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"Math Talks are Like an Alarm Clock Waking You Up": Language's Crucial Role in Mathematics

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Abstract:

Whole group math talks, or number talks, are a common practice to get students talking about their own understanding of mathematical concepts. The purpose of this study was to implement math talks in small group settings to see what would happen, specifically to students' conceptual understanding as well as their general perceptions of math talks. This study took place in a fourth-grade math classroom, and math talks were implemented with the whole class for a week and then moved to small groups for the remaining three weeks of the study. During the study, a pre- and post-assessment was given, field notes were taken, and focus groups and interviews were conducted. All data was analyzed using the constant comparative method, looking for recurring themes and descriptive statistics was used to analyze numerical data. The data revealed three major themes: content and processes, language's crucial role, and math confidence.

"I am having a hard time figuring out this division problem because I can never remember how to count by 7s," Garrett (all names are pseudonyms) explained to me during an independent work time. "Okay, what are some strategies we have learned about this year that might help you remember the multiples of 7s?" I asked back. "Well, I could use the domino strategy, or I could add on with the multiples of 7s I do remember," Garrett replied to me with what looked like a shimmer of hope on his face. "I think those are great ideas. Choose one of those methods and continue working through the problem. You can do it!" I said as I walked away. This interaction is one that happened quite often in my fourth-grade math classroom. Fourth-grade math is a challenging year as many concepts are not only new, but they overlap with one another. In this case, Garrett was working on a division problem yet had to use what he knew about multiplication to be able to solve the problem. Through my questioning, I was able to guide him in his thinking, so he himself could verbalize the connection of using the multiples of 7 to then aid him in the math process of dividing.

Though this interaction was simple and straightforward, language was used to support his mathematical thinking that in turn allowed him to solve the given math problem. This interaction made me wonder if these same interactions between students could occur in an intentional way that might deepen students' own math understanding.

Purpose

Math talks (also called number talks) have become a way to incorporate mathematical discussions into the classroom. Humphreys & Parker (2015) describe number talks as brief discussions focused on a particular mathematical concept. These daily discussions are based around the "why" of the concept through exploring different strategies for solving (Humphreys & Parker, 2015). Through teacher scaffolding, math talks incorporate student conversation and collaboration to better understand mathematical concepts (Wagganer, 2015). Moreover, existing research has focused specifically on language in the math classroom at the whole-group level with teacher scaffolding. In this research project, I focused on students using math language in small group settings with continuous teacher scaffolding. My study addressed this implementation by answering the following research questions:

> **Research Question:** What happens when math talks are implemented in small groups in a fourth-grade classroom?
> **Sub Question 1:** How could math talks impact students' understanding of math concepts?
> **Sub Question 2:** What are teacher and student perceptions of the math talks?

During the time of the study, I was a graduate student in my second semester of student teaching and conducted teacher action research. I was co-teaching in a fourth-grade classroom with twenty-three students, ten of which were identified as gifted and talented, and one identified with dyslexia. The school I was teaching at, Arthur Elementary, is in a small West Texas town with a population of around 123,000 people. At the time, Arthur Elementary served about 600 students from grades kindergarten to fifth grade. Of the student population, a little over half were White, around 30% were Hispanic, 6% were Black, 4% were two or more races, and 1% were Asian. About half of the students were considered low-income families, and 2% of the students were English Language Learners.

Literature Review

Language is an integral part of the classroom. From teacher communication during lessons, to student questioning, to student discussion during group work, language is part of the day-to-day happenings within a classroom. The subject of mathematics focuses language on conceptual understanding through being able to validate the "why" of a concept (National Council of Teachers of Mathematics,

n.d.). Regarding the conceptual understanding of math, language is found to produce positive effects on students through increased participation and engagement (Acar & Yilmaz, 2015; Bennett, 2010; Qaisar, Dilshad, & Butt, 2015; Quebec Fuentes, 2013; Zwiers et al., 2017). The subject of mathematics surrounds the use of numbers and often seemingly boils down to getting the correct numerical answer. When students are focused on getting to the correct answer, conceptual understanding can be sacrificed; however, the integration of language in the math classroom calls for students to participate in an engaging way that increases ownership in learning (Hufferd-Ackles, Fuson, & Sherin, 2004).

In addition, through the use of language in the classroom, students can explore different math strategies (Bennett, 2010; Hufferd-Ackles et al., 2004; Murata et al., 2017). Murata et al. (2017) researched math talks in two different first-grade classrooms over a month where students' strategies focused on the process of solving addition problems. Space was provided for students to consider and communicate their thinking, allowing ownership in student thinking (Murata et al., 2017). Moreover, when a student shares their strategies aloud, the other students might enter a different way of thinking which may allow for a meaningful discussion allowing critical thinking and new connections across content (Hintz & Kazemi, 2014; National Council of Teachers of Mathematics, n.d.; Quebec Fuentes, 2013).

Through the use of language in the math classroom, it is found that students can collaborate in a way that fosters understanding and connection (Hufferd-Ackles et al., 2004; National Council of Teachers of Mathematics, n.d.). The responsibility of learning shifts onto the students as they comprehend what they are learning through verbal processing, finding confidence as a math learner, and helping their peers along the way (Hufferd-Ackles et al., 2004; Humphreys & Parker, 2015). Zwiers et al. (2017) focused on the role meta-awareness plays regarding making connections as students are challenged to think about their own thinking and then utilize language to communicate their own thoughts, achieving effective discussions. Effective discussions look like "students pos[ing] and answer[ing] questions, clarify[ing] what is being asked and what is happening in a problem, build[ing] common understandings and share[ing] experiences relevant to the topic" (Zwiers et al., 2017, p. 7).

Research shows that listening is also an essential skill in collaboration (Hufferd-Ackles et al., 2004; Humphreys & Parker, 2015; Murata et al., 2017; Wagganer, 2015; Zwiers et al., 2017). Wagganer (2015) speaks on how she taught her class about active listening and found that when the students participated in active listening during discussions, students could better understand what the

person talking was trying to communicate. In addition, sentence stems were a strategy Wagganer (2015) utilized within math conversations that both encouraged active listening in student response and provided a way for students to continue the conversation.

Furthermore, research supports the need for language and collaboration in the classroom, and math talks are a way to incorporate both components. Usually, math talks are teacher-led and done at the whole-group level where students are asked to mentally consider how to solve a given topic (Hufferd-Ackles et al., 2004; Humphreys & Parker, 2015; Murata et al., 2017). In a study focused on math talks in two different first-grade classrooms, Murata et al. (2017) explored the differences that came in the students' discussion when the teacher provided a tight structure to a math talk versus a looser structure such as allowing students to discuss their own ideas. Murata et al. (2017) found that students with the looser structure brought about a more in-depth conversation which supported student responsibility.

The research about specific math talks focuses on them happening with the whole class at various levels. (Hufferd-Ackles et al., 2004; Murata et al., 2017). The levels are determined by the teacher and are broken up by questioning, explanations, representations, and student responsibility (Hufferd-Ackles et al., 2004; Murata et al., 2017). Through the levels, the teacher's role goes from leading the conversation about a math concept to allowing students to lead and direct the conversation with the teacher engaging when necessary (Hufferd-Ackles et al., 2004). While math talks usually call for a whole-class discussion, researchers have discovered that there are many benefits when students work in small groups. In a study focused on students' attitudes toward math, Qaisar et al. (2015) found that there was a positive effect on students' attitudes through the use of collaborative group work. A student even shared that there was freedom and safety to ask questions repeatedly (Qaisar et al., 2015). Quebec Fuentes (2013) also found an increased consistency in student-to-student questioning in working with groups.

Matney et al. (2020) investigated many different research studies over the years that focused on number talks (similar to what I will name as math talks) as they point out, "Number talks provide a space for students to demonstrate flexibility in computational methods, finding multiple solution methods when possible" (p. 248). Matney et al. continue to suggest that there is an additional need for more research in the area of number talks in the math classroom specifically relating to the efficacy of number talks. They describe the need for additional research as a "black hole," where there is current existing research on the topic but more is required, not only in pointing to number talks' potential but also evidence in its impact on students (Matney et al., 2020).

Based on existing research, I have developed the idea of math talk implementation within small groups, something that has not been done before. Whole-class math talks have been found to allow useful and beneficial language and collaboration (Hufferd-Ackles et al., 2004; Murata et al., 2017). Likewise, it has been found that the use of language and collaboration are necessary and beneficial components within small-group settings (Acar & Yilmaz, 2015; Qaisar et al., 2015; Quebec Fuentes, 2013). Moreover, through my study, I will merge the understandings of whole-class math talks by implementing them within small-group settings. This will allow for a better understanding of the possible impact on fourth-grade students' conceptual understanding of math content and overall perceptions about the implementation of math talks. This merge between whole-class math talks and small-group collaboration is important for teachers and researchers to examine because it can support students in understanding the process of mathematics rather than the usual focus on simply getting the correct answer. In addition, math talks in the small-group setting could be a way that teachers can better support students' ownership and understanding in the math classroom.

Methods

The following sections describe the action research study I conducted in a fourth-grade math classroom. I implemented math talks beginning at the whole-group level for a week to teach my students the process of a math talk. For the remaining three weeks, math talks occurred within small groups. During the time of the study, I acted as both a teacher and a researcher to scaffold them in their math thinking as well as observe what happened during the math talks. I also studied their perceptions of the math talks through focus group interviews. I conducted this study during my yearlong clinical teaching placement, so my students felt comfortable with me in the role of a teacher as well as a researcher.

Participant Selection

The participants of this study included a single classroom of fourth-grade students and one classroom teacher. A parent information letter and consent form were sent home and the students were asked to sign an assent form. Of the 23 students in the class, all 23 received parental permission and assented to participate in the study. The class consisted of 14 boys and nine girls. Twenty students were Caucasian, two students were Hispanic, and one was Caucasian and African American. The classroom teacher was a Caucasian female.

Data Collection

To begin the study, the student participants took a pre-assessment. The pre-assessment consisted of five questions where students had to explain specific math concepts they learned in the previous fall semester (see Appendix A). Each of the five questions on the pre-assessment focused on different math topics that were covered during the fall semester (multiplication, comparing fractions, subtraction, division, and multistep problem solving). Students responded to each question in writing and/or in pictures. To assess the pre-assessment, a rubric with the categories of accuracy, math strategies, math vocabulary, and explanation was used to determine content understanding (see Appendix C). Within each category, students received a point value (1-4) signifying where they were in their understanding: beginning steps (1 point), nearing proficiency (2 points), proficient (3 points), or advanced (4 points) for each of the five questions on the assessment. A perfect score using the rubric was an eighty, so each question was worth sixteen points. Furthermore, for each question on the pre-assessment, students were assessed on their accuracy, math strategies, math vocabulary, and their explanation of their process.

Next, the math talks were taught and implemented with the whole class. Prior to entering the first math talk, I front loaded the class on what to expect during a math talk and how to participate in a math talk. During this front loading, I explained what a math talk is, why they are important, what active listening is, sentence stems to support students in their conversations, and the difference between explaining and justifying. Whole-class math talks began with a problem put on the board that either focused on mathematical concepts the students had previously learned and practiced in the fall semester: multiplication, division, fraction comparison, subtraction, or multi-step word problems (the same five math skills students demonstrated on the pre-assessment). After a week, the math talks were implemented in small groups focusing on one of the five topics mentioned above. Students had access to sentence stems to scaffold conversation within the small groups. The current classroom seating chart formed the small groups. Math talks occurred Monday through Thursday for about 20 minutes each day for four weeks. During the occurrences of the math talks, field notes were taken (Hendricks, 2017). After each day of the implementation of the math talks, field notes were fleshed out in further detail. In addition, after each week, field notes for the whole week were thoroughly analyzed.

After the four-week implementation of the math talks, students took a post-assessment. The post-assessment was almost identical to the pre-assessment, using

the same concepts but different numbers (see appendix A). The post-assessment was assessed using the same rubric as the pre-assessment (see appendix C). Using the score results from the post-assessment, students were put into three different focus groups: low average, medium average, and high average. Each focus group had four to six students and lasted about twenty minutes. The semi-structured focus groups were then conducted with prepared questions that targeted student perceptions of the math talks. The focus groups were audio-recorded and transcribed (Hendricks, 2017). In addition, the teacher was interviewed for about twenty minutes, and this was also focused on her perceptions of math talks. The teacher interview was audio-recorded and transcribed as well (Hendricks, 2017).

Data Analysis

To analyze the field notes and interviews, I used the constant comparative method (Hubbard & Power, 2003). Through this method, I was consistently coding data from the beginning to compare the categories and concepts I was discovering throughout the study (Hubbard & Power, 2003). I began by coding the first 20 percent of the data, and I was able to identify around 20 level 1 codes (Tracy, 2013). Level 1 codes are general descriptions of the data (Tracy, 2013). Using the level 1 codes, I coded the remaining 80% of the data. I was then able to identify level 2 codes which synthesized the data, pointing to themes and overall findings (Tracy, 2013). In addition, I created an index to organize and keep track of the data supporting each of the level 2 codes by including the level 1 codes and their supporting data (Hubbard & Power, 2003). I created a codebook (see Appendix B) to depict both the level 1 and 2 codes I identified, an explanation of the code, and an example of the code. I also wrote memos on each of the level 2 codes to reflect and better understand the findings (Tracy, 2013).

The pre-and post-assessments were analyzed using a rubric which gave a student an average score out of 16 total possible points where accuracy, math strategies, math vocabulary, and their explanation were the four categories specifically graded. Beginning steps (1 point), nearing proficiency (2 points), proficient (3 points), and advanced (4 points) were the four levels the students were graded by in each of the four categories. Descriptive statistics were used to analyze this quantitative data (Hubbard & Power, 2003). A double bar graph was created to compare students' pre- and post-assessments as well as the class average, which would show if there was an improvement in scores (Hendricks, 2017). Based on the post-assessment averages, three focus groups were put together: low average, medium average, and high average.

Findings

After much time reading, analyzing, and coding data, I reflected on the proposed research question and sub questions:

> **Research Question:** What happens when math talks are implemented in small groups in a fourth-grade classroom?
>
> **Sub Question 1:** How could math talks impact students' understanding of math concepts?
>
> **Sub Question 2:** What are teacher and student perceptions of the math talks?

These questions focused specifically on the occurrences of math talks, the math understanding of students, and the perception of math talks from both the students and the cooperating teacher. The data provided three insightful findings about the content and processes of mathematics, language's crucial role in learning math, and an increase in students' math confidence. Within these three major findings, the answer to all three research questions overlapped. The happenings in the small groups impacted students' understanding of content and processes, students' ability to use language in the math classroom, and their math confidence. The impact on students' understanding was evidenced by their growth in math content and processes, their ability to use math language, and their math confidence. Lastly, the teacher and student perceptions point to their overall math content and process growth, language ability, and math confidence. The three major themes are explained below, integrating all three research questions in each theme.

Content and Processes

"I liked it because I got to hear other people's strategies… and share my own," Nick shared during a focus group. The implementation of math talks, a specific area that students grew in over time, allowed students to share different strategies regularly. At the beginning of the implementation, students often stated their answer to a given math problem without any explanation. However, through teacher scaffolding and daily math talk occurrences, students grew in their ability to verbally share their math thinking. They shared math thinking often through talking about strategies they used to solve a given math problem. The use of students' strategies contributed to their understanding of different math processes and ultimately how they arrived at their solution to the given problem. Joshua also shared the following regarding what he learned during math talks: "I learned that different people use like different strategies…and they are unique...." This description of using strategies points to the idea that individual students' math processes as well as math thinking can look different as they work through math problems.

Throughout the duration of math talks, students received a spiral review of different content areas, reviewing content areas students had learned about the semester prior. Students deepened their math understanding through this spiral review. Multiple students spoke about their growth in conceptual understanding through math talks during focus group interviews. Every few days, the focus of the content changed, starting with multiplication and division facts, to multiplication word problems (one step to multi-step), subtraction with regrouping, and lastly comparing fractions with unlike denominators. Throughout each content area, the teacher scaffolded small group conversation using higher order questioning. The higher order questioning focused on the process of the specific content, challenging students to think deeper and perhaps in a unique way.

Although the teacher scaffolding was integral to the flow of the math talks, it was necessary to have a gradual release of teacher scaffolding allowing students to direct and lead their conversations within their small group and with the whole class. This gradual release was challenging, yet students were pushed into a deeper understanding of math content and processes. Regarding the impact of student conversations about math content and processes, Stella shared, "… sometimes you don't understand something the teacher is saying but then if a kid explains it to you, you totally understand it." This student perspective points to the deeper understanding that appeared to come from implementing math talks.

Before and after the implementation of math talks, students took a pre-assessment and post-assessment. The data from the two assessments presented tremendous growth in students' content understanding. Figure 1 shows the average scores for each student for both assessments.

Figure 1

Pre- and Post-Assessment Scores

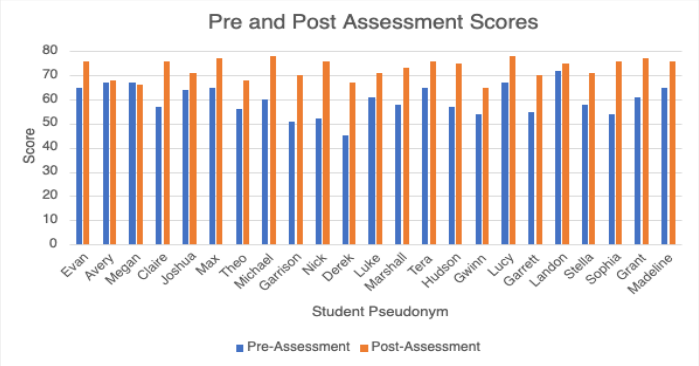
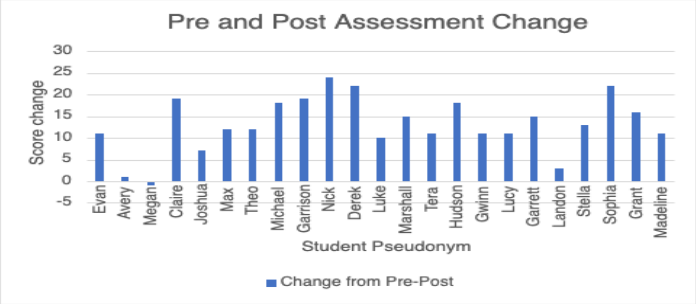


Figure 2 displays the change from the pre-assessment grade to the post-assessment grade for each student. All but one student grew in their assessment score from pre to post.

Figure 2

Pre- and Post-Assessment Change



Regarding the depth of content on the assessment, students were able to explain in a clearer manner how they got their answer as well as why they knew the answer was correct. The clarity and depth that grew in the assessments alone shows that students' math conceptual understanding was positively affected by the math talk implementation.

As depth of content and processes appeared to grow within students through the assessment data, students also developed the ability to connect across math content. Multiple students during the implementation of math talks pointed to the connections between different operations (addition, subtraction, multiplication, and division). For instance, some students explained multiplication as repeated addition and division as repeated subtraction. In addition to the connections in specific math content areas, students associated their experience in math talks with other activities they did in the math classroom during the focus groups. The teacher noticed that students generally grew in their ability to work in groups through this same association of experience in math talks.

Through the implementation of math talks, students demonstrated growth in their understanding relating to the content and processes of math. First, students' assessment scores speak to this growth. Additionally, their own comments regarding what they think they learned as well as the day-to-day occurrences during the math talk implementation point to growth in this area.

Language's Crucial Role

"… If you don't talk, how would someone know what's going on inside of your brain?" Tera asked this regarding her thoughts about talking in the math classroom. This statement is profound and sums up the crucial role of language that I found when implementing math talks. Throughout this study, I continuously saw the significance and purpose in the use of language specifically in math understanding. Through verbal language, multiple students pointed out the perspective that comes from talking to their peers. Nick noted, "…that having multiple perspectives can be very good for your brain." In addition, Garrett spoke about the benefit of perspectives because it allows opportunities to "compare" ideas. Overall, students' perceptions on math talks were positive and contributed to growth in their math understanding through the sharing of perspectives that occurred using verbal language in math talks.

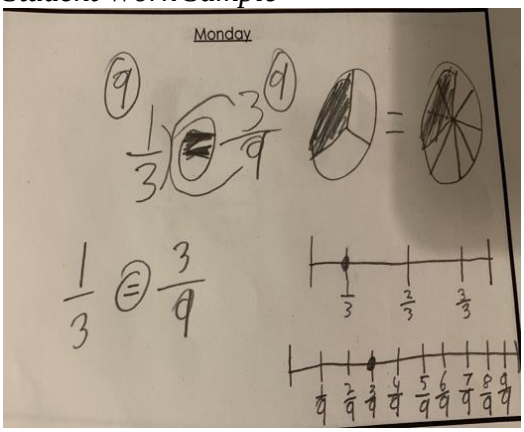
Students also reflected out loud on their math processes using verbal language. Students were able to catch mathematical mistakes through their reflections. Mistakes are common in learning math as they simply come up as a calculation error or a conceptual error. Furthermore, students not only focused on the answer they got but also the process to get the answer through the opportunity to talk to their peers. Lucy noted, "…it's important to talk because you usually catch mistakes when you talk to someone." In addition, Megan noted that math talks benefited her personally because it "…helped me know how to say it [math answer explanations] and helped me fix my problems to make it [math] easier." Moreover, students finding their mistakes and talking about their mistakes also played a role in deepening their math understanding during this study.

While language is often thought to primarily exist in the verbal sense, I found language to also occur non-verbally throughout this study. The non-verbal language appeared in students' need for a piece of paper and a pencil to work through math problems as well as the visual aspect of math by using different strategies. Gwinn pointed out the use of a piece of paper and a pencil in the first week of the implementation of math talks. During the first week, the focus was multiplication and division facts such as $6 \times 5 = 30$ or $21 \div 3 = 7$. With this focus in mind, I did not think having a piece of paper was as necessary compared to multi-digit multiplication word problems that we focused on the following week of the study; however, Gwinn proved me wrong. She explained her thinking regarding the division fact $20 \div 5$ to her group by using the eraser on her pencil as she "drew" on her desk. I asked her if she thought that having a scratch piece of paper would help her in her thinking to which she instantly said yes. From that day on, students were provided with a piece of paper to have space to non-verbally express their process by using strategies and calculating numbers to find an answer to a given problem.

The idea of visual math is one that also came up during the implementation of math talks in the classroom. Each day, after students shared in their small groups about the given problem, students volunteered to share their answers and processes with the whole class. When students shared with the class, they often came to the front of the classroom to use the document camera. Figure 3 is an example of a student's visual math work comparing two equal fractions.

Figure 3

Student Work Sample



The use of the document camera allowed the other twenty-two students in the classroom, as well as me, to clearly see the presenting student's math processes. This increased student engagement and directed the student in what to say as they explained their work. When students displayed their work under the document camera, multiple strategies were seen visually and spoken about such as arrays, number lines, and fraction models. In addition, the idea of math being visual also came up in focus groups. Tera spoke about the anchor charts around the classroom as "resources" that provided visual reminders of math concepts. Luke, Garrett, and Avery also pointed to a specific strategy called a part-part-total-chart as a visual way to organize numbers when adding and subtracting.

Conclusively, the role of language was perceived as a powerful discovery throughout this study by both the students and the teacher. Specifically, verbal as well as non-verbal language was found to be essential and impactful in the implementation of math talks. The use of language was an area that students flourished in over time, which was observed in the increased depth of conversation regarding specific math content areas in small groups and in whole-class conversations.

Math Confidence

Mrs. Ford, the cooperating teacher in the classroom, stated the following regarding her perception of what grew in students through the implementation of math talks: "It gives them confidence. I feel like that is the biggest thing I have seen with that class is that they are a lot more confident in how they answer." I had not directly seen the growth in students' math confidence until Mrs. Ford pointed it out. As I began to ponder this idea of confidence, I looked back to the flow of the math talks from the beginning of the study to the end. At the beginning of the study, I observed student confusion and even frustration in what it meant to explain a math answer. Through much scaffolding and consistent practicing, students grew in their ability to explain their answers to each other. By the end of the study, students were asking each other questions and did not always require the direct scaffold of questions from the teacher.

In addition, students grew in their use of mathematical vocabulary during math talks. From concept to concept, students reviewed the vocabulary associated with the topic of focus. For example, when talking about subtracting, the class brainstormed words in word problems that might indicate the use of subtraction. Moreover, as students got more and more comfortable in the actual talking piece of math talks, they grew in their confidence and word choice. Mrs. Ford noted growth in students' vocabulary usage as she stated, "…they can communicate mathematically what is going on a lot more effectively." Students also spoke about what they learned through math talks. Stella noted, "It's just like sometimes it [math talks] would make you understand something more most of the time and like you learned how to explain what you were doing." Marshall also noted that he learned "how to explain it [math process and answers] …before math talks you just knew how to do it [math process] but didn't know how to explain it [math process and answers]." Moreover, these students' perceptions point to an increase in their math confidence as well as the learning that took place during math talks.

As confidence grew in students, their engagement also grew. It seemed that students were excited about the challenge of something new when math talks were first introduced. This excitement lessened over time, yet their engagement within the classroom continued to increase. Mrs. Ford pointed to the engagement of students when sharing her thoughts regarding student perceptions about math talks as she stated, "… their general outlook of when you started math talks was always very positive, and they were very engaged." Continuing with the increasing engagement, students benefited from the challenge and depth they were pushed into. Overtime, the challenge and depth within content continued to extend during math talks and, the role of teacher scaffolding was still necessary but lessened.

Students were confident in their math understanding as well as the process of math talks. Students were led to a greater math understanding through the challenge and depth of math talks.

Multiple students compared their experience and perceptions of math talks using metaphors. Tera explained math talks as an alarm clock that wakes you up to which she clarified as a good alarm clock. Madeline suggested math talks were a workout for her brain to review math strategies. Lastly, Nick visually pointed to math talks as a way to open up your brain in your body for other people to see. These profound metaphors from students speak to the depth of thought some students came to and the overall benefit of math talks.

Implications for Teachers

The data I collected and analyzed through this study led to three influential findings regarding the implementation of math talks in a fourth-grade classroom: content and processes, language's crucial role, and math confidence. Throughout the study, math talks effectively utilized language to deepen students' conceptual understanding and increase their overall math confidence. In addition, math talks directly scaffolded and supported students' math understandings in a way that challenged and grew their learning.

The spiral review of math concepts students had already learned refreshed their brains on math processes and understandings. This benefited students' growing math knowledge and exposed some misconceptions students had within the math content. In addition, students made impactful connections across content and heard their peers' math understandings. The use of language (verbal and non-verbal) facilitated meaningful communication between students in both small-group and whole-class settings. Existing research supports the use and need for language in the classroom, but this study discovered the use and need for language through perspective. Everyone has their own perspective, or outlook, and students said hearing their peers' explanations of math strategies and answers during math talks provided a unique perspective that was helpful in deepening their own math understanding.

The use of language brought perspective to students as there was space to express their math understanding. The expression happened on paper with a pencil as students worked through given math problems and occurred verbally in their ability to express their answers and the math processes students utilized to arrive at their answers. The verbal piece of explaining answers was one that was uncomfortable and challenging for many students at the beginning of this study.

However, students grew immensely despite their uncomfortable and challenging feelings in starting math talks. This growth allowed opportunities for students to speak about math processes and understandings as well as inevitable math errors. Lastly, through the review of concepts and processes combined with the use of language, students' math confidence flourished. Students' growth in their math confidence was another finding in this study. I believe these findings on confidence contribute to existing research about math talks through the nuance of language that fostered a deepened math understanding. In this study, students' ability to communicate using math vocabulary developed, and their math understanding flourished. This growth took time, a lot of practice, and perseverance as math talks posed challenges. Nonetheless, the students grew in confidence within their understanding and expression of math content.

For teachers wanting to implement math talks in the classroom, I would suggest focusing on math concepts students have already learned or had experience with. I implemented math talks that focused on math topics that had been taught the semester prior. This allowed the focus of math talks to be a time to review math concepts not to learn new ones. Math talks provide a way to review and deepen students' existing math knowledge and teachers ought to use them this way in their math classroom. In addition, I found it quite important to know my students' math knowledge before beginning math talks. I utilized data from a pre-assessment to know where students were regarding expressing math concepts and processes before the implementation of math talks. The post-assessment data displayed the growth in students' conceptual understanding after implementing math talks. Lastly, I suggest consistently modeling and practicing math talks for about a twenty-minute period each day. This allows students to ease into the challenge, become comfortable with the flow, and begin to engage in math talks. With this consistency in mind, I am now wondering what the impact on students' math ability might look like if math talks were a consistent part of math lessons for a full year. How would that impact how students work with their peers and their need for scaffolding from the teacher?

Teachers have an opportunity to educate their students to grow into more than a "good" student. They have space to empower students to learn, to communicate well and in an effective manner, and to be confident human beings. Learning, communication, and confidence are not just useful within the classroom but also in day-to-day life. I am now wondering how an increased focus in language in other content areas as well as social and emotional teachings would impact students in the academic setting of school and in daily life outside of school. Though these questions do not pertain directly to the content of mathematics I focused on within this study, I was moved specifically by the crucial role of

language throughout the implementation of math talks. Language exists in all areas of the classroom and in the daily function of our world, and my hope is that we as educators recognize and implement this in our classrooms to foster growth within our students both inside and outside of the school day.

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Appendix A

Math Talk Pre-Assessment
(Post-Assessment looked identical but with different numbers)

1. What is 3X4? Explain why in words and by drawing a picture.

2. Compare the fraction three fifths and one third. Explain how you chose to compare them in words and by drawing a picture.

3. What is 50,000-32,961? Explain the subtraction process in words.

4. What is 20÷5? Explain why in words and by drawing a picture.

5. Read the following word problem. Use math strategies to solve. Explain in words your process.
   Sarah needs snacks for her birthday party. For snacks, she bought 8 boxes of chips. Each box has 25 chips in it. Sarah also bought 7 cookie trays. Each cookie tray has 36 cookies on it. How many snacks does Sarah have for her birthday party?

Appendix B

Table 1

Codebook

Code	Level	Description	Example
Content and Processes	2	Explanation and strategies used in math	"instead of multiplying you could add 8 + 8 + 8 + 8"
Math talks allow concepts to be reviewed	1	Past learned concepts reviewed	"I liked it because it was one of the chances when we're doing fractions… it was a chance where I got to use least common multiple, which I hadn't really done in a while."
Math processes	1	Strategies and processes used in solving math	She added 49 pages and 56 pages together to get 105 total pages.
Connections in math	1	Math concepts and their relations across content	"You can use multiplication to help you figure out division.
Math memorization	1	Fluent facts relating to math	"Someone told me that 5 X 6 = 30 and said to memorize it."
Seeing the details in math	1	The small, important aspects of math	"You're focusing on details more." (Referring to a question about the importance of language)
Teacher's scaffolding role	1	The teacher's necessary directing role in learning math	"If you add 8, 4 times, what is that called?" All students knew it was repeated addition.
Plan for student need and follow their direction	1	The plan and direction that fits student need and lead	"Yes! So, as that would happen… you would plan and change differently in this particular classroom. They are not gonna go to the same places that the other class is going to go and so would have to move and pace yourself according to what your class does"
Language's Crucial Role	2	The importance of language in math	"I think it's important to talk because you usually catch mistakes when you talk to someone."

Language use for math understanding	1	Descriptions of student understanding in their own language	"It would be the same because the problem side is like a nickname to the answer where the answer is just being called something else"
Math is visual	1	Seeing math on paper	He needed to come up on the board to show how. He wrote out a long division.
Math expression using paper		The need to write down math processes	"It's a lot easier to have them like written down so like if I get stuck I am like wait what do I do next? I can just like look over and be like ahhhh yeah."
Expressing math thinking	1	Speaking thoughts that convey mathematical understanding	"You can't add across the dog and cat stickers because there aren't 41 stickers on each sheet."
Mistakes caught through explanations	1	Through speaking math processes, errors arise	"You can use one GET and add the sheets together (34 + 27)." A lot of students immediately disagreed with her.
Collaboration can become chaotic	1	Mishaps can come in collaboration.	"I like partners because it's just kind of easier to do it but with groups sometimes there's so many answers and then like people have second thoughts and it just gets everybody confused."
Math Confidence	2	Students' growth in ability to communicate math understanding	"I think you have… they have a language that they are more confident in."
Math talks allows deeper understanding	1	Students growth in deeper math understanding	"I think it was good for the math talks because it helped me better understand what I learned."
Students challenged and pushed deeper	1	The challenge and depth of math talks	I liked it a lot. It was fun because you had to think harder about some of the problems to be able to like explain it.
Increasing student engagement	1	Student enjoyment and attention	"I felt like they um just their general outlook of when you started math talks was always very positive and they were very engaged."

		relating to math talks	
Math talk metaphors	1	Comparisons relating to student understanding of math talks	"Kinda like Lucy's except it feels like you're opening up from your brain in your body to other people."
Collaboration allows perspective	1	Hearing other's ideas create space for students to see a different side or understand in a different way	"I like it because I got to hear other people's strategies… And share my own."
Math Talk challenges	1	Difficulties regarding math talks	"I feel like the questions after the uh when you do the problem like explain how you did it and why you did it, that was kind of hard."

Appendix C

Table 2

Pre- and Post-Assessment Rubric

	Beginning Steps (1 point)	**Nearing Proficiency (2 points)**	**Proficient (3 points)**	**Advanced (4 points)**
Accuracy	Student did not get any correct answers	Student got at least 50% of the answers correct	Student got at least 75% of the answers correct	Student got over 75% of the answers correct
Math Strategies	Student did not use any math strategies	Student used some strategies; sometimes incorrectly	Student used strategies correctly at least 75% of the time	Student used strategies correctly more than 75% of the time and used them in their explanation
Math Vocabulary	Student did not use any math vocabulary	Student used some math vocabulary, sometimes incorrectly	Student used math vocabulary correctly at least 75% of the time	Student used math vocabulary correctly more than 75% of the time and used it in their explanation
Explanation	Explanation did not make sense	Explanation lacks clarity and isn't correct	Explanation is clear and is correct 75% of the time	Explanation is very clear and is correct more than 75% of the time