewed at each meeting the strengths of implementation and challenges they were facing. This allowed the team to reflect consistently on the use of Number Talks.

At the end of the 9 weeks and upon the collection of NSS post-assessment data, I reviewed the collected data with the team and developed an action plan for the implementation of Number Talks school-wide, based on the data collected and analyzed throughout the 9-week process. Once completed, this action plan was shared with the Lower School Math Committee and the Lower School Shared Leadership Team for review before implementation school-wide during the following school year.

Intervention and Action Plan

I developed the Number Talk Implementation Action Plan in Table 22 with feedback from the participants in the study. The purpose of the action plan was to utilize the process, the research, and the results from the study to support the implementation process of Number Talks for the entire school as a part of the new mathematics curriculum adoption.

Each action step is defined in Table 22. After the table, each action step is explained, along with the step's connection to the five key components of Number Talks. Additionally, reflection on the creation of each action step, based on the study and the theory supporting the importance of the step, is included.

Table 22

Action Plan – Number Talk Implementation

Objectives:
1. Implement Number Talks in all grade levels 1st -5th.
2. Provide teachers with Number Talk professional development to support implementation with fidelity.
3. Assess student progress with number sense throughout implementation.

Action Step(s)	Person responsible	Identified resources	Potential barriers	Evaluation
1. Develop Number Talk template and lesson plans for each grade level 1st-5th.	Researcher, Math Committee Representative	*Number Talks* by Parrish Grade Level Math Course Outline	Time Gathering the team	PLC Meetings
2. Utilize bi-weekly PLC meetings to reflect on strengths and challenges of implementation.	Researcher and Assistant Principal	PLC Meeting Agenda for Number Talks	Time Schedule Changes Distance Learning	Meeting Agenda
3. Utilize Number Talk walk-through with all Lower School staff	Researcher, Assistant Principal, Director of Curriculum and Instruction	Google Form	Consistency Time	PLC Meetings Shared Leadership Team
4. Identify tool to assess students number sense three times a year.	Assistant Principal and Math Committee	NSS Tool for 2nd-5th	Identifying a tool that meets our needs. Training for implementation.	Survey Math Committee Feedback

Action Step 1: Curriculum Development

The Committee on Early Childhood Mathematics from the National Research Council (2009) found an understanding of how children should develop and learn key mathematical concepts and practices is not well understood or implemented. In order for a classroom teacher to effectively implement Number Talks, they must utilize purposeful computation problems. Problems selected must support student development of patterns so students can develop computational strategies they can apply to current learning but also to future learning (Humphreys & Parker, 2015). This is supported by the constructivist theory as students develop meaningful understanding when they are able to explore and connect patterns across their learning (Piaget, 1976; Reid & Reid, 2017; Van de Walle et al., 2018; Von Glasersfeld, 1995).

The classroom teachers implementing Number Talks during this study found the 9 weeks of weekly lesson plans to be supportive of the implementation process to allow for purposeful computation problems. This support was evident in the research because all three teachers scored one of the highest means for Step 1 of Number Talk implementation (Table 12). Step 1 is purposeful computation problems written on the board. Utilizing the purposefully designed lesson plans ensures from the beginning the Number Talk time was purposeful and focused. A prerequisite to professional learning being successful is timely and high-quality support of teachers and their unique learning needs. Additionally, leadership must create support systems for ongoing professional learning (Learning Forward, 2020).

The biggest fear of the participants, once the 9 weeks were completed, was how to plan for future instruction. The 9 weeks of lesson plans allowed the team of teachers to build implementation confidence throughout. This improved confidence is evident in Table 13, as the participants were observed implementing the five key components of Number Talks correctly or with improvement in 86% of the observations. Because of their new knowledge of Number Talks, the team was able to work with me to create an outline for future units and plans. The team felt providing this same type of scaffolding support for other grade levels as those grade levels begin implementation would be important for implementation fidelity. This type of implementation support is another key standard in the Standards for Professional Learning to increase educator effectiveness and student results (Learning Forward, 2020).

Action Steps 2 and 3: Professional Development

In order for students to be able to construct meaning from their learning, the sociocultural theory requires students to work within relationships with other students. Creating an environment for students that is safe for discussion and risk free is key to students interacting with other students to develop meaning (Van de Walle et al., 2018). Student discussion and interaction improves as teachers step out of the authority role of imparting information and into the role of listening and facilitating the discussion (Humphreys & Parker, 2015; Parrish, 2010, 2014). Facilitating discussion shifts the focus from ability to effort within mathematical discussion.

NMAP (2008) found students directly connect their goals and beliefs around mathematics to their performance. A teacher’s ability to facilitate discussion between students shifts the focus from correct answers, or ability, to processes and effort. The participants all agreed this was difficult, especially the beginning of implementation, because the students were providing information and answers that seemed irrelevant. The team of implementing teachers reflected in the PLC meetings on the rollercoaster of implementation. Having a place to share about successes but ask questions about challenges with implementation served to be beneficial for all participants. This type of reflective environment where the focus is on collaborative inquiry and collective performance is a prerequisite to effective professional learning (Learning Forward, 2020).

The Number Talk Observation Tool I utilized provided accountability for consistent implementation, along with the opportunity for me to provide frequent and supportive evaluation. This consistent implementation is evident in Table 12, where the lowest averaged mean was on Step 5 with a mean of 2.57. A 2 equates to the “step somewhat appropriately implemented,” and a 3 equates to the “step appropriately implemented.” On all the steps of Number Talk implementation, the mean ranged from 2.57 to 3. This range shows that the participants consistently implemented the steps somewhat appropriately to appropriately.

Additionally, while Teacher C had the lowest overall mean of 2.68, her average still shows consistent implementation of the steps somewhat appropriately to appropriately. Teacher C also, as shown in Table 13, was found more often to have implemented the five key components correctly or with implementation improvement on classroom environment and community, teacher as facilitator, and mental math. With classroom discussion and purposeful computation, there was an equal number of implemented correctly and with improvement as not implemented correctly. Because of consistent fidelity checks and bi-weekly collaborative reflection with peers, Teacher C was able to make consistent improvement throughout the implementation process. The commitment to a healthy and productive learning community by this team of teachers supported the continuous improvement of implementation (Learning Forward, 2020).

The weekly reflection on the Number Talk five key components revealed consistent improvement in the areas of classroom environment and teacher as facilitator after PLC meetings where the participants were able to learn from each other through discussion of successes and challenges. In the Week 2 PLC meeting (Table 14), time management (classroom environment), along with being student-driven, utilizing correct questions, forgetting to record on the board, connecting the pieces, and modeling different modalities (teacher facilitation), were all coded as challenges. The participants also noted feeling tied very tightly to the provided lesson plans. In the Week 6 PLC meeting (Table 16), the participants noted improved timing based on improved teacher facilitation and increased participation by all students (classroom environment), along with an improved ability to use the lesson plans but adapt and respond based on the needs of the students during the Number Talk. At the end of the 9-week implementation (Table 18), the participants noted zero challenges directed to the classroom environment and teacher facilitation beyond a concern about creating purposeful lesson plans on their own.

Participants were able to discuss with each other how to facilitate learning without taking over the thinking of the students. My twice weekly observation allowed the participants to receive rapid and frequent feedback from an impartial observer to allow for formative improvement. Again, both of these pieces of an effective learning community and the use of evaluative learning data are connected to educator effectiveness and improved results for students in the Standards for Professional Learning (Learning Forward, 2020).

Action Step 4: Student Assessment

As students construct meaning, they connect old learning to new learning as they develop a deeper understanding of numbers and how they interact (Van de Walle et al., 2018). Developing student mental math skills supports this deeper understanding of number relationships, problem-solving, and sensemaking skills (Parrish, 2014).

Just as teacher support must be more formative in nature to allow teachers to continually improve implementation, student understanding must be assessed to allow for frequent shifts in instruction for either whole groups or small groups of students who need additional support. Because mathematical knowledge developed in primary grades is related to mathematics learning for many years after (NMAP, 2008), utilizing research-based formative instructional tools like the NSS is an important piece of assessing the effectiveness of Number Talks, along with addressing continuous improvement.

Participants saw improvements in their quick checks of students within daily lessons, but utilizing the NSS allowed to not only reflect on growth but also target areas for students with greater need was addressed as an area of importance by the participants. The NSS data also aligned with findings in the review of literature and affirmed the change in curriculum was beneficial to student growth and understanding of mathematics, especially for supporting early number competency.

The beginning goal of the math committee when evaluating the math curriculum was to ensure what we were utilizing would support long-term number sense development. A strong foundation in number competency early in a student's development is a strong predictor of success in math over verbal, spatial, and memory skill competencies independent of cognitive ability and social class (Jordan, 2013; Jordan, Kaplan et al., 2009; Locuniak & Jordan, 2008). The statistical analysis of the kindergarten cohort found the total cohort scored a higher mean on the post-NSS than the pre-NSS, with a p value less than an alpha value of .05 for the entire cohort, showing a statistically significant difference. The NSS is an effective tool for measuring number competency because it is a research-based tool for screening kindergarten and early first-grade students to assess early numeracy competencies that can be used to predict "achievement level and growth in elementary school mathematics" (Jordan et al., 2012, p. 1).

In addition to the entire cohort showing a positive statistically significant difference between the pre-NSS and post-NSS, each class also showed a statistically significant difference. Teacher A scored the highest average overall mean on the observational tool for implementation fidelity (2.94 of 3), and Class A showed the most statistically significant difference between the pre- and post-NSS (p = 7.56089E-07). Teacher C scored the lowest average overall mean on the observational tool for implementation fidelity (2.68 of 3), and Class C showed the next most statistically significant difference between the pre- and post-NSS (p = 7.69887E-05) after Class A. Utilizing the NSS tool to measure number sense allowed the team to ensure Number Talks made a positive impact on number sense development in combination with the observational tool and PLC meetings to provide for continuous fidelity of implementation and improved professional learning (Learning Forward, 2020).

Action Plan Summary

The previous section shared and described a targeted action plan for the implementation of Number Talks school-wide for the school where the participants and I work. The action plan included stated objectives, along with specific action steps as they pertained to the five key components of Number Talks, along with reflection on the reported observations and data from the study. After the action plan was developed, the action plan and supporting research from the study were presented to the Lower School

Math Committee and the Shared Leadership Team. This presentation included the observational tool and weekly reflection data (Tables 12 and 13), a summary of the PLC implementation discussions of strengths and challenges of implementation (Tables 14-18), and the statistical analysis of the pre- and post-NSS scores (Tables 19-21). The action plan will be utilized by the Math Committee to implement Number Talks school-wide for the following school year.

Within the explanation of the action plan, reflection on Learning Forward's (2020) Standards for Professional Learning was included. Prerequisites for professional learning that increase the effectiveness of educators are a commitment to all students, educators ready to learn, the ability to learn collaboratively, and high-quality resources that meet the unique learning needs of the participants. It is important to note that success of Number Talk implementation and any other new undertaking within a school setting are supported by the processes in place before implementation as they align with change theory. Change is a process, not an event (Hall & Hord, 2015). Beyond providing teachers with a box of new curriculum, the point of view of those implementing the innovative change must be considered. Before the implementation of Number Talks, stakeholders within the lower school reviewed appropriate data points and came together around the vision and purpose of the new implementation.

Additionally, as the principal, I have served the kindergarten team as a change facilitator to support them to develop competence and confidence to implement Number Talks, along with provided a resource system through bi-weekly collaborative reflection to work through the stages of concerns of the participants. As the team moves to implement the action plan school-wide, the kindergarten team will take on the role of additional change facilitators to support school-wide successful implementation. With the use of the action plan, created with the input of the kindergarten team, professional learning will continue to be intentional and ongoing as it was during the research study. Innovations, meant to increase educator effectiveness and improve student learning, cannot be put on a teacher's plate during back to school planning (Hall & Hord, 2015). It is important to partner with teachers to address emerging and evolving needs, consider the concerns of those implementing change as change is very personal, and provide teachers with timely and specific assistance that is relevant to them and the new learning. These aspects are an important part of change theory and supported a successful implementation of Number Talks (Hall & Hord, 2015; Learning Forward, 2020).

Implications and Recommendations

The purpose of this study was to examine the implementation process and impact of a 9-week Number Talk intervention to build number sense in kindergarten students. Properly trained teachers must provide students with high-quality mathematics instruction to equip students to construct a deep understanding of number sense (Reid & Reid, 2017). The constructivist theory states that learners are not blank slates, but rather creators and constructors of learning (Piaget, 1976; Van de Walle et al., 2018; Von Glasersfeld, 1995).

To be able to construct learning, the classroom teacher must be equipped to facilitate learning so students have the pieces needed to develop a deep number sense understanding (Van de Walle et al., 2018). While the statistical analysis of the quantitative data showed Number Talks to have a statistically significant positive difference on student scores between the pretest and the posttest of the NSS, the evaluation of the implementation process by the teachers and me supported the team's recommendations for future teacher implementation.

During the study, teachers were observed twice weekly implementing Number Talks. This frequent observation, along with bi-weekly PLC meetings to discuss strengths and challenges of implementation, equipped the teachers with the reflective tools to improve the implementation of Number Talks. This level of reflection is evident in Tables 14-18, which show the coding of the Number Talk implementation PLCs. When a team member shared in Week 2 (Table 14) that they forgot to record responses of students, another team member was able to share how they recorded responses to give immediate implementation feedback that could improve classroom implementation the following day. Also, in Week 2, everyone on the team mentioned a struggle with time management, along with how to connect all the pieces of the Number Talk. This allowed for immediate reflection with me that the team could quickly practice in their classrooms and report back at the next bi-weekly PLC meeting. Marshall (2018) would connect this time of reflection and feedback as a proactive instructional stance to supporting the practice of teachers in the middle of their work rather than a reactive practice of evaluation where teachers are complimented and critiqued on their work after it is over. When coaching teachers throughout the implementation process, teachers are supported to "make discoveries and take risks, not just to implement what we tell them to do" (Marshall, 2018, p. 29). This type of coaching aligns with transformational coaching, which supports the meeting of teachers where they are and supporting them to grow and improve. It allows for a loop of shared feedback that supports, rather than controlling or manipulating perceived by-in (Crane, 2014). Additionally, the PLC meetings provided systematic ways to support understanding and walk teachers through the stages of concern throughout implementation (Hall & Hord, 2015).

When individuals are learning something new, there is a strong learning curve at the beginning that steadily improves for a year or 2 and then plateaus. The learner's learning curve can continue if they are engaged in a deliberate practice of growing and improving through feedback and reflection (Calkins et al., 2019). This deliberate practice of goal-setting, when those involved are able to work together to coauthor a solution, can lead to improved confidence in individual ability and enthusiasm, along with providing individuals with time to explore and question the practice (Calkins et al., 2019; Marshall, 2018). As task concerns (the amount of learning time) and impact concerns (the effect on students) are addressed through collaborative innovation and implementation, shared learning increases and educator effectiveness improves (Hall & Hord, 2015). Creating opportunities for engagement and ownership within teaching and learning, rather than focusing on a system of compliance, builds innovation in individuals and the collective culture (Marshall, 2018; Pink, 2009).

This collective ownership was evident in our reflective practice throughout the 9-week implementation. The teachers did not continue to implement a new curriculum incorrectly or without support. The frequent partnership between the participants and me not only improved fidelity of implementation but also built confidence in the team members, camaraderie around a common goal, and healthy discussion around improving the implementation of the five key components of Number Talks. This is evident in Table 18, where the participants met after the 9-week implementation to discuss future implementation. The challenge column of the transcript coding only reflected a worry about future planning and implementation support.

The focus around implementation fidelity modeled for the participants the sociocultural theory from which Number Talks support learning in students. The sociocultural theory suggests learners learn from those with whom they are working who are more knowledgeable in an area (Van de Walle et al., 2018). Just as Number Talks improve classroom discussions that are based upon a child's ideas and solutions to support learning, the discussions had by the participants improved learning and implementation. For example, Teacher A scored high on Step 5 of Number Talks on the Observational Tool, while Teacher C scored lower on this step. Step 5 is recording all answers provided by students on the board to support discussion, but Teacher C reflected on the struggle with this step in our second bi-weekly PLC meeting and Teacher A was able to share how they ensured the step occurred during Number Talks. Teacher C reflected on the amount of teacher talk and the aim to improve this during the next week of implementation.

The frequent formative feedback via me, discussion with peer participants, and self-reflection created an environment of continual improvement and collaboration. Research has found that formative feedback is of the greatest benefit when feedback is connected to learning goals, is planned by the participants, and is used to make changes to learning goals (Crane, 2014; Learning Forward, 2020; Pelgrim et al., 2013). The bi-weekly PLC meetings allowed for reflective conversation directly around the learning goal of implementing Number Talks, was a planned area of focus by the PLC team, and participants were able to use the feedback as quickly as the next day in their daily Number Talk. This aligns directly with the findings of Pelgrim et al. (2013).

This collaboration and focus on continual improvement are also noticeable in the themes coded from weekly observation reflection. For each key component of Number Talks, statements like more participating, improved conversation, allowing more student discovery, and improved facilitation reveal the collaborative effort towards improved instruction by the participants. Researchers around mathematics instruction and improving mathematics understanding for students acknowledge the importance of supporting educators with high-quality, research-based instruction and instructional pedagogy to support students in the construction of meaning and numerical relationships which builds number sense (Hall & Hord, 2015; Learning Forward, 2020; NCTM, 2014; Reid & Reid, 2017; Van de Walle et al., 2018). Supporting teacher construction of meaning within mathematics instruction supports a deeper knowledge of mathematical content and facilitation of the content with students to build student discussion around the appropriate tasks and effective questioning (Reid & Reid, 2017). Improved teacher implementation of a research-based curriculum builds number sense in students, allowing for high levels of achievement from the beginning to be maintained through schooling to increase American student success and confidence in mathematics. Early number sense predicts mathematics success more than other measures of cognition (Jordan et al., 2007; Locuniak & Jordan, 2008; Mazzocco & Thompson, 2005; Watts et al., 2014); and mathematical knowledge developed in primary grades is connected to mathematics learning for many years after (NMAP, 2008).

When students develop a gap in number sense early in their education compared to peers, this gap is maintained or widened as students age through middle and high school (Neergaard, 2013). Research is showing early proficiency in mathematics as a stronger predictor of the long-term success of students than any other childhood skill, including literacy (Duncan & Magnusson, 2011). Therefore, targeted instruction to build number sense early in students is important. Clements et al. (2013) identified most current mathematical standards utilized by schools underestimate a child's innate ability to understand mathematics, and students often have untapped potential to grasp math concepts and skills. This was observed and commented on by the participants within PLC discussions. Participants were unsure how much to allow students to discuss independent of them, were unsure in the beginning how much to correct and guide, and commented on students progressing faster than they expected and with connections that surprised them.

Building number sense in young students is important. Early mathematical competencies have been found to have a strong relationship to student success in school during the first 4 years of elementary education (Cerda et al., 2015). The early development of number relationships provides students with the foundation needed to learn complex calculation procedures involving larger numbers as well as supporting problem-solving in future learning (Jordan, Kaplan et al., 2009).

With 9 weeks of daily implemented Number Talks, student achievement on the NSS showed a statistically significant difference for the entire kindergarten cohort. Other than basic counting skills, which most students scored well on in the pretest, student scores showed a statistical difference between pre and posttest in all areas of the NSS subtests. When isolating for students who scored below the 50th percentile, between the 50th and 75th percentile, and 75th percentile and above (Table 21), all three cohorts of students improved with a statistically significance between the pretest and the posttest. It is of importance to note that the cohort of students scoring below the 50th percentile on the pretest showed a smaller *p* value than students in the cohort scoring between the 50th and 75th percentile. Therefore, the growth of students who scored below the 50th percentile on the pretest was larger than the students scoring between the 50th and 75th percentile. This is important as educators seek to close the achievement gap at an early age and before students fall further behind in mathematics. Research has shown supporting kindergarten students who are at risk for failure to build number competencies has resulted in significant gains on first-grade mathematics assessments compared to control groups (Jordan, Glutting et al., 2009). Utilizing Number Talks within the primary classrooms not only supports number sense development in students but supports closing the gap early for students who have the most significant mathematical needs. NMAP (2008) found utilizing research-based instructional programs that target developing number sense from an early age best support numeracy development in students.

Students scoring above the 75th percentile had the smallest *p* value and therefore the most statistically significant difference in their pre and posttest scores. This indicates that while Number Talks supported struggling students to grow in their number sense, it also built in the flexibility needed for the classroom teacher to support already achieving students to achieve at an even higher level. All math growth for students at an early age is important to support the later achievement of more complicated mathematical competencies (Watts et al., 2014).

Recommendations for Future Study

This study focused on the implementation process and impact of Number Talks to build number sense in kindergarten students. The following recommendations are noted for future studies at the conclusion of this action research study.

1. After seeing the positive correlation between Number Talks and number sense development within a 9-week study, lengthening the treatment phase of the study would allow multiple assessment points throughout the process, while also determining the longer impact of Number Talks.
2. After learning from three participants throughout the implementation process and observing the importance of constructing learning not just for the students but also for the teachers, a study focusing solely on the fidelity of implementation or the professional learning support needed for implementation would further the understanding of teacher education.
3. Replicating the study completed with a different age of students, students of a different socioeconomic background, or isolating for gender would continue the understanding of number sense development for primary age students.
4. The NSS can be utilized through first grade. A continuation of the research completed following a cohort of students from kindergarten through first grade would inform the ability of Number Talks to close the learning gap for students.
5. Replicating the study over a longer range of time, past elementary age to middle and high school, would track the impact of Number Talks on the number sense development of students as they move from primary mathematics to algebra and higher mathematics.

Reflections

Marshall (2018) described the principal role as the “head learner” (p. xvii). Marshall reminded principal leaders that while there are many urgent matters, such as student safety and discipline, these should not be confused with the important matters like ensuring good learning for students and teachers. Completing this action research with the team of kindergarten teachers brought me back to the importance of partnering with my teachers to ensure both student and teacher learning is a priority. Rigby et al. (2017) found teachers who are more engaged with other teachers and stakeholders are more likely to improve their own instructional practices. This was found to be even more accurate when the learning opportunities teachers engaged in were immediately actionable and directly related to their own classroom practices. In the beginning, adding in twice weekly observations of three teachers, along with additional bi-weekly PLC meetings, felt overwhelming; but completing this action research reminded me that while I have to respond to the urgent, I can make time for one of my most important roles of leading our team to improve instruction.

Teaching and learning are three dimensional and require more than compliance from teachers, but rather a high level of engagement that is created when teachers are invited into the process of learning, evaluating, implementing, and improving instruction and pedagogical practices (Marshall, 2018). At a school level, the research we completed and the action plan we developed created buy-in at a teacher level. The teacher leaders on our math committee all agreed our math curriculum needed to be changed, but their knowledge of Number Talks was limited. The qualitative and quantitative research we gathered during this study reinforced the ability of Number Talks to develop number sense in even our youngest students. Additionally, the action plan developed by the kindergarten team of teachers gave vision and concrete next steps to implementing Number Talks school-wide.

Finally, completing this action research study helped me to see myself as a researcher. In the beginning, this research study began as a requirement. As it developed and I realized the potential of the action research to positively impact my school, my excitement grew. I have realized as an instructional leader, I can support other teams of teachers through the action research process to evaluate curriculums, improve curriculum implementation, and improve instruction and pedagogy with the end goal of improved student learning.

Conclusions

In conclusion, there are several key findings that define the work completed in this action research study. First, educators must prioritize partnering together to utilize the action research process to learn, analyze, and improve instruction that prioritizes student learning (Kajander, 2010; Mathematics Learning Study Committee et al., 2001). Second, number sense development is possible for our youngest students and is the foundation for mathematical growth (Watts et al., 2014). Number Talks are curricular tools that allow students to construct their mathematical thinking through interaction with peers and teachers as facilitators (Jordan et al., 2012; Jordan, Kaplan et al., 2009). Finally, in order for educators to create classroom environments that support student construction of mathematical meaning, they must be given the tools and professional support to know how to implement Number Talks correctly (Mathematics Learning Study Committee et al., 2001; Reid & Reid, 2017).

Most researchers would agree that as a country, we are currently falling short of developing students who enjoy, understand, and are able to apply mathematics to their careers and their daily lives. Educators can agree the only way to stop falling short is to improve our instruction, but many are unsure how. As a result of this study, I have seen the importance of educators partnering through the action research process to learn and analyze how to improve instruction.

Success in algebra and beyond depends on a deeper understanding of number sense and important mathematical concepts that educators in primary grades often conceal in the memorizing of algorithms and procedures. The Integrated Theory of Numerical Development supports connecting for students that numbers have value and magnitude (Siegler et al., 2011). These connections developed in Number Talks, combined with a focus on students constructing meaning as they learn and process this learning with other students and a facilitating and supportive teacher, has been shown in this study to positively impact the number sense development of kindergarten students. As a result of this study, I have seen the importance of equipping primary teachers with the tools to develop strong classroom environments and communities, equip students for classroom discussions, embrace their role as a facilitator of discussion, utilize mental math strategies with students, and provide purposeful computation problems for lessons: the key components of Number Talks. This work can be done with our youngest students, and the foundation this work develops is important for further mathematical growth.

Finally, Number Talks can change a student's view of mathematics by building number sense in a constructive and creative environment. Even the youngest students were observed utilizing sensemaking abilities to observe and respond to Number Talks, which was shown in the NSS to impact number sense development. Additionally, I observed the teacher participants also using sensemaking abilities to observe students and make frequent adjustments to instruction to support students constructing meaning around mathematics. As a result of this study, I know the importance of reflective processing with other educators to provide constructive and creative environments for mathematical learning for students.

Number Talk implementation with kindergarten students showed a positive correlation to number sense growth. Teacher comments and reflection support the use of Number Talks, along with the need for implementation support to ensure Number Talks are understood by teachers and presented to students strategically and purposefully. While our nationwide success in mathematics will take time to grow and change, it is important to understand the impact of building a conceptual understanding of mathematics in students at an early age. Jordan (2013) found student success in kindergarten to be associated with earning potential and financial management as they become an adult, and the mathematical knowledge development in kindergarten is related to a student's mathematics learning for years after (NMAP, 2008). The way to change the current trends in American mathematics could lie in targeting our youngest mathematicians and creating a strong mathematical foundation from the start.

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Appendix A

Observation Checklist- Google Form PDF

Number Talk Implementation Observation

* Required

1. *

Example: January 7, 2019

2. Teacher Observed *

Mark only one oval.

- Teacher A
- Teacher B
- Teacher C

3. Observation Number *

Mark only one oval.

- Week 1- Observation A
- Week 1- Observation B
- Week 2- Observation A
- Week 2- Observation B
- Week 3- Observation A
- Week 3- Observation B
- Week 4- Observation A
- Week 4- Observation B
- Week 5- Observation A
- Week 5- Observation B
- Week 6- Observation A
- Week 6- Observation B
- Week 7- Observation A
- Week 7- Observation B
- Week 8- Observation A
- Week 8- Observation B
- Week 9- Observation A
- Week 9- Observation B

4. Steps of a Number Talk *

Mark only one oval per row.

	0- Step not demonstrated	1- Step improperly implemented	2- Step somewhat properly implemented	3- Step appropriately implemented
Purposeful computation problem written on board (or shown) for students.	⬭	⬭	⬭	⬭
Students solve problem mentally.	⬭	⬭	⬭	⬭
Students put thumb up in front of chest when an answer is determined.	⬭	⬭	⬭	⬭
Teacher calls on students for answers when most have thumb up.	⬭	⬭	⬭	⬭
Teacher records all answers on board- correct and incorrect.	⬭	⬭	⬭	⬭
Students share strategies and justify answers for peers.	⬭	⬭	⬭	⬭
Teacher facilitates discussion and justification by asking What did you see? How did you see it? How do you know? and records thinking on the board.	⬭	⬭	⬭	⬭

5. Reflection- 5 Key Components of Number Talks

(Completed once a week) What am I noticing about classroom environment and community, classroom discussions, the teacher's role as facilitator, the role of mental math, and purposeful computation problems?

Appendix B

Math Talk PLC Agenda Template

[redacted]

Math Talk PLC Agenda

Date of Meeting:

Grade Level:

Team Members Present:

Strengths of Implementation:

Concerns of Implementation:

Conversation Support (Steps of Number Talks/Key Components of Number Talks)

Steps	Description of Steps
1	Purposeful computation problem written on board for students
2	Students solve problem mentally
3	Students put thumb up in front of chest when an answer is determined (can add fingers as discover more solutions)
4	Teacher calls on students for answers when most have thumb up
5	Teacher records all answers on board- correct and incorrect
6	Students share strategies and justify answers for peers
7	Teacher facilitates discussion and justification by asking, "What did you see?", "How do you see it?", and "How do you know?" and records thinking on the board

Key Components

1. Classroom environment and community
2. Classroom discussions
3. Teacher's role as facilitator
4. Role of mental math
5. Purposeful computation problems

[redacted]

[redacted]

Next Steps (review of upcoming number talk lessons):

Questions about future implementation:

[redacted]

Appendix C

Number Talk Week 1 Schedule

MONDAY
1- Counting Warm Up- hundreds chart on board, sitting in a circle • **Let's count to 20, this time taking turns. I will start**. 1 (point to the child to the left) • Do this several times so that all students are able to participate. • If a child messes up, say, **"That was a good try, but the next number is _____. Lets try again."** • Then back up two people and start again. 2- Finger Counting • Say, **"Let's count to 5 on our fingers. Watch me 1, 2, 3, 4, 5."** (demonstrate) • Say, "**Now you try! 1, 2, 3, 4, 5. Let's try again. 1, 2, 3, 4, 5."** • Say, **"How many fingers do I have on this hand? That's right, I have 5 fingers on this hand."** • Do the same thing with your other hand • Say, "**Do you have five fingers on each hand?"** • Say, **"From now on, we do not need to count to find out how many fingers are on one hand. We know! How many fingers are on one hand?"** • Review both hands. • Say, **"Suppose I hold my hand behind my back. How many fingers are on my hand?"** (We will use this to practice automaticity later with numbers.)
TUESDAY
1- Finger Automaticity • Say, **"Let's practice making numbers on our fingers quickly."** • Say, **"Show me 1 on your fingers."** • Repeat with 1-5 • Say, **"Let's play a game. I want you to look at the number I show you and you put up that many fingers."** • Shuffle cards (numbers and words 1-5) and show them one at a time. Go through the shuffled cards 3 times. 2- Subitizing Numbers (Use Subitizing Cards 1-24) • Example- Show card #21- Say, **"Here is a card with 4 circles. See, here are 3 circles hiding inside the 4 circles. 3 and 1 more is 4."** (use your finger to circle the dots as you say the quantities). • Put the card down and then hold it back up and say, "**How many?"** then say, **"What do you see?"** and **"How do you see it?"** (The goal that they would say I see 3 and 1 more or 2 and 2 more. • For example- **"I see 2 circles and 2 circles hiding inside the 4 circles. 2 and 2 is 4."** • Put the card down and then hold it up and ask, **"How many do you see?"** and **"How do you see it?"** • **Repeat with Subitizing Cards #19-24.**
WEDNESDAY
1- Subitizing Numbers • Repeat subitizing exercise from the previous day. 2- Partners of 4 (2 + 2) Using Dot Chart for 4 • Hold up the Dot Chart for 4 • Say, **"Let's put the pencil in the middle of the dots."** • Say, **"How many dots are on this part?"** and **"How many dots are on this part?"** • Say, **"So, how many dots are in all?**" and **"How do you know?"** • Show the partner dot card for 4. • Say, **"This card show 2 and 2 is 4. 2 plus 2 equals 4."** 3- Partners and Number Sentences

- Show the card 2 + 2 = 4.
- Say, **“Here is another way to show 2 and 2.”**
- Say, **“This says 2 plus 2 equals 4.”**
- Show the partner dot card and the number sentence.
- Say, **“See how the dots on each card match the numbers on the number sentence? 2 plus 2 equals 4.”**
- Say, **“Let’s say this number sentence together 2 plus 2 equals 4. Repeat and touch the numbers and the signs when saying it.”**
- Say, **“Tomorrow we will write story problems to match this number sentence.”**

THURSDAY

1- Finger Counting (review from Monday)
2- Number Sentences on Fingers

- Show 2 + 2 = 4 number sentence card
- Ask, **“How can we show this number sentence using our fingers?”** and **“How do you know it is the same?”**
- Goal- 2 fingers on one hand, 2 fingers on the other hand, bring them together to make 4.

3- Story Problems

- Say, **“Now I am going to tell you another story.”** Give 2 children 1 crayon each and say, **“Only 2 children have crayons. The teacher gave 2 more children crayons.”** Give the other 2 children crayons. Say, **“How many children now have crayons?”** and **“How do you know?”**
- Connect the story to the partner dot card, the number sentence card.
- Say, **“Now it is your turn. Think of a story problem in your head that matches this number sentence. Give me a thumbs up when you have one.”**
- Have a couple of students share and have the class prove if it matches the number sentence or not.

FRIDAY

1- Subitizing Numbers- review from Tuesday.
2- Partners and Number Sentences

- Show them 2 + 2 = 4 partner dot card.
- Say, **“I can use this partner card to show a take-away problem, too. Watch what I do.”**
- Say, **“I have 4, but if I take away 2, then I have 2 left.”** (cover up 2 when you say it)
- Show the 4 - 2 = 2 Number Sentence Card.
- Say, **“Here is another way to show 4 take away 2. This say 4 minus 2 equals 2.”**
- Say the number sentence together.

3- Story Problems

- Say, **“Yesterday we told story problems with 2 + 2 = 4. Today’s story problems are going to be a little different. 4 children have their hands folded. 2 children unfold their hands.”** (have 4 children help you)
- Say, **“How many children have their hands folded now?”** and **“How do you know?”**
- Show the 4 - 2 = 2 card and say, **“That is right because 4 children minus 2 children equals 2 children.”** (point to the students who were demonstrating)
- Say, **“Now it is your turn. Think of a story problem in your head that matches this number sentence. Give me a thumbs up when you have one.”**
- Have a couple of students share and have the class prove if it matches the number sentence or not.

Appendix D

Number Sense Screener Quick Script

Quick Script

Number Sense Screener™
Quick Script, K–1

The *Number Sense Screener™ (NSS™) Quick Script, K–1, Research Edition* is a quick reference to use during testing, but it is not sufficient for accurate administration of the NSS. Before administering this assessment, please consult the *Number Sense Screener™ (NSS™) User's Guide, K–1, Research Edition* for a list of required materials and explicit instructions on administrating and scoring the NSS.

Begin the assessment by introducing yourself and addressing the child by name. Say, *"We are going to play some number games. It is important that you listen carefully and do your best. Are you ready to play?"*

A. COUNTING SKILLS

Enumeration

1. Say to the child, *"Here are some stars. I want you to count each star. Touch each star as you count."*
   - In the blanks, record the number the child says as he or she touches each star. If the child stops before 5, put a dash in the remaining blanks.
   - In the box marked "Correct[+]/Incorrect[#]" write + (= correct) if the count is error free, or write - (= incorrect) if the child makes an error.
2. When the child is finished counting, turn to the blank page and ask, *"How many stars were on the paper you just saw?"*
   - Write + (= correct) if the child says "5," or write the number the child said (= incorrect) if the child said any other number.

Count Sequence

3. Say to the child, *"I want you to count as high as you can. But I bet you're a very good counter, so I'll stop you after you've counted high enough. Okay?"*
   - Allow the child to count up to 10. If the child does not make any mistakes, record a +. If the child makes an error, record in the blank after "Count to 10" the highest correct number counted.
   - If the child self-corrects, allow the child to keep counting (make a notation that the child self-corrected). The child is allowed to restart counting only once.
   - If the examiner allows the child to count past 10, record in "Max count (optional)" the highest number to which he or she counted correctly (see Chapter 2 in the NSS user's guide).

B. NUMBER RECOGNITION

Say to the child, *"I'm going to point to some numbers. I want you to name the number when I point to it. Some may be hard for you, so don't worry if you don't get them all right."* As you show each number, point to the number and say, *"What number is this?"* Write + (= correct) if the response is correct. If the child's response is incorrect, write the incorrect response in the blank. Begin with the smaller numbers (e.g., 2, 4, 9) to help the child be more comfortable (see NSS stimulus book); however, only the numbers 13, 37, 82, and 124 should be scored. For example,

Items A–C should not to be included in the NSS score:	A.______(2)	B. ______ (4)	C. ______(9)	
Items 1–4 are to be included in the NSS score:	1.______(13)	2. ______ (37)	3. ______(82)	4. ______(124)

C. NUMBER COMPARISONS

Turn to the blank page and say to the child, *"Now I am going to ask you about some more numbers. Listen carefully and do your best."* For each item, point to the numbers as you say them. Turn the page to show the number 7. Say to the child,

1. *"What number comes right after 7?"* (8) (Do not turn the page.)
2. *"What number comes two numbers after 7?"* (9)
3. Turn the page. *"Which is bigger or more, 5 or 4?"* (5)
4. Turn the page. *"Which is bigger or more, 7 or 9?"* (9)

Turn to the blank page. *"This time I'm going to ask you about smaller numbers."*

5. Turn the page. *"Which is smaller or less, 8 or 6?"* (6)
6. Turn the page. *"Which is smaller or less, 5 or 7?"* (5)

Turn the page to show the visual array of three numbers. Point to 5 then 6 then 2, respectively, while asking,

7. *"Which number is closer to 5, 6 or 2?"* (6)

D. NONVERBAL CALCULATION

Matching Demo (practice item)

- Turn to the blank page. Place the white mat in front of the child and open the box of 10 black dots (tokens).
- Say to the child, *"We are going to play a game with these dots. Watch carefully."* Place three dots on the mat in a horizontal line. Say, *"See this... there are three dots."* Allow the student to observe the dots for about 3 seconds. Cover the dots with the box cover.
- Show the first multiple-choice page, gesture to the page, and say, *"Now point to the number of dots that are in the box."*
- Correct the child if a wrong answer is given. Make sure the multiple-choice format is understood. DO NOT score this item.

Addition (3 items)

1. 2 + 1 = 3
   - Turn the NSS stimulus book to the blank page.
   - Place *two* dots on the mat in a horizontal line. Say to the child, *"See this...there are two dots."* Allow the student to observe the dots for about 3 seconds. Cover the dots with the box cover.
   - Put out one more dot. Say, *"Here is one more dot."* Before the transformation, say, *"Watch what I do."*

Sources: Number Comparisons: Griffin (2002); Nonverbal Calculation: Levine, Jordan, and Huttenlocher (1992).

(continued on back)

- Slide the dot under the box cover in full view of the child. (When there is more than one to add, slide in dots one at a time.)
- Show the appropriate multiple-choice page in the NSS stimulus book. Say, *"Point to the number of dots that are hiding in the box now. Look at all the choices before you pick."*
- Record + (= correct) if the response was correct and write the number that the child pointed to if the response was incorrect.

Note: As this is a nonverbal test, do not penalize the child if he or she points to the correct box but says the wrong answer. In the same way, if he or she points to the wrong box and says the correct answer, count it as correct. Note any such inconsistencies in the margin.

Repeat as above, replacing the underlined words with the appropriate addends for the task. Turn the page before each task to reveal another blank page.

2. 3 + 2 = 5
3. 4 + 3 = 7

Subtraction (1 item)

4. 3 − 1 = 2

- Turn to the blank page and say, *"Now we are going to do something a little bit different. Watch carefully."* Place three dots on the mat in a horizontal line. Say, *"See this? There are three dots."* Cover them.
- Before the transformation, say, *"Watch what I do."* Take out one dot from under the box cover in full view of the child.
- Say, *"See, here is one dot."*
- Show the appropriate multiple-choice page. Say, *"Now point to the number of dots that are hiding under the box now. Look at all the choices before you pick."*
- Record + (= correct) if the response was correct and write the number that the child said if the response was incorrect.

Note: As this is a nonverbal test, do not penalize the child if he or she points to the correct box but says the wrong answer. In the same way, if he or she points to the wrong box and says the correct answer, count it as correct. Note any such inconsistencies in the margin.

E. STORY PROBLEMS

Turn the NSS stimulus book to a blank page.

- Say to the child, *"I'm going to give you some story problems. You can use your fingers, or this number list, or paper and pencil to help you find the answer. Some questions might be easy for you and others might be hard. Don't worry if you don't get them all right. Listen carefully to the question before you answer."* (See Chapter 2 in the NSS user's guide for instructions on the use of tools and recording of strategies.)
- The item may be repeated once if requested or if it is clear the child was not listening.
- Write + (= correct) if the response is correct. If the child's response is incorrect, write his or her incorrect response in the blank. Circle the strategy you observed. If the child uses a strategy that is not listed, record what he or she did in the "Notes" block.

Addition

1. *"Jill has 2 pennies. Jim gives her 1 more penny. How many pennies does Jill have now?"* (3)
2. *"Sally has 4 crayons. Stan gives her 3 more crayons. How many crayons does Sally have now?"* (7)
3. *"José has 3 cookies. Sarah gives him 2 more cookies. How many cookies does José have now?"* (5)

Subtraction

Say to the child, *"Now these questions are a little different. Listen carefully to the question before you answer."*

4. *Kisha has 6 pennies. Peter takes away 4 of her pennnies. How many pennies does Kisha have now?* (2)
5. *Paul has 5 oranges. Maria takes away 2 of his oranges. How many oranges does Paul have now?* (3)

F. NUMBER COMBINATIONS

- Say to the child, *"I'm going to ask you some more number questions. Just like before, you can use your fingers, this number list, or paper and pencil to help you find the answer. Some questions might be easy for you and others might be hard. Don't worry if you don't get them all right. Listen carefully to the question before you answer."*
- The item may be repeated once if requested or if it is clear the child wasn't listening.
- Write + (correct) if the response is correct. If the child's response is incorrect, write his or her incorrect response in the blank. Circle the strategy you observed. If the child uses a strategy that is not listed, record what he or she did in the "Notes" block.
- There is one page for each combination in the stimulus book. Touch each number and operator as you say it.

Addition

1. *How much is 2 and 1?* (3)
2. *How much is 3 and 2?* (5)
3. *How much is 4 and 3?* (7)
4. *How much is 2 and 4?* (6)

Subtraction

Turn to the blank page and say to the child, *"These questions are a little bit different. Listen carefully."* Then turn to the next combination.

1. *How much is 7 take away 3?* (4)
2. *How much is 6 take away 4?* (2)

Appendix E

Permission to Utilize Number Sense Screener

From: [redacted]
Sent: Thursday, March 21, 2019 5:58 PM
To: [redacted]
Subject: Re: Brookes Publishing

[redacted]

On another note, I am completing my dissertation and would like to use the NSS as my assessment tool for an action research project with kindergarten students. I will complete this in the fall, but I am working on my writing now. I want to request permission to use the NSS as my assessment tool, but I am not positive how to go about that. I see on the website there is a permission tab: https://brookespublishing.com/rights-permissions/permissions/ but none of the options here list using an assessment tool for a dissertation. I don't think you will need our permission as long as you are not changing the tool. We have people use our tools for many things and as long as the tool is not being changed, it ok.

Appendix F

Research Study Site Permission

[redacted]

June 5, 2019

Dear Gardner Webb University Institutional Review Board:

The purpose of this letter is to inform you that I give Rebecca Knight permission to conduct the research titled The Impact of Number Talks on Kindergarten Math Growth in a Large Private Independent School at Savannah Christian Preparatory School. We have agreed that all participant names and individual assessment scores will be kept confidential. All details of the study will be explained to those participating and their families prior to beginning the study and participation will be completely voluntary. Students without consent will receive the same academic treatment as those participating and participation by teachers will be voluntary.

I understand that Rebecca Knight will receive consent for all participants. Rebecca Knight has agreed to provide my office a copy of all Gardner Webb IRB-approved, stamped consent documents before he/she recruits participants on site. Any data collected by Rebecca Knight will be kept confidential and will be stored in a locked cabinet within her office. Rebecca Knight has agreed to provide to us a copy of the aggregate results from her study.

Sincerely,

Dr. Chris Harmon

[redacted]

Appendix G

Letter of Teacher Assent

Gardner-Webb University IRB
Informed Consent Form

Title of Study: *The Impact of Number Talks on Kindergarten Math Growth in a Large Private Independent School*

Researcher: Rebecca Knight, Doctoral Program- Gardner-Webb University

Purpose

The purpose of the research study is to examine the implementation process and impact of a nine-week number talk intervention to build number sense in kindergarten students.

Procedure

Before beginning daily number talks, the students will be assessed individually using the Number Sense Screener. I will train you on how to implement the Number Sense Screener, as this is a part of our new curriculum adoption. Students will be testing individually, with four students being assessed a day and the entire class completed within a week. Once all students are assessed, we will begin the nine weeks of daily number talk intervention. These will be completed in 5-10 minutes each day as a part of your regular math block. Lesson plans for these number talks will be given to you and will be reviewed at our kindergarten PLC meetings. Once the nine weeks of interventions are completed, we will reassess using the Number Sense Screener. The data from the pre- and post-assessment will provide us the information to determine if students show growth after the number talk intervention.

During the implementation of the daily number talks, I will complete a number talk checklist of the seven steps of a number talk twice weekly in your classroom. This same checklist will be utilized in our regular observations of all lower school classrooms as we learn to implement number talks as a part of our new curriculum. Additionally, our kindergarten professional learning community (PLC) will meet every other week to allow you all to discuss the implementation process. We will complete one final focus group at the end of the nine-week implementation. With your permission, I will record these PLC meetings to be able to review them later. Your identity will remain confidential throughout the research and writing.

Time Required

It is anticipated that the study will require about 40 minutes of your time for five days during the pre- and post- assessment weeks, along with about 10 minutes a day during the nine-week implementation period. Finally, PLC meetings will take about 30 minutes four times throughout the study, followed by a final focus group at the end that will last about one hour.

Voluntary Participation

Implementation of number talks and the NSS tool, along with participation in your PLC are required as a part of our curriculum adoption and your position as a lower school teacher. But, your participation in recorded conversations during the PLCs is voluntary. You have the right to withdraw from the recorded conversations as a part of the research study at any time without penalty. You also have the right to refuse to answer any questions during the recorded conversations and focus group. If you choose to withdraw, you may request that any of your data which has been collected be destroyed unless it is in a de-identified state.

Confidentiality

The information that you give in the study will be handled confidentially. Your information will be assigned a *code number (or pseudonym*.) The list connecting your name to this code will be kept in a *locked file in the counselor's office.* When the study has been completed and the data has been analyzed, this list will be destroyed. Your name will not be used in any report. *The recordings of our PLC and focus group meetings will be deleted after the data is analyzed and I have completed my dissertation defense.*

Risks

There are no anticipated risks in this study.

Benefits

There are no direct benefits associated with participation in this study. The study may help us to understand how to better implement number talks as a part of math curriculum to improve number sense development in primary aged students. The Institutional Review Board at Gardner-Webb University has determined that participation in this study poses minimal risk to participants.

Payment

You will receive no payment for participating in the study.

Right to Withdraw From the Study

You have the right to withdraw from the study at any time without penalty. If you choose to withdraw from the study, your audio will be destroyed.

How to Withdraw From the Study

If you want to withdraw from the study, tell the researcher and leave the room during the recorded portion of the PLC. There is no penalty for withdrawing. If you would like to withdraw after your materials have been submitted, please contact Rebecca Knight to have your materials withdrawn if possible. All material collected during the recorded PLC and focus group will be confidential and anonymous.

<u>If you have questions about the study, contact the following individuals.</u>

Researcher's Name: Rebeca Knight, Doctoral Candidate
Department: School of Education
Gardner-Webb University
Boiling Springs, NC 28017
Researcher Telephone Number: 704-577-9983
Researcher Email Address: rknight@gardner-webb.edu

Faculty Advisor Name: Dr. Mary Roth, Committee Chair
Department: School of Education
Gardner-Webb University
Boiling Springs, NC 28017
Faculty Advisor Telephone Number: 704-652-2924
Faculty Advisor Email Address: mroth@gardner-webb.edu

If the research design of the study necessitates that its full scope is not explained prior to participation, it will be explained to you after completion of the study. If you have concerns about your rights or how you are being treated, or if you have questions, want more information, or have suggestions, please contact the IRB Institutional Administrator listed below.

Dr. Sydney K. Brown
IRB Institutional Administrator
Gardner-Webb University
Boiling Springs, NC 28017
Telephone: 704-406-3019
Email: skbrown@gardner-webb.edu

<u>Voluntary Consent by Participant</u>
I have read the information in this consent form and fully understand the contents of this document. I have had a chance to ask any questions concerning this study and they have been answered for me. I agree to participate in this study and understand that meetings I participate in will be recorded.

______________________________________ Date: ____________
Participant Printed Name

______________________________________ Date: ____________
Participant Signature

You will receive a copy of this form for your records.