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The Effects of 'Number Talks' on Number Sense in a Second Grade Math Class

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ABSTRACT

The purpose of this study was to evaluate the effectiveness of using 'Number Talks' intervention on students' ability to use number sense to problem-solve and persevere in solving problems within a second-grade math class. The 22 participants were volunteers in my second-grade class. A quasi-experimental design method was used to compare results between a control group and intervention group using a pre-post test design. The intervention group received 15 minutes of 'Number Talks' a day for a total of 12 days while the control group participated in traditional daily math activities. Perseverance was measured using a tally chart to record number of strategies students used to solve problems. Written reflections were completed once a week for three weeks to build students' ability to explain reasoning in writing. Comparison of the mean pre-post test scores of the intervention group and control groups indicated no significant differences in the scores. Comparison of the mean post test scores between the intervention and control groups indicated no significant differences in the scores. However, the disaggregated data showed some positive results in individual cases and improvements with written responses.

SECTION ONE

Introduction

According to the 2007 National Center for Educational Statistics, "more than half of our nation's students are performing below grade level in the area of mathematics… overall, these data seem to suggest that students in early grades are not mastering the basic math foundations and skills necessary to acquire more advanced skill" (Poncy, Mccallum, & Schmitt, 2010 p.917). As a result, state leaders developed Common Core Standards for Mathematical Practices to support and deepen students' understanding of mathematics, as well as to improve student achievement scores (Ohio Department of Education, 2010).

Common Core has emphasized several key mathematical foundations to be taught including number sense, algebraic thinking, measurement, and geometry. Studies have identified weaknesses in students' understanding of number sense which correlates with their difficulty in solving cognitively complex problems in later grades (National Mathematics Advisory Panel, 2008). Number sense refers to the mental ability to be flexible and fluent with numbers (simple math facts), the composition and decomposition of numbers, or breaking apart number to add or subtract, our system of tens (understanding place value of hundreds, tens, and ones), making sense of what numbers mean (such as 50 is 5 tens and 0 ones which is different from the number 5 which is only 5 ones), and making comparisons (knowing that 82 is larger than 28).

Perseverance is another important skill students need in order to be effective at solving problems. The Standards for Mathematical Practice (2018) describe eight standards to help students be successful. The first one being "Make sense of problems and persevere in solving them" (Standards for Mathematical Practice, 2018 p.1). Schwartz (2006) defines perseverance as sticking with a problem longer and continuing to try multiple strategies even when faced with obstacles.

Current researchers suggest educators need to look more to the Common Core Standards for Mathematical practices and use mathematical discourse to deepen and support understanding of number sense. The common core emphasizes number sense as a crucial topic in mathematics because it is viewed as a key foundational skill for supporting more complex mathematics in higher grades. Despite these changes to educational standards, educators are relying on teaching strategies they learned when they were in school such as algorithms or following text books, even though these have been argued to be an ineffective approach in supporting problem solving (Faulkner, 2009; Ball, Ferrini-Mundy, Kilpatrick, Milgram, Schmid, & Schaar, 2005).

In the second-grade classroom, Common Core State Standards in Mathematics require teachers to prepare students to solve problems accurately, efficiently, and fluently (e.g., 2.OA.B.2 Fluently add and subtract within 20 using mental strategies). However, every year this is a struggle for my students. Assessment data collected from beginning, middle, and end of year student growth measures show that my students have a lack of understanding of number sense. For example, five students scored in the kindergarten range for number sense and 11 students scored at the first-grade level. That is over half of my class below grade level for number sense. What this means is that these students need additional support in counting and cardinality (counting forwards and backwards by 1s and 10s, identifying one more and one less, and comparing written numerals), and base ten (recognizing numbers up to 100, comparing numbers, adding and subtracting within 20, and adding and subtracting two digit numbers).

Additionally, my observations during lessons confirm that students are reluctant to discuss math, have difficulty defending their reasoning, and show a lack of flexibility and fluency with numbers. I have found that many of my students rely heavily on rote memorization, use of their fingers, and teacher-taught algorithms to solve problems, and when asked to explain their problem-solving strategies or reasons for their answers, they struggle to explain their thinking, well. This concludes that they are lacking in strategies to solve basic mathematical problems leading to difficulty with understanding more complex math problems and an inability of explaining their thought process or reasoning. I have had difficulty finding the best way to help my students acquire the skills they need to think flexibly, with reasoning, and to have conversations about mathematics as mechanisms for improving number sense.

Some math teachers have used 'Number Talks' as a strategy that can be used to bridge this gap. 'Number Talks' are classroom conversations and discussions around purposefully crafted computation problems that assist students with developing efficient, flexible, and accurate mental computation strategies (Parrish, 2014). Therefore, incorporating 'Number Talks' into mathematical instruction may be significant in helping students build a toolbox of efficient strategies based on numerical reasoning to compute accurately, efficiently, and flexibly in order to solve problems.

The purpose of this capstone project is to find answers through instructional inquiry to the following questions: What effect does a 'Number Talks' intervention have on second grade students' problem-solving accuracy and abilities to explain their thinking with reasons? And does a 'Number Talks' intervention support students' perseverance in solving problems?

SECTION TWO

Literature Review

Standards for Mathematical Practice

Common Core State Standards (CCSS) were developed to improve student achievement and compete with countries' achievement scores around the world (Ohio Department of Education, 2010). Osborne (2015) expresses "The new, deeper standards require a more refined skill set for teaching" (p. 23). Thus, Ohio created their own set of standards labeled "Ohio's New Learning Standards" to help all students achieve the goal of college and career readiness. These standards explain what students should be able to understand and do within mathematics.

The Common Core and Ohio defines eight standards called the Standards for Mathematical Practice which "describe varieties of expertise that mathematics educators at all levels should seek to develop in their students" (Ohio Department of Education, 2017 p. 4). They are important processes and proficiencies that have the potential to significantly impact and improve student learning (Moyer-Packenham, Bolyard, & Tucker, 2014). The eight mathematical practice standards are: (a) make sense of problems and persevere in solving them, (b) reason abstractly and quantitatively, (c) construct viable arguments and critique the reasoning of others, (d) model with mathematics, (e) use appropriate tools strategically, (f) attend to precision, (g) look for and make use of structure, (h) look for and express regularity in repeated reasoning (Standards for Mathematical Practice, 2018). Each standard provides a one paragraph description of activities and learning outcomes that connect to the practice.

The complexity of mathematics teaching creates discrepancies in interpretation and implementation of these standards (Li, 2013). Therefore, Li (2013) wanted to gain deeper insights of the mathematical practices and determined that mathematical practices are a habitual way of thinking and reasoning about mathematics. She describes three overarching themes that reflect mathematical practices: (a) behavioral engagement and commitment, (b) employment and development of knowledge, skills, and strategies, (c) internalization and habitualization. Behavioral engagement and commitment is described as students working independently or collaboratively to complete mathematical tasks and activities in which they reflect on their progress and strategies, make adjustments needed for improvement, and see it through to completion through perseverance. Employment and development of knowledge, skills, and strategies are explained as students having knowledge of algorithms, routine procedures, logical reasoning, and strategies needed for solving mathematical problems. Internalization and habitualization is the point when students use what they have learned through teacher-designed activities and choose the mathematical practices that are most relevant to the task at hand. Finally, Li suggests that teachers need to have opportunities to experience, deepen their understanding, and use these practices in their own learning of mathematics in order to model and provide meaningful and authentic activities to foster the mathematical practices and habits within students (Li, 2013).

Moyer-Packenham, Bolyard, & Tucker (2014), used information learned from Li (2013) and other researchers to design their own study to better understand the mathematical practices. They focused on the idea that the mathematical practices are both a process and a product. It is a product when the child has a well-developed understanding of mathematical practices and uses them as a tool to solve problems. It is a process when children's mathematical processes are still developing and changing each time they work on solving new problems (Moyer-Packenham, Bolyard, & Tucker, 2014). Through their examination of 25 second-grade students engaged in solving mathematical tasks with rational numbers, they gained a deeper insight to the process and product of the mathematical practices. During this study, the mathematical practices were not taught to the students. Instead, they developed through one-on-one interviews with the students because the mathematical tasks promoted the development of their mathematical practices. Questioning was also used as a strategy to promote mathematical practices during the interview process. The results suggest that the children already had a foundation of mathematical practices and that they were able to apply these practices to the mathematical tasks (Moyer-Packenham, Bolyard, & Tucker, 2014). While it has been stated it is important to teach specific mathematical practices to students to help them become better mathematical problem solvers, these researchers also found that students are able to form some of the mathematical practices on their own with the proper questioning and problem-solving tasks.

The Common Core State Standards seek to address inequality in American schools while helping to prepare students for success as an adult. Therefore, it is argued that schools must provide intentional experiences that engage students in challenging and engaging activities and teach skills such as problem solving and perseverance to set them up for mastery (Laursen, 2005; Seherer & Gustafsson, 2015). The next section will address the importance of problem solving and perseverance in order to prepare students for success.

Problem Solving and Perseverance

Important 21st century skills students need to be taught in order to become efficient mathematicians and function effectively in today's society are both problem-solving and perseverance (Doyle, 2005; Larson & Miller, 2011; Laursen, 2005; Mwei, 2016). No longer are teacher taught techniques, and mastering facts and procedures ideal components of teaching mathematics. Instead, the ability to make sense of problems, solve problems efficiently, and persevere in solving them are key skills that should be taught to all students through explicit instruction and guided discovery (Larson & Miller, 2011; Mwei, 2016; Schoenfeld, 2013).

Over the years, problem-solving has been given many different definitions. Schoenfeld (2013) defines problem-solving in a general way, describing that it is formulating a solution when the method for solving a task is unknown, but problem-solving is not defined by the complexity or difficulty of the task. Lester (2013) has a very similar view, defining problem-solving as what a person does to achieve a goal which requires them to engage in various cognitive actions. No matter how problem-solving is defined, the researchers all argue the importance of the ability to effectively problem-solve, and therefore a skill all learners should be exposed to (Larson & Miller, 2011; Lester, 2013 Mwei, 2016).

Perseverance is another important skill needed in order to be effective at solving-problems. Too often students give up when problems are difficult (Schwartz, 2006). Schwartz (2006) defines perseverance as sticking with a problem longer and continuing to try multiple strategies even when faced with obstacles. This determination to continue can make all the difference when problem-solving (Schwartz, 2006). Scherer and

Gustafsson (2015) also argue that perseverance stems from their willingness to engage in problem solving. Perseverance is a crucial element of problem-solving because a student's persistence is what helps them to remain with a task and use multiple strategies to continue to work through a problem, which leads to success (Laursen, 2005; Scherer and Gustaffson, 2015; White, Prager, Schaefer, Kross, Duckworth, & Carlson, 2017).

Researchers including Mwei (2016) and Lester (2013) describe steps involved in the problem-solving process that educators should be teaching to help students be successful problem-solvers. The steps are as follows: (a) making sense of the problem by thinking about what information should be attended to or ignored, (b) formulating a plan through use of different strategies and mathematical concepts, (c) carrying out the plan by selecting a strategy based on effectiveness and efficiency, and (d) looking back at the problem to test and verify the accuracy of the solution (Lester, 2013; Mwei, 2016). Lester (2013) goes further to describe what he identifies as the seven important problem-solving principles including; working with problems for a prolonged period of time, having ample opportunities to solve a variety of tasks, tasks related to important mathematical concepts, instruction facilitated and directed by the teacher, the teacher monitors, facilitates, and models problem solving, children work together in small groups to explore and solve mathematical ideas, and assessments which include and measure student performance.

Through developing these skills to problem solve and persevere in the classroom, students will be able to transfer these thinking processes to achieve better outcomes in everyday situations through creating solutions and asking questions (Larson & Miller, 2011). This supports the end goal of preparing students to become more successful citizens in college and their career. Therefore, it is up to the teachers to help facilitate this in the classroom through designing and selecting challenging and appropriate tasks, listening and observing students engaging in problem-solving, teaching and focusing on methods that are accessible for students to use to problem-solve, and creating a classroom community that is set up for exploring new ideas and sharing outcomes (Lester, 2013). The first step to problem solving is being able to make sense of the problem. Therefore, it would be important to understand number sense and how it develops in order to support problem-solving.

Number Sense

Number sense has been a crucial topic in mathematics education for many years because it is viewed as a key foundational skill for supporting more complex mathematics in higher grades (Aunio & Rasanen, 2016; Ball, Ferrini-Mundy, Kilpatrick, Milgram, Schmid, & Schaar, 2005; Kilpatrick, Swafford, & Findell, 2008; Mohamed & Johnny, 2010). Many researchers have studied this idea of number sense, all coming up with varying opinions and ways to define it. The most general way to define number sense is an understanding and application of mathematical relationships (Greenes, Schulman & Spungin, 1993). However, Ball et al. (2005) states that in order for teachers to teach mathematics effectively, they need to have a solid understanding of the material being taught. Therefore, I am going to take a deeper look at different ways number sense is described and studied, as well as, some methods for supporting number sense in the classroom.

A few researchers have described number sense as numerical estimation, believing that number sense and estimation are largely congruent (Kilpatrick, Swafford,

& Findell, 2008; Siegler, 2009). Siegler (2009) argues that estimation can happen without number sense, but number sense cannot happen without the ability to estimate. Furthermore, Kilpatrick et al. (2008) shares that when students use estimation before solving a problem it facilitates their number sense and understanding of place value. Estimation is a form of mental math in which students use reasoning and problem-solving to make sense of the problem they are solving. Through learning estimation techniques, students can decide if an operation makes sense for solving a problem and check if they are performing the operation correctly (Kilpatrick et al. 2008).

Other researchers believe number sense to be much larger than just estimation, but agree that estimation makes up one aspect of number sense. Number sense is defined by these researchers as a way of thinking flexibly about numbers, making connections between numbers, using numerical estimation, basic counting skills, understanding the value of numbers, and the ability to compose and decompose numbers fluently and efficiently (Ball et al. 2005; Dunphy, 2007; Kilpatrick, Swafford, & Findell, 2008; Mohamed & Johnny, 2010; National Mathematics Advisory Panel, 2008). The National Mathematics Advisory Panel (2008) states that formal instruction of place value, composing and decomposing numbers, the meaning of operations (addition, subtraction, multiplication, and division), and how to apply these principles to solve problems needs to take place in the classroom to build number sense. Number sense is important to explicitly teach in early grades because studies have shown that middle and high school students are lacking in number sense and the ability to solve complex problems related to number sense (Kilpatrick et al. 2008; Mohamed & Johnny, 2010; National Mathematics Advisory Panel, 2008). In fact, Mohamed and Johnny (2010) completed a study to investigate the relationship between student performance in number sense and mathematics achievement. The results from their study showed that despite students obtaining high scores on school exams, these students were still weak in number sense.

With the identified weaknesses in number sense, it is important to think about how educators are teaching number sense to students. Researchers suggest that educators lack a deep understanding of the fundamental mathematics they teach because they rely on the foundation in which they were taught mathematics, through procedures and algorithms (Ball et al. 2005; Faulkner, 2009). While algorithms can help students solve mathematical problems, they often have difficulty understanding how and why they work (Ball et al. 2005). Instead, educators need to promote proficiency with computational procedures, reasoning, problem-solving, identifying number relationships, operations, and estimation (Ball et al. 2005; Dunphy, 2007; Faulkner, 2009; Greenes et al. 1993; Kilpatrick et al. 2008; Mohamed & Johnny, 2010). Therefore, in order to support best practices for building students' number sense, educators need to deepen their understanding of the foundation of mathematics, as well as, instructional techniques. One way to do this is through examining mathematical discourse as an instructional tool for deepening number sense.

Mathematical Discourse

It is essential for current and future educators to understand how mathematical discourse can be used in the classroom, and the impacts it can have on student learning. Mathematical discourse is a discussion in which students share their ideas, reflect on their understanding, make sense of problems, and critique other's ideas, all within a collaborative and supportive learning environment as facilitated by the classroom teacher

(Kersaint, 2017). Using mathematical discourse can facilitate the development of mathematical thinking within children through purposeful and meaningful conversations (White, 2003). However, implementing mathematical discourse in the classroom can be difficult when there are some students who are eager to engage in classroom discussions, and others who will only wait to be called on or do not want to share at all. This could limit their ability to reach deeper-level understanding because they do not feel confident in the material being taught. Therefore, teachers should establish a classroom community, facilitate discussions that engage all students, and assess quality discourse (Stein, 2007).

Implementing practices that support classroom discourse is challenging for many teachers because it does not resemble their current understanding of mathematics instruction or the way they were instructed as students (Nathan & Knuth, 2003). White (2003) examined how two third-grade teachers used classroom discourse to teach mathematics in order to enhance student understanding of mathematics with diverse populations. Through observations, White (2003) identifies four types of classroom discourse that were used to promote mathematical understanding. These include: (a) valuing students' ideas, (b) exploring students' answers, (c) incorporating students' background knowledge, (d) encouraging student-student interactions. White found that the diverse students were able to creatively and resourcefully solve problems, and think critically through the facilitation of mathematical talk through mathematical discourse.

Mathematical discourse is described as a way to facilitate deeper thinking through open conversations and guiding questions. While this is one way to help students solve problems and deepen their understanding of number sense, Parrish (2014) also suggests introducing 'Number Talks' into classroom instruction as a way to support mathematical discourse, number sense, problem-solving, and mathematical content standards and practices. The next section will describe 'Number Talks' and the impacts it has had in the early childhood classroom.

'Number Talks'

Educators of mathematics often mimic the same teaching procedures that they were taught growing up (Fulkner, 2009; Lester 2013; Parrish, 2014; Schoenfeld, 2013). However, with the new deeper learning standards that focus on mathematical practices and preparing students for future success, we can no longer think of mathematics as we once did. This does not mean that the standard algorithms and procedures for solving mathematical equations are eliminated altogether. Instead, they should be taught only after students' mastery of number sense can support their understanding of the algorithms and procedures (Parrish, 2014). Educators can use 'Number Talks' to build number sense through mathematical discourse while supporting the development of mathematical practice standards and content standards (Parrish, 2014).

To begin, the process of 'Number Talks' should be defined. Parrish (2014) and Berger (2017) describe 'Number Talks' as classroom conversations ranging from 5-15 minutes around carefully designed computation problems to be solved mentally. These problems are crafted to elicit specific strategies and teach students about number relationships and theory. During 'Number Talks' students are gathered in a place away from their desk to limit the use of pencil and paper. Students look at a problem posed on the board and use mental strategies to find the solution. Once solved students use a 'quiet thumb' to show that they have used a strategy to form a solution. At this point, the teacher begins to call on students and record student strategies on the board no matter if they are right or wrong. This allows the opportunity for other students to clarify their thinking, test other strategies to see if they are mathematically logical, apply mathematical relationships, build a toolbox of efficient strategies, and make decisions about choosing efficient strategies. This is also the time that students must defend and justify their thinking. They can have a conversation about if they agree or disagree with another students' strategy (Berger, 2017; Parrish 2014).

The main goal of 'Number Talks' is to support students in becoming accurate, efficient, and flexible problem-solvers through mental math strategies. Parrish (2014) identifies five key components of 'Number Talks' including (a) building a classroom environment that helps students feel comfortable offering responses, questioning, and investigating, (b) classroom discussions to clarify thinking, investigate mathematical relationships, create a toolbox of efficient strategies, and test other strategies to see if they are efficient and mathematically logical, (c) teacher's role as a facilitator, (d) mental math, (e) purposeful computational problems (Parrish, 2014). It is critical to acknowledge that during 'Number Talks' the teacher is no longer directly teaching the students to solve problems. Instead, students take responsibility for their learning and the teacher acts only as a facilitator through mathematical discourse to encourage students to share their thinking. This means that the teacher is managing the conversations, recording students' thought processes, helping students make connections, and questioning to lead students to deepen their understanding.

Parrish (2014) suggests that through implementing 'Number Talks' students will gain a deeper understanding of place value, composition and decomposition of numbers, and understand how to apply properties of mathematics to solve problems. Berger (2017) shares a similar belief of ‘Number Talks’ while also recommending it as a fun and engaging way to build procedural fluency and mental calculation for all ages. To understand if ‘Number Talks’ increase student achievement and mental math abilities several researchers in their Master’s program completed studies involving ‘Number Talks’ in the classroom.

‘Number Talks’ in the early grades

Parrish (2014) and Berger (2017) both suggest that ‘Number Talks’ provide a way for students to take ownership of their learning thus finding their own solutions to solving problems, understanding multiple strategies, defending and justifying their reasoning, and resulting in a deeper understanding of number sense. So, Ruter (2015), a student completing her Master’s program, designed a study to determine if ‘Number Talks’ increased student achievement on critical thinking math tasks. The study took place in two second-grade classrooms in which one class was used as the experimental group and one as the control group through a quasi-experimental design. ‘Number Talks’ was implemented in the classroom two to three times a week for a four-week period, and data was analyzed from a pre-test and post test. The results indicated that the experimental group showed growth on two out of the four problems given. However, it was noted that the experimental group did better to explain their thought process and steps taken to solve the problem (Ruter, 2015). The information from this study supports that ‘Number Talks’ help students to engage in more meaningful mathematical discourse which deepens their understanding of mathematics and ability to explain their thinking.

Similar findings were achieved in a study by Johnson and Partlo (2014) in two fourth grade classrooms. Again, ‘Number Talks’ were completed every other day resulting in two to three days per week, with one class over a four-week time period, and the other over an eight-week period. A pre-test and post test consisting of five addition and five subtraction problems were used to analyze data. The results showed that the percentage of students answering questions correctly increased from the pre-test to the post test (Johnson and Partlo, 2014). The researchers also discovered the class that received 'Number Talks' for the eight-week period of time saw better gains than the class with only four weeks of the same instruction. The information from this study shows that the longer 'Number Talks' is implemented, the better potential for student growth.

The information from the researchers suggests that 'Number Talks' can have an impact on student achievement and mental math capabilities. However, there were limitations to their studies including interrupted instruction and lack of consistency due to winter breaks, and not only one researcher administering all instruction and assessments. Further research could be conducted to see what would happen if the instruction of 'Number Talks' was implemented during an uninterrupted time period in which it can be administered on a consistent daily basis. Will students have the same or better gains?

Summary

Based on the research, educators should implement 'Number Talks' to increase proficiency among students within problem-solving and perseverance in problem-solving. These classroom conversations would incorporate the use of mathematical discourse, mathematical practices, and content standards to increase students' understanding of number sense. This would support students' ability to become more flexible, fluent, and efficient problem-solvers, as well as, prepare them for success in the future.

SECTION THREE

Research Design and Method

Setting and Student Population

The purpose of this study is to investigate the effectiveness of incorporating 'Number Talks' in a second-grade classroom on increasing number sense through problem-solving skills and perseverance in solving problems. I developed an instructional inquiry project using a quasi-experimental design which will be described in this section.

The 'Number Talks' research study is being conducted in a Midwestern, rural elementary school within a self-contained second-grade classroom during the 2018-2019 school year. The school district contains one elementary, middle, and high school consisting of 1,604 students total. The demographic population of the school district includes 91.6% white, 3.6% multiracial, 3% Hispanic, 0.8% Asian, 8.9% students with disabilities, 1.3% English language learner, and 20.6% of students are economically disadvantaged. The elementary school consists of grades K-5 and includes 756 students. Each grade level consists of six classrooms which have a range of 18-25 students per room.

The participants in this study included 22 second-grade students. The students within my classroom are primarily White, with one African American, one Asian, and one Latino/English Language Learner. The school identifies two students within my classroom as gifted in reading and no students with learning disabilities. Of these students, 10 are boys and 12 are girls ranging in age from 7-8. The intervention group and comparison group comprised of five boys and six girls. It is important to note that their participation in the study was voluntary and written consent was provided by the families for participation.

Method

I used a quasi-experimental methodology, comparing the learning outcomes of two groups of students with a pre-post test design on measures of problem-solving, perseverance in solving problems, and 'Number Talks' activities. I randomly selected 11 participants to participate in the 'Number Talks' group, which was the intervention group. The participants completed the intervention of 'Number Talks' activities with me daily for four weeks, whereas the other 11 students in the class engaged in typical problem-solving lessons that included: whole class instruction and small group math stations relating to the current math standard.

Within the small group math stations, students routinely solved problems that required number sense, perseverance in solving problems, and mathematical reasoning. These stations included math games related to the current standard for learning, an independent practice worksheet connected to the learning standard, math fact fluency practice using flash cards with a partner, and completing a technology lesson using the i-Ready curriculum.

The comparison group received 15 minutes of 'Number Talks' instruction as well as time to complete the math stations. 'Number Talks' are an instructional technique that incorporates daily conversations and discussions, in which students share their thinking and agree or disagree in a whole group setting, around purposefully crafted computation problems that assist students with developing efficient, flexible, and accurate computation strategies (Parrish, 2014). For example, counting on/counting back, making ten, finding friendly/landmark numbers, and using place value to mentally build an understanding of number sense and problem solving.

Procedure

First, I administered a pre-test, which comprised two traditional computational problems and two word problems that reflected number sense concepts. Next, I implemented the 'Number Talks' intervention with my comparison group for a duration of three weeks. During the intervention phase of the study, I implemented a 'Number Talks' curriculum comprising the following strategies: using conversations and scaffolded discussions to explore doubles/near-doubles, making tens, making landmark or friendly numbers, and breaking each number into its place value. Each of these mathematical concepts reflect the Ohio Learning Standards in Mathematics and number sense in grade two. During this time, students also completed a written reflection log once a week to reflect on strategies used and learned during 'Number Talks'. At the end of the intervention period, I administered a post-test made up of similar questions related to the pre-assessment.

Data collection

As described in the procedures, several measures were gathered for data collection. The measures included a pre-test of number sense and problem-solving, perseverance tally chart, student learning reflections, and a post test of number sense and problem-solving.

Pre-test of number sense and problem-solving. At the beginning of the study, a pre-test (Appendix A) was administered to all participants to determine a baseline of problem-solving accuracy and the ability to explain mathematical thinking with reasons.

The pre-test consisted of four questions including two traditional computational problems and two word problems. These problems were modeled after problems found within *Number Talks Whole Number Computation* (Parrish, 2010) including specific strategies such as doubles/near doubles, making tens, making landmark or friendly numbers, and breaking numbers into their place value. Participants were asked to solve the following problems using as many strategies that they could think of and to write to explain their thinking with reasons. Each problem was scored using a three-point rubric.

Post test of number sense and problem-solving. At the end of the three-week intervention, all participants took a post test (Appendix E). Like the pre-test, the post test consisted of four questions including two traditional computational problems and two word problems. These problems were modeled after problems found within *Number Talks Whole Number Computation* (Parrish, 2010) including specific strategies such as doubles/near doubles, making tens, making landmark or friendly numbers, and breaking numbers into their place value. Participants were asked to solve the following problems using as many strategies that they could think of and to write to explain their thinking with reasons. Each problem was scored using a three-point rubric.

The problem-solving skills rubric (Appendix B) was created to score the pre-test and post-test on a three-point scale. One point was earned for accurately solving the problem, a second for accurately solving the problem and explaining their thinking or accurately solving the problem using multiple strategies, and a third for accurately solving the problem using multiple strategies and explaining their thinking. The purpose of the rubric was to identify accuracy in solving problems, the ability to use one or multiple strategies, and the ability to explain their thinking with reasons. Additionally, student responses on the pre- and post test were evaluated for the quality of their explanation with reasoning, the identification of specific problem-solving strategies, and the use of academic language in mathematics.

Perseverance tally chart. A daily perseverance tally chart (Appendix C) reported the number of strategies participants identified to solve a given problem. Perseverance was identified as continuing to work through a problem and finding multiple ways for problem solving to reach accuracy. Perseverance is a crucial element of problem solving because a student's persistence is what helps them to remain with a task and use multiple strategies to continue to work through a problem which leads to success (Laursen, 2005; Scherer and Gustaffson, 2015; White, Prager, Schaefer, Kross, Duckworth, & Carlson, 2017).

Student learning reflections. Participants completed learning reflections (Appendix D) weekly, a total of three times, to demonstrate their abilities to explain their mathematical thinking in writing. These reflections were evaluated for the quality of their explanation with reasoning, the identification of specific problem-solving strategies, and the use of academic language in mathematics.

Data analysis

After collecting all the data, I used spreadsheets to organize my numerical data, and grouped the written reflections by student in order to be able to see any growth in the quality of written reflections over time. The pre- post test were scored using the three-point rubric for each problem. The scores for each question and total score were added to an Excel spreadsheet for all participants. The average scores for each question and the total scores were calculated and recorded within the Excel spreadsheet. Tests of significance with a paired sample and independent sample t-test using scores from the pre- and post test ($p<.05$ indicating significance) were conducted.

A perseverance tally chart was used to keep track of the frequency counts of the total number of strategies students knew for solving a problem. These tallies were added to a spreadsheet to keep track of frequency, for example if strategies known for solving a problem increases over time.

Finally, written reflections were examined for the quality of their explanation with reasoning, the identification of specific problem-solving strategies, and the use of academic language in mathematics. I analyzed each reflection, a total of three per student, and recorded the data in a spreadsheet.

SECTION FOUR

Results and Analysis

The data and results of pre-tests, post tests, student reflections, and perseverance tally chart make up the extent of this section. This section is organized around the two research questions which guided the work of this study:

1. What effect does a 'Number Talks' intervention have on second grade students' problem-solving accuracy and abilities to explain their thinking with reasons?
2. Does a 'Number Talks' intervention support students' perseverance in solving problems?

This section examines the ability for students to accurately solve problems using explanations with reasoning and perseverance.

Effect of 'Number Talks' on Accuracy and Explanations

After scoring the pre-test and post test based on the problem-solving skills rubric (Appendix B), I calculated the mean pre- and post test scores for both intervention and control groups. Table 1 indicated the results of the mean scores for the pre- and post tests for both groups of students.

Table 1

Average scores from pre- and post tests by group

Group	Pre-test average	Post test average
Intervention Group	6	7.5
Control Group	8.3	9.2

I conducted a paired sample t-test on the means of the pre and post test scores of the intervention group. In order for the results to show significance the t statistic should be 2.262 or above. The results indicated a lack of significance with t (10) = 0.057. Additionally, I conducted a paired sample t-test on the mean scores of the post test results between the intervention group and control group. Again, the results indicated a lack of significance between the results with t (10) = 0.18. These results suggest that the 'Number Talks' intervention did not influence the outcome of accuracy and explanations.

Parrish (2014) argued 'Number Talks' provide a way for students to take ownership of their learning through finding their own solutions to solving problems, understanding multiple strategies, defending and justifying their reasoning, and resulting in a deeper understanding of number sense. While the results from my study do not show a significant increase in student growth to support Parrish's argument, Johnson and Partlo (2014) did a similar study with a different outcome. One key finding from Johnson and Partlo (2014) was that there were more student gains when the intervention was implemented in a classroom for an eight-week time period vs. a four-week time period. Likewise, 'Number Talks' is a discussion-based method of learning, and theories of how learners use discussion would suggest the timeframe for the process may take more than several weeks (Johnson and Partlo, 2014; Parrish, 2014). Thus, suggesting that the duration of the intervention could have impacted the outcome of the results.

To further my analysis, I disaggregated the intervention group's assessment data by individual student to understand the impact of the intervention on individual cases. One particular case is Eric (pseudonym). Table 2 shows Eric's rubric scores for each question item at the pre-post test time frames.

Table 2

Pre- and post test results by question

	Pretest					Post test				
	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4	Total
Eric	2	1	0	0	3	3	0	2	2	7

The results indicate that on the pre-test, Eric incorrectly answered two of the questions (Q3 and Q4), correctly answered two of the questions (Q1 and Q2), and used multiple strategies for one question (Q1). However, Eric did not write to justify or explain his thinking for any of the questions on the pre-test. On the post test, Eric decreased the number of incorrect responses, and increased the use of multiple strategies and writing to explain his reasoning. For example, on question 1 (50+50) Eric wrote, "I know that 50 is the same as 5 but has 5 tens so if I know 5+5 is 10 that makes 50+50=100". The results in Eric's case suggest that while overall the 'Number Talks' intervention did not have a significant impact on student learning for the whole group, the intervention did prove to be successful with this particular case. This could be because throughout the intervention Eric practiced writing to explain his thinking on a weekly reflection which in turn helped him to solve more problems accurately and justify his thinking. Likewise, Ruter (2015) discovered in a similar study that the participants in her experimental group gave better explanations on the post test even if the answer was inaccurate.

Written Responses and Mathematical Discourse

Parrish (2014) suggested that daily classroom 'Number Talks' help build number sense through mathematical discourse. Parrish (2014) also described that students will gain a deeper understanding of mental math strategies and be able to explain their thinking with their classmates through mathematical discourse as facilitated by the teacher. As part of my study, I wanted to examine if ‘Number Talks’ did indeed support students in explaining their mathematical thinking with strategies and reasons. A strategy, again, is an explicit reference to a mathematical tool and a reason is often a broader set of words that support a claim. So, when a student writes, for example, 'I made a ten and counted on because 6 and 4 is 10 + 3 more = 13,’ the words ‘made a ten’ suggest a specific strategy and the rest is the reason to support their claim.

On the pre-test and post test (Appendix A and E) students were instructed to explain their thinking for each of the four problems. Additionally, students in the intervention group completed a weekly reflection log (Appendix D) to explain their thinking on one ‘Number Talks’ lesson each week. I analyzed all the results from the reflections, looking closely for patterns in the way students explained with reasons, named specific strategies, or used other academic language.

Table 3 (continued)

Pre- and Post test written response scores

	Pre-test			Post test		
Pseudonyms	Reasons	Name of strategy	Other academic language	Reasons	Name of strategy	Other academic language
Eric	0	0	0	4	1	0
John	4	0	0	4	1	0
Jennifer	4	0	2	4	0	3
Cam	1	3	0	4	0	0
Todd	0	0	0	4	0	0
Kelly	4	0	2	3	2	0
Ruth	4	4	0	1	3	0
Carson	0	0	4	0	0	0
Cindy	4	2	0	1	3	0
Kristine	1	0	0	2	1	0
Anna	4	0	0	4	0	0

I noticed in eight out of the 11 students in the 'Number Talks' intervention seemed to support the use of mathematical discourse to explain their thinking. A particular case involves Cam (pseudonym). On the pre-test Cam only correctly explained his thinking with reasons on one out of the four questions. On the other three questions Cam named a specific strategy ("base ten blocks", "number line") but did not explain why this strategy would work for this particular problem. By the end of the invention, on the post test, Cam was able to successfully explain his thinking with reasons for each of the four problems, even if his answer was inaccurate. For example, on question 1 (50+50) Cam wrote, "because five+five = 10 and 0+0=0 so 50+50=100".

Another case similar to Cam is Eric. Eric did not complete any of the writing to explain his thinking or describe strategies used. Throughout the intervention on the written reflections, Eric was able to either explain with reasons, or name strategy that was used or learned. For example, on question 4 (35+26), Eric wrote, "I saw 35 and 26 so I added the 5 and 6 to get 11 and the 3 and 2 to get 5 the 5 is 5 tens so 50+11=61". By the end of the intervention, on the post test, Eric explained with reasons for each of the four problems and named one strategy that was used for solving.

These data suggest that the 'Number Talks' intervention is one that can be used to build students' ability to express themselves, explain their thinking, and describe specific mental math strategies used. These case study results line up with previous studies. Rueter (2015), for instance, completed a similar study in which she also noticed that students participating in the 'Number Talks' did better to explain their thinking and grew their ability to use mathematical discourse to deepen their understanding. Thus, the use of mathematical discourse and reflection logs for written responses has the potential to help improve students' ability to elaborate and justify their problem-solving with reasons.

Perseverance

Schwartz (2006) defined perseverance as sticking with a problem longer and continuing to try multiple strategies even when faced with obstacles. For this purpose, I decided to measure perseverance by tracking the number of strategies students used to solve a problem. A tally chart organized the data (see table 4) into a table with frequency counts of the number of strategies used by the student.

Table 4 (Continued)

Perseverance tally chart totals for number of strategies used

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Cam	1	0	1	1	0	0	0	1	0	1	1	0	0
Jennifer	1	2	2	2	2	2	1	1	1	2	2	2	1
Kristine	1	1	2	2	2	1	1	1	2	2	x	x	1
Anna	1	1	1	1	1	2	1	1	1	1	1	1	2
Carson	1	0	1	1	0	0	1	1	0	0	1	x	x
John	1	1	2	2	2	1	2	2	2	2	1	1	2
Kelly	2	2	3	2	3	2	1	2	2	2	2	2	2
Todd	1	1	2	2	2	1	2	2	2	3	2	2	2
Eric	0	1	1	1	2	2	1	1	1	1	1	1	1
Cindy	1	1	2	2	2	1	1	1	2	2	2	2	2
Ruth	2	2	2	2	2	1	2	2	2	3	2	2	3

Note. x = student was absent

I used this method for tracking perseverance because I predicted that with daily 'Number Talks' students would be able to think of more strategies by the end of the study. Therefore, I would see a trend of increasing number of strategies on the tally chart to indicate students persevering when solving problems. However, results concluded that no significant changes occurred among any particular students. Some consistently used one strategy to solve problems while others fluctuated between one and three strategies dependent on the problem given to solve. These data do not indicate that these students made growth in using multiple strategies from the beginning of the intervention to the end of the intervention. The result of the frequency counts for strategies used to solve problems, at least in the length of the time of the intervention, indicates 'Number Talks' does not influence mathematical perseverance; alternatively, perseverance may need to be quantified in other ways. Schwartz (2005) quoted Einstein stating, "It's not that I'm so smart. It's just that I stay with problems longer" (p. 51), therefore, perseverance could be measured through extent of explanatory writing (word count) in future studies from collected writing samples.

Taken together, the results here suggest that while the 'Number Talks' intervention was not a factor in effecting students' abilities to problem-solve and persevere in problem-solving. However, some individual cases did show positive outcomes particularly with students' ability to elaborate their thinking in writing. Equally important, data from the perseverance tally chart did not prove or disprove students' ability to persevere in solving problems. Therefore, these inconclusive results suggest that further research would need to be completed to better answer the research questions.

SECTION FIVE

Discussion and Conclusion

The aim of this study was to determine the effectiveness of using a 'Number Talks' intervention on increasing second grade students' ability to use number sense to problem solve and persevere in solving problems. The research questions that guided this study were:

1. What effect does a 'Number Talks' intervention have on second grade students' problem-solving accuracy and abilities to explain their thinking with reasons?
2. Does a 'Number Talks' intervention support students' perseverance in solving problems?

The results from this study suggested that the 'Number Talks' intervention did not significantly impact students' problem-solving abilities or perseverance in problem-solving through identifying more than one strategy to solve problems. However, there were some individual cases where students made improvements with using more strategies to solve problems and demonstrated this in the quality of their written responses and explanations of their reasoning. The individual cases indicated that the 'Number Talks' could have had a positive impact on student growth in accuracy and explanations. Together these data suggest the results from this study could be found inconclusive and that further research needs to be completed.

Additionally, results from the perseverance tally chart implied that tracking the number of strategies used to solve a problem during the 'Number Talks' intervention might not have been the best method for measuring perseverance among second-grade students. Instead, I found that perseverance might possibly be measured through tracking student written responses for word count and quality of explanations (e.g., giving two reasons). While this research does not support ‘Number Talks’ as an effective intervention for influencing problem-solving skills or perseverance in solving problems, some limitations from the study could explain these outcomes.

Limitations

There are several possible limitations that could have impacted the results of this study, including the duration of the intervention and the measurement of the outcomes via the problem-solving skills rubric. The first limitation, duration of the intervention, reduced the intervention phase from, an originally planned, 20 days to 12 days due to the several “snow days,” teacher sick days, and holidays. It is difficult to predict whether 20 days would have been better for the outcomes, but the trends in the written explanations, elaborated and accurate, on the reflections throughout the treatment suggest ‘Number Talks’ influenced the quality of students’ mathematical explanations in just 12 days. Perhaps, then, the intervention had started to influence the students’ approaches to problem-solving. Research conducted by Johnson and Partlo (2014) affirms this speculation, suggesting that a longer period of eight weeks of ‘Number Talks’ implementation, in their study, showed effects on student outcomes.

Another possible limitation is an issue with measurement with the problem-solving skills rubric (Appendix B). This rubric was not designed to take into account the possibilities of tracking growth in student writing. The rubric measured a combination of accuracy, number of strategies, and explanations. I did not think I would need to separate the score for the writing because originally, I was trying to look at the whole outcome of the problem (accuracy, strategies, and writing), not each individually. A rubric that scores accuracy and explanations separately could have provided different results or outcomes.

As discussed in the previous section, tracking perseverance by recording the number of strategies students used to solve problems may not have been the only way to understand students' levels of perseverance. Collection of more explanatory writing, using word count and quality of writing, could also index perseverance in problem-solving. Closer examination of the writing about problem-solving could have led to identifying positive growth results in perseverance among the students participating in the intervention. Indeed, the results of the current study showed many of the participants in the intervention group explained their thinking with more details in their writing, suggesting they spent more time thinking about or persevering with the problems they solved than they did at the beginning of the study. The number of questions provided on the pre- and post test could have impacted data analysis, too. When looking at the results, the disaggregated data showed more positive effects than the aggregated data. If there were more questions for the students to answer, the disaggregated data could have provided even more meaningful results. For example, more questions would provide the students additional opportunities to show growth, success, or lack thereof, and provide deeper analysis of different trends within the question sets.

Next Steps

Through my observations of the 'Number Talks' intervention and understanding the varying range of students' abilities, it might also be interesting to create more differentiated 'Number Talks' groups to see how lower students respond to 'Number Talks' that are more at their learning level. Additionally, I would continue to implement more written reflections for explaining mathematical problem-solving. In future research studies on ‘Number Talks’ it would be beneficial to increase the amount of time the intervention is implemented as this could have a greater impact on student learning outcomes.

As a result of this study, further research studies should increase the length of time the intervention is implemented and possibly differentiate ‘Number Talks’ groups. A future research study using a quasi-experimental design could be implemented to compare how ‘Number Talks’ effects lower achieving students vs. on level or higher achieving students on problem-solving over an eight-week period. Differentiated ‘Number Talks’ would be used, and student progress could be tracked through written reflections and multiple assessments (pre-, mid, and post) with a larger number of questions.

In the end, I learned that ‘Number Talks’ could still be beneficial for improving number sense and problem solving among students in my classroom, but it might take longer than three weeks to notice positive results. The study influenced my teaching to incorporate more use of mathematical discourse and written reflections because of the improvements I saw in the quality of writing. The study supported students in learning to communicate their mathematical thinking with their peers and in writing thus supporting their ability to problem-solve.

I would like to share the information from this study with my colleagues, so they can better understand how ‘Number Talks’ works as an intervention in their classroom. I will also share my findings from the student reflection logs because those were not originally part of the ‘Number Talks’ intervention. However, I found that they made a positive impact on many of the students’ explanatory writing within the intervention group.

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Appendix A
Pre-Test

Pre-Test

Name: _______________ Date: ____________

Solve the problems. Include your strategies. Explain your thinking.

1. 35 + 35

____

____

2. 8 + 2 + 3

____

____

3. Joey baked 29 cookies for the bake sale. Sarah baked 13 cookies for the bake sale. How many cookies did they bake all together for the bake sale?

____

____

4. Kate collected 12 seashells at the beach. Her brother collected 19 seashells. How many did they collect combined?

____

____

Appendix B

Problem-Solving Rubric

Problem Solving Rubric

0 points	1 point	2 points	3 points
Incorrectly solves the problem.	Accurately solves the problem using one strategy but does not explain their thinking with reasoning.	Accurately solves the problem using one strategy AND explains thinking with reasoning. OR Accurately solves the problem using multiple strategies but does not explain with reasoning.	Accurately solves the problem using multiple strategies AND explains thinking with reasoning.

Appendix C

Perseverance Tally Chart

Perseverance Tally Chart

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**
Cam						
Jennifer						
Kristine						
Anna						
Carson						
John						
Kelly						
Todd						
Eric						
Cindy						
Ruth						

	Day 7	**Day 8**	**Day 9**	**Day 10**	**Day 11**	**Day 12**
Cam						
Jennifer						
Kristine						
Anna						
Carson						
John						
Kelly						
Todd						
Eric						
Cindy						
Ruth						

Appendix D

Student Written Reflection

Student Written Reflection

Name:___________________ Date: _______

Did you get the answer correct? YES NO

Explain how you solved the problem. Include strategies used.

____

____

____

Did you learn a new way to solve the problem? Explain the new strategy you learned.

____

____

____

Appendix E

Post Test

Post-Test

Name: _______________ Date: ____________

Solve the problems. Include your strategies. Explain your thinking.

1. 50 + 50

____

____

2. 2 + 6 + 8 + 3 + 4

____

____

3. Mary baked 18 cupcakes for a friend's party. Molly also baked 15 cupcakes for the friend's party. How many cupcakes did they bake altogether?J

____

____

4. Jack counted 35 books in his bedroom. He counted 26 more books in his brother's bedroom. How many books did he count in all?

____

____