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Abstract

This action research study examines the effects of using number talks instruction in the second grade classroom on number sense/critical thinking in mathematics. The sample included 47 students from two second grade classes in two suburban public elementary schools serving mostly upper middle class neighborhoods. For four weeks in the middle of the second trimester, an experimental group was exposed to the teaching of math through number talks, in addition to their regular math instruction. A control group was instructed using their regular methods and curriculum. Both groups were given a pretest and posttest of “rich math tasks.” Comparison data showed that there was not a significant difference found between the experimental group and the control group.

Jo Boaler et al. (2014), well known mathematician and Professor of Mathematics Education at Stanford University, recently wrote an article on the importance of number sense. In that article, she states:

> number sense is the foundation for all higher-level mathematics (Feikes & Schwingendorf, 2008). When students fail algebra it is often because they don't have number sense. When students work on rich mathematics problems… they develop number sense and they also learn and can remember math facts (p. 2).

Number sense has long been an important part of learning math at all ages, and with the implementation of the Common Core State Standards, the bar has been raised for schools. The first Standard of Math Practice states that students will make sense of different math problems while persevering in solving them. It can be argued that without a solid grasp on number sense, students will be unable to achieve this standard. Similarly, in order to be marked proficient in math in second grade, students must be able to add and subtract fluently within 100. While solving problems, students should be able to use strategies based on place value, properties of operations, and the relationship between addition and subtraction. Here again, one can see the importance of number sense. Without number sense, students will not be able to use numbers fluently, especially in the way that some researchers describes fluency. According to Parish (2014), fluency is the ability to know how a number can be composed, decomposed, and then using the information to use numbers flexibly and efficiently.

One way to increase student number sense is through number talks (Boaler, 2013, p.5). Number talks consist of putting a math problem on the board, having students solve it, and then having them explain their strategy for solving the problem. Many students are able to solve math problems, but are unable to make meaning of them, or explain how they solved them. In number talks, students are asked to clearly communicate their thinking and justify their process. Number talks therefore lead students to develop strategies which are more efficient, accurate, and flexible (Parish, 2011).

Purpose of the study

The purpose of this study, therefore, is to determine if number talks have a positive effect on second grade students' number sense and their ability to think critically. The study researched the following questions

1) After implementing number talks two to three times per week, is there an increase in students' ability to answer "rich math tasks?"

Definitions

For clearer understanding of the terms used in this study, below are their meanings.

Number Sense- refers to a student's ability to make sense of what numbers mean, understand their relationship to one another, perform mental math, understands symbolic representations, and use numbers in real world situations.

Number Talks – a teaching strategy where the teacher poses a math problem, allowing students to formulate an answer. Students share their answers and explain to the class how they came to that answer.

Math Fluency- refers to a student's ability to use numbers efficiently, accurately, and flexibly. Often this refers to their ability to quickly recall the answers to basic math facts.

Critical Thinking- a way of thinking in which the thinker improves the quality of their thinking by analyzing, assessing, and reconstructing their thinking. It is self-directed, self-disciplined, and self-corrective.

Literature Review

Number Sense often refers to a student's flexibility with numbers. If a student has good number sense, they have a good sense of what numbers mean, can understand how numbers relate to each other, and is able to perform mental math. Students with good number sense understand the symbolic representation of numbers and are able to apply those numbers and symbols in real-world situations. The National Council of Teachers of Mathematics in 1989 identified five components of number sense: number meaning, number relationships, number magnitude, operations involving numbers and referents for number, and referents for numbers and quantities.

Number talks were developed by Sherry Parish (2014) after she observed many students who thought of "mathematics as rules and procedures to memorize without understanding the numerical relationships that provide the foundation for these rules" (p. 4). Parish (2014) also observed adults who treat mathematics in the same way. Number talks are math problems presented to students. The students are given time to come up with an answer, and after all children signal (using a thumbs up next to their chest) that they have an answer, the teacher asks for students to share their answer. After the teacher has collected the answers, he/she will ask for students to defend their answers. Students must then explain the process they used to find out the answer to the math problem. The teacher scribes the student's process and asks clarifying questions but does not do any instructing if the student is wrong. The teacher calls on several students to defend their answers. For students who have incorrect answers, the hope is that while they are explaining their answer, they will catch their mistakes. If this does not happen, the teacher can ask for other opinions on the answer/process. The goal is at the end all students will have “revised” their thinking and understand how to get to the correct answer. The purpose of this study is to determine if number talks had a positive effect on second grade students’ number sense and ability to think critically.

Number sense is developed at a young age, and understanding can be established before students begin kindergarten. In a 2011 study by Sood and Jitendra, the effects of number sense intervention on the number-sense related outcomes of kindergarten students were studied. This included students who were at risk for math difficulties. Researchers studied the effects of number-sense intervention on the retention of number-sense-related outcomes three weeks following the end of the intervention, with both students at risk for math difficulties as well as students who were not at risk. It was hypothesized that instruction in number sense would improve the learning of kindergarten students. The study was conducted over four weeks in the northeastern United States, in a suburban elementary school. The study participants included all kindergarteners from five classes within the school, and the participants were randomly assigned to either the number sense instruction or the control group. At the end of the study, the results showed that the experimental group outperformed the control group in all number-sense-related measures. The effect sizes that compared the intervention group with the control group were medium to large (0.55 for spatial relationships, 1.14 for more and less relationships, 0.87 for five and ten benchmarks, and 0.68 for nonverbal calculations). Additionally, the results were maintained three weeks after the intervention took place (0.68 for spatial relationships, 0.59 for more and less relationships, 1.20 for five and ten benchmarks, and 0.73 for nonverbal calculations). The results of the study were found to be consistent with the hypothesis. Intentional instruction can increase students' number sense for kindergartners.

Number sense plays a role in the growth trajectories of young elementary aged students. Salaschek, Souvingnier, and Zeuch (2014) used latent growth curve models to determine if growth in first grade differs significantly between individuals. Next, data-derived trajectory groups were made, and it was expected that researchers would find mostly cumulative growth patterns within the groups. Then, they analyzed whether related trajectory groups could also be found for specific competences. Lastly, researchers were interested in the stability of trajectory groups, whether students belonged in similarly characterized groups across the competences. The study consisted of 153 first-grade students in eight classes from six schools. The schools were found in urban and rural Germany. The classes completed short math assessments every three weeks from November to May. The assessment tested nine types of tasks in three competences, basic precursors, advanced precursors, and computation competences. The study mostly confirmed what researchers were hypothesizing, that is, mostly cumulative overall growth patterns were found. Performance at the beginning of the study predicted growth throughout the school year for students. Students displayed higher performance on the seventh overall assessment than they did on the first assessment (Salaschek, Souvingnier, and Zeuch, 2014).

Number sense can also play a predictive role in students' ability across the intermediate grades to solve word problems. Researchers pursued the development of word problem solving in the intermediate grades in a 2012 study by Cirino, Hamlett, Fletcher, Fuchs, Fuchs, and Tolar. The researchers stated that solving word problems is complex, since it requires that students read and understand written material that expresses numerical relations. The study evaluated growth models for both low and high complexity word problems from the beginning of third grade through the end of fifth grade. Researchers hypothesized that in third grade, there were several predictors of performance on word problem solving skills. These predictors were computation, language, nonverbal reasoning, and attentive behavior. They hypothesized that computation is the limiting factor for lower complexity problems, whereas nonverbal reasoning is the limiting factor for high complexity problems. A similar pattern of predictors was made for growth; however the limiting factor for growth on low complexity problems was predicted as attention behavior. Nonverbal reasoning was predicted as more likely to be related to growth in high complexity problems. The sample for the study was 261 randomly assigned students from 42 third-grade classes. These students were split into four different cohorts. These cohorts were followed from third through fifth grade. Students were screened using the Test of Computation Fluency in August of third grade. They were then assessed on the Word-Problem Battery (Fuchs et al., 2003) in September and April of third grade, and in March in fourth and fifth grades. Results suggested that the four constructs were distinct and each of them is moderately related to word problem solving. The results also showed that computation was more closely correlated to low-complexity word problems, and language was closely correlated to high complexity word problems. Both language and attentive behavior were moderately predictive of performance at the end of fifth grade. The researchers' hypotheses were only partially supported in the results of this study. For low complexity problems, attentive behavior was not related to initial word problem solving, while computation, language, and nonverbal reasoning were related to initial word problem solving. Neither computation nor nonverbal reasoning was related to initial word problem solving for high complexity problems. As hypothesized, computation did have the strongest effect on initial low complexity problems, but counter to the hypothesis, language and attentive behavior were the strongest predictors of initial high complexity problems.

Teacher knowledge and understanding of number sense impacts student understanding of number sense. Tsao and Lin (2012) investigated the understanding of elementary teachers in Taiwan with respect to the significance and importance of number sense, the strategies to involve number sense in the instruction and the children's number sense development. The researchers believed that although number sense is something that is often spoken about in education, it is rarely focused on in teacher practice research. This study was conducted using qualitative research with small numbers of samples and in-depth interviews. Researchers interviewed nine subjects who taught sixth grade. The interview consisted of questioning teachers in order to understand the participant teachers' number sense, how their understanding of number sense affected their teaching and their knowledge of children's number sense development. It was found that not many of the teachers had heard the term "number sense." Most of the teachers also believed that building students' basic math concept was the most essential piece of building student number sense. Many of the teachers thought that good arithmetic ability and abstract thinking ability could develop children's number sense. According to the study, "number sense" is a math concept that is very valued in education today. However, many teachers may not have developed their own number sense and are not aware of how it may affect their students' number sense growth.

Cognitive styles impact individuals' achievement in understanding number sense. Chrysostomou, Pantazi, Tsingi, Cleanthous, and Christou (2013) conducted a study in which they examined the effect of students' cognitive styles on achievement in number sense and algebraic reasoning tasks and on strategies adopted for solving these tasks. This study examined the relationship between spatial imagery, object imagery, and verbal cognitive styles with number sense and algebraic reasoning. The participants in this study consisted of 83 prospective elementary teachers, all of whom had taken mathematics classes during their lower and upper secondary education. At the university level, all of the participants had taken the same four math classes, Foundations and Fundamental Concepts of Mathematics I and II, Statistical Methods, and Mathematics Education. The participants were asked to complete a mathematics test in 50 minutes and then self-report on a cognitive style questionnaire. Researchers discovered that only spatial imagery is a statistically significant predictor of prospective teachers' total achievement in number sense and algebraic reasoning and achievement in the subcategories. As the participants spatial imagery increased, their total achievement and achievement in every subcategory increased. Overall, the results showed that spatial imagery was the only significant predictor of prospective teachers' achievement in number sense and algebraic reasoning. It is important for teachers to explicitly teach number sense to students of all ages.

According to a study conducted by Stella and Fleming (2011), there is great concern about mathematics understanding in students attending schools with high levels of poverty. Researchers explicitly taught number sense skills to students in order to increase their comprehension of mathematics. Researchers asked how teachers could make number sense clear and accessible to their students. The participants were chosen from a Title I urban elementary school, enrollment of 350 attended, with about 95% of students receiving free or reduced lunch. The study subjects were 26 at-risk fifth-grade students, fifteen males and eleven females. Thirteen of the students were English Language Learners, and all of them qualified for free and reduced lunch. Students took a pre and post -test assessment at the beginning and end of the first six weeks of school. Students then took another pre-assessment at the beginning of the second six weeks of school. All 26 students were then given the treatment, daily explicit place value practice, a twenty minute structured number sense lesson each day, and lastly a place value activity to work with place value through the hundredths place. At the conclusion of the study, it was found that the overall class average improved by 3.57 points. While students did make gains in mathematic comprehension, the gains were not statistically significant.

Language matters in the elementary classroom. In a study done by Boonen, Kolkman, and Kroesbergen (2011), researchers investigated the impact and role of teachers' mathematical language input on kindergarteners' number sense acquisition. The study focused on the variations of math talk provided by the teacher and how the math talk impacted the growth of early mathematical skills. The study was conducted over one school year, and it was hypothesized that there would be a relation between teachers' math talk and the students' number sense scores at the end of the study. The sample consisted of 251 Dutch kindergartners (125 boys and 126 girls), selected from 15 middle class elementary schools. Participating students were asked to complete eight tasks, and teachers were videotaped for two consecutive hours on a single morning in their classrooms to produce the measures in the study. The results of this study supported the hypothesis, as there was a relation between teachers' math talk and children's number sense scores at the end of the school year; particularly the students' counting skills. However, the results of the study indicated that the role of math talk was not as straightforward as was hypothesized. While there was a positive impact between math talk and cardinality and conventional nominatives, there was a negative correlation between calculation and number symbols. The results suggested that teachers should be careful and selective with the amount of math talk they offer to young students.

In some schools, formalisms are often taught before students have mastered number sense. Nathan (2012) questions this belief in a study on how to rethink the formalisms, which he defines as specialized representations such as symbolic equations or diagrams with no inherent meaning except that which is established in convention. Nathan (2012) claims that formalisms first view exercises significant influence on formal education, he believes this view is misguided. In this study, it is suggested that formalisms are introduced too early in the development of learners' conceptual understanding, possibly encouraging a "formalisms-only" mind-set towards instruction and learning. Nathan admits that there are some ways that a formalisms-first mindset is effective, since it is convenient for students (and teachers) to have a formal way for using symbols or equations to get an answer. However, Nathan stands by his claim that learning is much more meaningful when students understand the theory and meaning behind the equations. It is important for learners to understand the flexibility of mathematics before they can fully understand the reasons for the equations, or formalisms.

An increase in number sense can increase individuals' math fact fluency. Boaler (2014) unpacks the impact of number sense on math fact fluency. According to Boaler,

> Many classrooms focus on math facts in unproductive ways, giving students the impression that math facts are the essence of mathematics, and even worse that the fast recall of math facts is what it means to be a strong mathematics student." (p. 1)

When students simply memorize the answers to math facts, they often do so without using number sense, which leads to mistakes being made. Memorizing math facts can lead to students suffering in two ways. Timed math fact testing is the beginning of math anxiety for about one-third of students (Boaler, 2014). This math anxiety causes a block in student's brains, not allowing them to access the facts they have memorized. When students can't access the memorized facts, their anxiety heightens, and confidence in their math skills decreases. The new Common Core standards in American education have a large emphasis on fluency within math facts. According to Boaler, students grasp fluency after developing number sense, when they are confident in their math skills because they understand numbers. Once students have a good understanding of number sense, math fluency is going to develop and grow as well.

Intentional practice in number sense strategies have also been effective with adults. Park and Brannon (2014), proposed that nonverbal numerical quantity manipulation is a key factor that improves the link between primitive number sense and symbolic arithmetic competence. In the experiment, researchers used multiple (five) training sessions aimed at isolating and improving the cognitive components of non-symbolic arithmetic tasks. Study participants included 88 individuals between the ages of 18 and 34, all recruited from the Duke University community. Prior to the training sessions, participants were given a pretest. Over a two-week period, participants were trained on six different sessions. The end of each session was followed by a posttest session. When the experiment concluded, researchers found that the six training sessions had improved participant performance on each of the five training tasks. Overall, this study proved that providing adults with training sessions on approximate arithmetic improved exact symbolic arithmetic.

There are many ways for teachers to help their students develop number sense in the classroom. In the article "What is a Reasonable Answer?" Tracy Muir (2012) examines frameworks for helping students develop number sense. Muir argues that number sense is important for students in understanding when their answer is reasonable. A solid understanding of number sense may help students make comparisons, interpret data, and make estimates. Muir (2012) gives many activity suggestions to help teachers gain an understanding of their students' number sense as well as continue to develop it. Each of these activities ends with a discussion where students have to defend their answer, and also decide if their answer makes sense. Students who are have difficulty in math tend to lack number sense, whereas students with good number sense usually find math less daunting. Muir (2012) argues that because number sense is so integral to understanding mathematics, it is important to provide students with many opportunities to engage in number sense, utilize in number sense, and discuss number sense. Muir's (2012) article is a good reminder that teachers need to constantly be aware of providing their students with ample opportunities to engage in number sense building activities.

Much research has already been done on number sense and the effect that it has on student achievement in math. When students have a good understanding of number sense, they are able to understand how numbers relate to each other, what numbers mean, and are able to perform mental math. They are able to work with numbers flexibly, efficiently, and accurately.

Methodology

Participants

The study focused on 47 students from two second-grade classes in two suburban elementary schools serving mostly upper middle class neighborhoods. The experimental class had 24 students in it, 14 females and 10 males. The control group had 23 students, 15 females and 8 males. The schools were located in a suburb of Denver, Colorado. Students were between the ages of seven and eight. It is worthwhile to note that at the school of the experimental group, students can be accelerated in math if they are classified as high achieving. Therefore, the experimental group consisted of students all taking second-grade math, with four high achieving students removed from the classroom to participate in the third-grade math curriculum.

Materials

Materials for the experiment include a pre-test consisting of two critical thinking problems, each problem consisting of two levels. These problems were developed by the Noyce Foundation, found at insidemathematics.org, called Problem of the Month. The two questions used for the pre-test (Appendix A) were “The Wheel Shop” and “Friends You Can Count On.” The post-test (Appendix B) also consisted of two critical thinking problems, similar but different from the pre-test questions-each problem consisted of two difficulty levels (Level A and Level B). The posttest questions were also developed by the Noyce Foundation. The two post-test questions were “Measuring Up” and “Squirreling It Away.” Each post-test problem also consisted of two difficulty levels (Level A and Level B). All four of the problems used on the pretest and posttest focused on mathematical concepts within the “Operations and Algebraic Thinking” domain of the Common Core Mathematic Standards. These problems are designed to have a low floor and high ceiling so that all students can engage in the problem, while struggling and persevering to solve it. It is worthwhile to note that according to the Inside Mathematics website, Level A would be challenging for second and third graders, while Level B would be challenging for fourth and fifth graders. The researcher decided to include level B problems to give ample opportunity for students to show growth, therefore not establishing a “ceiling” for high achieving students. Participants' pre-tests and post-tests were evaluated on a researcher-developed rubric (Appendix C).

Design

The study was conducted using quasi-experimental design. The independent variable was the instruction in number talks over the course of the experiment. The experimental group received the independent variable, the control group did not. The dependent variable was participant performance on the critical thinking problems. The dependent variable was analyzed within each group as well as between the groups. Sub-sections of each group were also analyzed.

Procedure

Prior to the implementation of the Math Talks strategy with the experimental group, all participates were given a pretest of rich math tasks, or critical thinking problems. This pretest consisted of two word problems, each problem containing two levels. Students were given as much time as needed to complete the two problems. No teacher assistance was given on the mathematical portion. Questions were read aloud to students to eliminate the impact of reading ability on the mathematical answers. Responses were analyzed using the researcher-created rubric.

The experimental group received number talks in the classroom two to three times a week over a period of four school weeks. To collect post experimental data, participants took a posttest consisting of two (similar but different) rich math tasks, each problem having two levels. All four of the problems used on the pretest and posttest focused on mathematical concepts within the "Operations and Algebraic Thinking" domain of the Common Core Mathematic

Standards. The pretest and posttest data were compared at the end of the experiment to determine if number talks increased participant achievement on rich math tasks.

The control group was another same-grade class in the same district that used the same math curriculum. The control group was given the pretest and the posttest, but was not exposed to number talks. Their pretest and posttest data was also compared to determine if there was any significant change in the data. Lastly, the data from the experimental and control groups were compared to determine significance of the data.

Results

Data Analysis

Participants were scored on a researcher-developed rubric for both the pre-test and post-test. The dependent variable was analyzed within the experimental group as well as the control group. Then, the dependent variable data was analyzed between the groups.

A t-test was used to compare and determine the significance of the growth data between the experimental and control groups. A paired t-test was used to show whether each group's growth was significant or not. For both tests, a value of $p<0.05$ was used to show statistical significance. Any probability less than .05 suggested that the particular outcome happening randomly would occur less than 5% of the time. Therefore, with any results with $p<.05$, the null hypothesis was rejected in conclusion that the number talks had an effect on the results.

Findings

The mean growth/change data and p values for all four problems are recorded in Table 1. Figure 1 depicts a side by side comparison of the growth/change in each group for all our problems. For the table and the figure, P1LA stands for problem 1, level A. P1LB stands for problem 1 level B. P2LA stands for problem 2, level A, and P2LB stands for problem 2, level B.

Table 1

Growth/change mean scores, growth difference, and associated p-values.

Test	Experiment Growth	Control Growth	Difference	P-value
P1LA	**-1.2083**	**0.0870**	**-1.2953**	**0.0024**
P1LB	**1.333333**	**0.73913**	**-1.1522**	**0.000022**
P2LA	**0.5000**	**0.9565**	**-0.4565**	**0.1847**
P2LB	**0.7917**	**0.3478**	**.4438**	**0.2309**

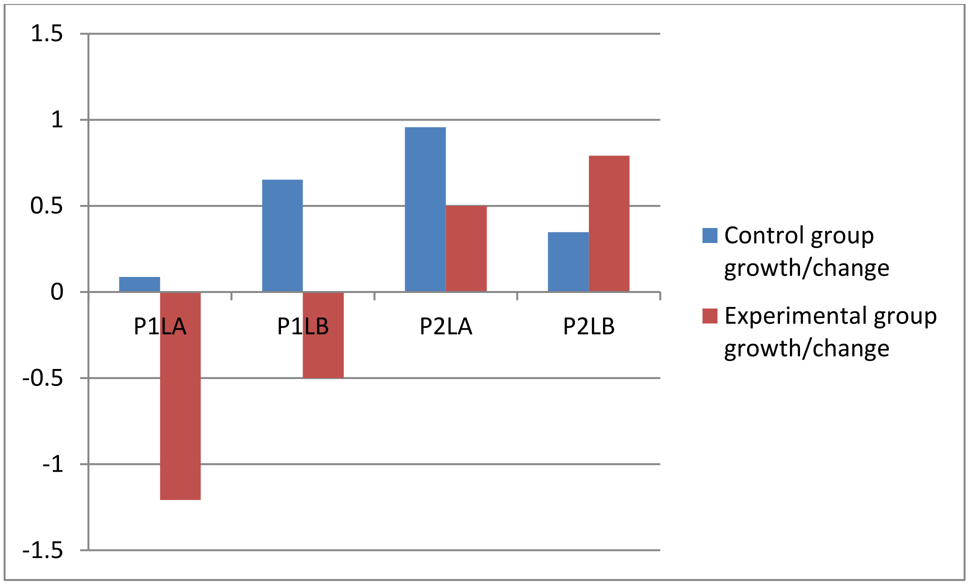

Figure 1. Bar graph shows a side by side comparison of the growth/change data for the control and experiment group.

For P1LA, there was a significant average difference of -1.29 between the experiment and control group (P=0.002). The paired t-tests for this problem showed P= 0.7651 for the control group, and P= 0.0003 for the experimental group.

The change score for the experimental group in the P1LB test was -1.15 less than the control group (P=0.000022). The paired t-tests for this problem showed P=0.0011 for the control group, and P=0.0074 for the experimental group.

For P2LA, there was an insignificant average difference of -0.46 between the experiment and control group (P=0.1847). The paired t-tests for this problem showed P=0.0004 for the control group, and P=0.0558 for the experimental group.

The change score for the experimental group in the P2LB test was 0.4438 more than the control group (P=0.2389). The paired t-tests for this problem showed P=0.1479 for the control group, and P=0.01 for the experimental group. Full student data can be seen in Appendix D.

Discussion

Summary

The purpose of this study was to determine if number talks had a positive effect on second grade students' number sense and ability to think critically. This study focused on the following question: does exposure to number talks increase student achievement on critical thinking math tasks?

This study looked at two second-grade classes in a Denver, Colorado suburb to determine whether or not a class instructed with number talks in addition to the regular math curriculum would increase students' performance on a critical thinking math task. The research suggested that the experimental group would increase their performance on the post test, but in this study, the experimental group showed growth on only two of the four problems. The control group showed growth on all four of the posttest problems.

The researcher also noted that there was a difference in the way students in each group explained their thinking. While the control group showed more growth, students in the experimental group did a better job of explaining their thinking and the steps that they took to solve the problem. While students in the experimental group may have gotten an incorrect answer, they articulated their mathematical process better than those in the control group who did get a correct answer, but struggled to explain their thinking.

There are many possible reasons why the experimental group did not show as much growth as the control group. One of these reasons involves the average scores from the pretest. The scores from the experimental group on the pretest problems were higher than those of the control group. The experimental group was therefore left with less room to make growth than the control group.

Another possible reason the experimental group may not have made as much growth as the control group is that the researcher did not administer the pretest and posttest to both the experimental and control groups. Although explicit directions were given to the teachers administering the tests, the problems may have been presented in slightly different ways, which could have affected the outcome.

Another possible reason that the study did not have the expected outcome could be because winter break fell in the middle of the four weeks during which the experimental group was instructed with number talks. This may have impacted how much students remembered from the number talks, and may have set back their learning.

While the researcher tried to find problems that were similar in content for both the pretest and the posttest, the problems did differ slightly. This means that while the main content for the problems were the same, they did assess slightly different topics, which could have affected the growth for some students. On the posttest, problem 1 had a lot of text.

One last reason that the study may have turned out differently than hypothesized is the actual curriculum. It is possible that the math curriculum used in this study did not support number talks and what the students were learning. If the schools had been using a different math curriculum, the results may have been different.

Implications

The implications of this study are valuable for the field of education, especially in the area of mathematics. The results of this study differed from what the research suggests. Though the results in the 2011 study by Stella and Fleming were insignificant, they did find that the average class score increased after the class participated in a six-week clarity treatment on place value and number sense skills. Boonen, Kolkman, and Kroesbergen (2011) had similar results in their study on the effect of math talks on kindergartners. The researchers found that there is a positive correlation between teachers' math talk and children's number sense at the end of the school year. Due to this, another study would be warranted.

When the next study is conducted, there are a few changes that should be made in order to aid in achieving better results. First, if possible, the researcher should administer the pretest and posttest to both the experimental and control groups. This way, there will be no variation in how the tests are administered.

Secondly, the timing of the study should be changed. The researcher would suggest that in a secondary study, the weeks of number talks should be completely consecutive and should continue for more than four weeks. In the secondary study, the researcher suggests that number talks be taught for an entire year before testing student growth. This amount of time would give a more accurate picture of student achievement. The study should also be expanded into schools that use different math curricula and serve communities with differing needs.

Overall, this study found that number talks do not always increase student achievement in second graders. This result had many different factors and possible reasons why this may have occurred. However, the researcher continues to argue that with the different timing, resources, and student populations, the study results could have been different. The researcher recommends that this study be recreated with the aforementioned changes.

Limitations

While great care was taken to plan and implement this action research, there were some factors that could have affected the findings. This study was performed on two second grade classes from schools in a suburb of Denver, Colorado. These schools serve mostly upper middle class neighborhoods. In order to further extend the findings of this study, more research should be done in other second grade classrooms in the same school, other schools in the district, schools in other districts, and schools in other areas of the country.

Due to the timing of the research, the four weeks of number talk instruction were split up by winter break. Three weeks of instruction occurred prior to winter break, and the last week of instruction was completed after the two week break. This break from school may have hindered the students' performance.

Additionally, the amount of support the students received at home would have affected how students did on the problems. If parents consistently asked students to explain their thinking, students may have improved on the critical thinking task. If students were not asked to explain their thinking, they may not have showed as much growth.

Lastly, while the problems were read out loud to the students, the amount of text and difficulty of the text may have hindered some students from performing their best. The students needed to read the text of the problem in order to understand what the problem was asking. For students that have challenges with reading, this could have affected how they performed on the problems. For visual learners, or students with test anxiety, this method may have degraded their performance.

References

Boaler, J., Williams, C., & Confer, A. (2014, October 24). Fluency without Fear: Research Evidence on the Best Ways to Learn Math Facts. In *Youcubed*.

Boonen, A. J., Kolkman, M. E., & Kroesbergen, E. H. (2011). The relation between teachers' math talk and the acquisition of number sense within kindergarten classrooms. *Journal of School Psychology*, *49*, 281-299.

Chrysostomou, M., Pitta-Pantazi, D., Tsingi, C., Cleanthous, E., & Christou, C. (2013). Examining number sense and algebraic reasoning through cognitive styles. *Educational Studies in Mathematics*, *83*, 205-223. doi:10.1007/s10649-012-9448-0

Feikes, D. and Schwingendorf, K. (2008). The importance of compression in children's learning of mathematics and teacher's learning to teach mathematics. *Mediterranean Journal for Research in Mathematics Education,* 7(2).

Muir, T. (2012). What is a reasonable answer? Ways for students to investigate and develop their number sense. *Australian Primary Mathematics Classroom*, *17*(1), 21-28.

Nathan, M. (2012). Rethinking formalisms in formal education. *Educational Psychologist*, *47*(2), 125-148.

Parish, S. D. (2011). Number talks build numerical reasoning [Electronic version]. *Teaching Children Mathematics*, 198-206.

Parish, S. (2014). *Number Talks Helping Children Build Mental Math and Computation Strategies* (2nd ed.). Sausalito, CA: Math Solutions.

Park, J., & Brannon, E. M. (2014). Improving arithmetic performance with number sense training: An investigation of underlying mechanism. *Cognition*, *133*, 188-200.

Problem of the Month (2014). In *Inside Mathematics*. Retrieved October 24, 2014, from www.insidemathematics.org

Salaschek, M., Zeuch, N., & Souvignier, E. (2014). Mathematics growth trajectories in first grade: cumulative vs. compensatory patterns and the role of number sense. *Learning and Individual Differences*, *35*, 103-112.

Sood, S., & Jitendra, A. K. (2011). An exploratory study of a number sense program to develop kindergarten students' number proficiency. *Journal of Learning Disabilities*, *46*(4), 328-346.

Stella, M.E. & Fleming, M.R. (2011). Clarity in mathematics instruction: The impact of teaching number sense and place value. Unpublished manuscript.

Tolar, T. D., Cirino, P. T., Fletcher, J. M., Fuchs, D., Hamlett, C. L., & Fuchs, L. (2012). Predicting development of mathematical word problem solving across the intermediate grades. *Journal of Educational Psychology*, *104*(4), 1083-1093.

Tsao, Y. & Lin, Y. (2012). Elementary school teachers' understanding towards the related knowledge of number sense. *US-China Education Review, B(1)*, 17-30.

Appendix A

Pretest Question 1 Level A

Problem of the Month

The Wheel Shop

Level A:

You go to a shop that sells tricycles. There are 18 wheels in the Wheel Shop.

How many tricycles are in the shop?

Explain how you know.

Appendix A

Pretest Question 1 Level B

Level B:

The Wheel Shop sells other kinds of vehicles. There are bicycles and go-carts in a different room of the shop. Each bicycle has only one seat and each go-cart has only one seat. There are a total of 21 seats and 54 wheels in that room.

How many are bicycles and how many are go-carts?

Explain how you figured it out.

Problem of the Month The Wheel Shop Page 2

Appendix A

Pretest Question 2 Level A

Problem of the Month

Friends You Can Count On

Level A:

The friends in your class like to exchange stickers. You decide to give each classmate three stickers. You have 19 classmates. How many stickers will you need? Show how you figured it out.

Your best friend decides to give each classmate 4 stickers. How many will your best friend need to give away?

Two more classmates join your class. You and your best friend give them stickers also. How many total stickers were exchanged? Explain how you figured it out.

Your younger brother wants to give some stickers to his classmates. Explain to him how to figure out how many he needs to bring to class.

Problem of the Month Friends You Can Count On P 1

Appendix A

Pretest Question 2 Level B

Level B:

You and your friend went to a frozen yogurt store. You both like to get frozen yogurt cones with different toppings. The store has a sign showing the different kinds of cones, yogurt and toppings you can buy:

Cones	Yogurt	Toppings
Sugar Cone	Vanilla	Oreo Cookie
Chocolate Dip Cone	Chocolate	Reese's Pieces
	Strawberry	Rainbow Sprinkles
		Gummy Bears

You and your friend wonder how many different cones you can make? Find all the different combinations of cones, yogurt and toppings you can make and explain how you know you have found all of them.

How would your numbers change if the store added a waffle cone? Explain.

Appendix B

Post Test Question 1 Level A

Problem of the Month

Measuring Up

Level A

A small group of six soldiers came into a small town. They were very hungry, but none of the townspeople offered them food. One of the soldiers announced that they would make *Stone Soup*. "How do you make Stone Soup a towns' person asked?" Well the soldier replied, "You need a big pot, water and a large stone." The townspeople, very curious to see how Stone Soup was made, gathered together the materials. The soldiers started to cook the soup over a fire they made. Once the soup began to boil, a soldier said, "sure this will be a tasty stone soup, but a delicious stone soup would have additional ingredients." The townspeople, now even more curious, asked what extra ingredients might be added. "Well for each person you would need 2 baby carrots, 3 green onions and five chunks of meat."

What ingredients are needed to make a delicious stone soup for the six soldiers?

What ingredients are needed to make a delicious stone soup for ten people?

What ingredients are needed to make a delicious stone soup for 25 people?

Explain how you determined you answers.

Appendix B

Post Test Question 1 Level B

Level B

The townspeople brought more and more ingredients and put them in the soup. They began to lose track of how many people they could serve. One young girl who was careful to count the green onions announced that there were 69 green onions in the soup.

How many chunks of meat would need to be in the soup to make the recipe taste right?

How many people can be served soup with all these ingredients? Show how you figured it out.

One man said, "If we have 69 green onions, then I know we need 45 carrots." Is the man right, explain your answer.

Appendix B

Post Test Question 2 Level A

Problem of the Month

Squirreling It Away

Level A:

Austin has a bag of 17 acorns. Eight squirrels came up to him. He gave each squirrel an acorn. Then five more squirrels came up to him and he gave away one acorn to each of them. How many more squirrels can he still feed?

Show how you figured it out?

How do you know you have the right answer?

Appendix B

Post Test Question 2 Level B

Level B:

Austin likes to watch squirrels find and store acorns for the winter. Brown Squirrels can carry two acorns at a time. Gray Squirrels can carry three acorns at a time and Black Squirrels can carry five acorns at a time. There is a pile of 24 acorns.

How many trips would a Brown Squirrel need to make to store all of the acorns in the pile?

How many trips would a Gray Squirrel need to make to store all of the acorns in the pile?

How many trips would a Black Squirrel need to make to store all of the acorns in the pile?

If all three squirrels worked together to store the acorns how many trips would the squirrels need to make to store all of the acorns?

Explain your solution.

Appendix C

Rubric

Rubric for Problem of the Month

4	Correctly answers the questions posed. The student is thorough in their justification/explanation their thinking using numbers, pictures, or words. There are no errors in the computation, and shows all steps in their thinking. The student show a clear mastery of the mathematical concepts addressed in the problem.
3	Correctly answers most of the questions posed. Student attempts to justify/explain their answer but is not completely clear. The student may have some misinterpretations or minor errors in their computation. The student shows most of the steps used to solve the problem, but they may be difficult to follow. The student shows a solid understanding of mathematical concepts, but not mastery.
2	Answers some of the posed questions correctly, may have. There is some evidence of understanding, but there are errors in the computation. The student attempts to justify/explain their work but the explanation or work is confusing and unclear. The student needs more support on the concepts in the problem.
1	The student attempts to answer the problem/questions posed, but there are errors in the computation. There either is no justification/explanation, it does not make sense, or it may be incorrect
0	The student does not attempt to understand or solve the problem.

Appendix D

Experimental Group Data

	Pre Test				Post test			
Name	P1 LA	P1 LB	P2 LA	P2 LB	P1 LA	P1 LB	P2 LA	P2 LB
Student 1	4	0	2	1	1	1	1	3
Student 2	4	1	2	1	1	1	3	1
Student 3	4	2	3	0	3	3	4	3
Student 4	4	2	3	1	3	2	4	3
Student 5	3	1	2	1	2	1	1	3
Student 6	4	3	1	2	2	1	3	3
Student 7	4	2	2	0	4	1	3	3
Student 8	3	1	1	1	3	1	3	3
Student 9	4	2	3	1	2	1	3	1
Student 10	1	1	1	1	2	0	1	1
Student 11	2	0	1	1	0	1	3	1
Student 12	4	0	1	1	1	0	1	1
Student 13	4	3	3	4	2	1	4	3
Student 14	1	1	1	1	2	0	3	1
Student 15	4	2	3	0	3	1	4	3
Student 16	2	2	2	2	1	1	4	1
Student 17	4	1	3	2	4	0	3	3
Student 18	2	0	1	4	1	0	0	3
Student 19	2	1	0	1	1	0	1	1
Student 20	4	1	3	1	1	1	1	3
Student 21	4	1	3	2	1	1	1	1
Student 22	2	1	1	2	0	0	1	1
Student 23	4	2	2	1	3	1	3	3
Student 24	1	2	2	2	3	1	3	3
Average Scores	3.125	1.333333	1.916667	1.375	1.916667	0.833333	2.416667	2.166667

Appendix D

Control Group Data

	Pretest				Post test			
Name	P1 LA	P1 LB	P2 LA	P2 LB	P1 LA	P1 LB	P2 LA	P2 LB
Student 25	4	1	3	0	2	1	3	2
Student 26	4	2	1	1	1	1	2	1
Student 27	2	1	2	1	3	1	4	1
Student 28	2	1	2	0	3	1	4	2
Student 29	1	1	1	0	3	1	2	3
Student 30	3	2	2	0	3	2	1	1
Student 31	3	0	2	1	3	1	3	1
Student 32	2	0	1	0	2	1	3	0
Student 33	4	1	2	0	3	1	4	1
Student 34	3	1	1	2	3	2	1	2
Student 35	0	0	2	3	3	1	4	3
Student 36	2	0	1	1	2	1	4	1
Student 37	2	0	1	1	3	2	3	0
Student 38	1	1	2	2	3	1	2	2
Student 39	1	1	2	1	3	2	3	2
Student 40	4	1	2	0	4	2	4	0
Student 41	2	1	2	2	2	1	3	0
Student 42	2	1	2	1	2	2	2	1
Student 43	4	0	2	1	3	3	3	0
Student 44	4	1	2	1	3	2	1	2
Student 45	2	0	2	1	2	1	3	2
Student 46	4	1	2	2	3	1	3	1
Student 47	4	0	2	1	3	1	1	2
Averages	2.609	0.739	1.783	0.957	2.696	1.391	2.739	1.304