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“Math Talks are Like an Alarm Clock Waking You Up”: Language’s Crucial Role in Mathematics

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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 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.

“Math Talks are Like an Alarm Clock Waking You Up”: Language’s Crucial Role in Mathematics

“I am having a hard time figuring out this division problem because I can never remember how to count by 7s,” Garret (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,” Garret replied to me with what looked like a shimmer of hope on his face. “I think those are great ideas. Choose one of them 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 overlap with one another. In this case, Garret 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 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 a way that could deepen their 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 specifically 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 (Waggoner, 2015). Moreover, existing research has focused specifically on language in the math classroom at the whole group level with the 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, was located 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 has been found to produce positive effects for students through increased participation and engagement (Acar & Yilmaz, 2015; Bennett, 2010; Qaisar, Dilshad, & Butt, 2015; Quebec Fuentes, 2013; Zwiers et al., 2017). Often the subject of mathematics surrounds the use of numbers and 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 engagingly and increase 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 two different first grade-classrooms' math talks over a month period where student strategies focused on the process of solving addition problems. Space was provided for students to communicate their thinking fully, allowing ownership in student thinking (Murata et al., 2017). When a student shares their strategies aloud, the other students around can enter into a different way of thinking which may, in turn, bring about 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, students have been able to 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 make sense of what they are learning through verbal processing, finding confidence as a math learner, as well as helping and supporting their peers along the way (Hufferd-Ackles et al., 2004; Humphreys & Parker, 2015). Zwiers et al. (2017) focused on the role meta-awareness plays in regard to 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 have “students pose and answer questions, clarify what is being asked and what is happening in a problem, build common understandings and share experiences relevant to the topic” (Zwiers et al., 2017, p. 7).

Research has shown 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 were able to better understand what the person talking was trying to communicate. In addition, sentence stems were another strategy Wagganer (2015) brought within math conversations that both encouraged active listening in student response and provided a way students could continue the conversation.

Furthermore, there is much research supporting the need for language and collaboration in the classroom, and math talks are a way to incorporate both of these 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 in which supported student responsibility.

The research about specific math talks focuses on the conduction of them occurring as a whole class at various levels that is determined by the role of the teacher (Hufferd-Ackles et al., 2004; Murata et al., 2017). The levels are determined 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 such as positive student attitude relating to math and peer support (Qaisar et al., 2015; Quebec Fuentes, 2013). In a study focused on students' attitude toward math, Qaisar et al. (2015) found that student attitudes were positively affected through the use of collaborative group work, and a student even shared that there was freedom and safety to ask questions over and over again. Quebec Fuentes (2013) also found an increased consistency in student to student questioning in working with groups.

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 to better understand the possible impact on fourth-grade students' conceptual understanding of math content and overall student perception about the implementation of math talks.

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 about a week to allow my students to become comfortable with the process. 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

Beginning the study, the student participants took a pre-assessment. The pre-assessment consisted of five questions where students had to explain math concepts they learned in the previous fall semester (see Appendix A). Students responded to each question in writing as well as in pictures. To assess the pre-assessment, a rubric with the categories of accuracy, math strategies, math vocabulary, and explanation were used to determine content understanding. 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), and advanced (4 points).

Next, the math talks were taught and implemented with the whole class. Whole class math talks began with a problem put on the board that either focused on the following mathematical concepts the students have learned and practiced in the fall semester: multiplication, division, fraction comparison, subtraction, or multi-step word problems. After a week, the math talks were implemented in small groups focusing on one of the five concepts mentioned above. Sentence stems were provided to each group to scaffold the conversation within the small groups. The small groups were formulated based on the groups where the students sit in the classroom. Math talks occurred Monday thru 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 fleshed out in more detail.

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. The post-assessment was assessed using the same rubric that was utilized for the pre-assessment. Using the results from the post-assessment, students were put into three different focus groups: low average, medium average, and high average. Each focus group had around 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 was also focused on her perceptions of math talks. The teacher interview was audio-recorded and transcribed (Hendricks, 2017).

Data Analysis

To analyze the field notes and interviews, I used the constant comparative method (Hubbard & Power, 2003). Through the constant comparative 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. Using the level 1 codes, I was then able to identify level 2 codes which synthesized the data, pointing to the themes and overall findings (Tracy, 2013). In addition, I created an index to organize and keep track of the data that supports each of the level 2 codes by including the level 1 codes and its 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, seeing if there was an improvement in their scores (Hendricks, 2017). Based on the post-assessment averages, focus groups were put together: low average, medium average, and high average.

Findings

After much time reading, analyzing, and coding data, I reflected back on my proposed research questions. These questions focused specifically on the occurrences of math talks, the math understanding of students, and the perceptions of math talks from both the students and the cooperating teacher. My data provided three insightful findings about the content and processes specifically relating to mathematics, language's crucial role, as well as an increase in students' math confidence.

Content and Processes

"I liked it because I got to hear other people's strategies... and share my own." This was a perception about math talks Nick shared during a focus group. The sharing of strategies was a process that occurred regularly throughout the implementation of math talks, which was a specific area that students grew in over time. At the beginning of the implementation, students often stated their answer to a given problem without any explanation. However, through teacher scaffolding and daily math talk occurrences, students began and continued to grow in their

ability to verbally share their math thinking. The sharing of math thinking often occurred through talking about strategies and how the use of strategies contributed to their understanding of different math processes. 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 math processes as well as math thinking can look different for individual students as math problems are worked through.

Throughout the duration of math talks, a spiral review of different content areas occurred, and the reviewed content areas included what students had learned about the semester prior. This spiral review allowed students to deepen their math understanding as multiple students spoke about their own 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 through the use of higher order questioning. The higher order questioning focused on the process of the specific content, challenging students to think deeper and perhaps in a different way.

As the teacher scaffolding was integral to the flow of the math talks, a gradual release of teacher scaffolding allowed students to direct and lead their conversations within their small group and with the whole class. This gradual release was challenging, yet it pushed students in a way that allowed 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 again points to the deeper understanding that appeared to come from the implementation of math talks.

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

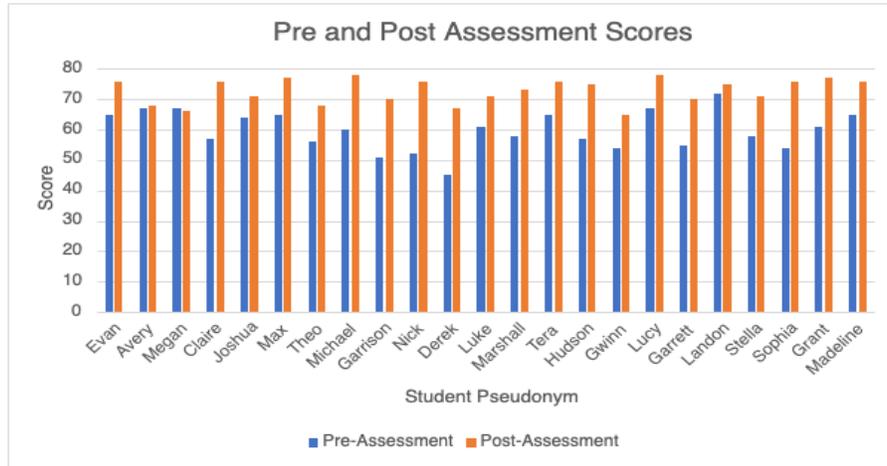


Figure 1. Each student’s pre and post assessment score.

Figure 2 shows 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.

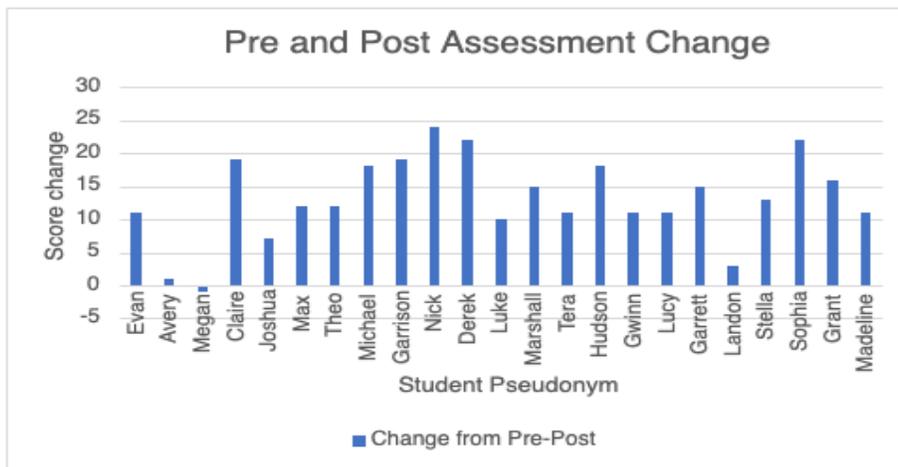


Figure 2. Each student’s pre to post assessment change.

Regarding the depth of content on the assessment, it was noted that students were able to explain in a clearer manner as to 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 the math talk implementation positively affected students' math conceptual understanding.

As depth of content and processes appeared to grow within students through the assessment data, students' ability to connect across math content also developed. 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 during focus groups associated their experience in math talks with other activities they did in the math classroom. The teacher also noted this same association of experience in math talks to benefit the way students generally grew in their ability to work in groups.

Ultimately, students demonstrated growth in their understanding relating to the content and processes of math. While most students' score increases speak to this growth, their own comments regarding what they think they learned as well as the day to day occurrences during the math talk implementation also points to student growth in this area. Furthermore, the implementation of math talks allowed students to advance in their understanding in math content and processes.

Language's Crucial Role

"... If you don't talk, how would someone know what's going on inside of your brain?" Tera asked this in regard to her thoughts about talking in the math classroom. This statement was profound yet summed up the crucial role of language that was found within 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 noted the

perspective that comes from talking to their peers. Nick noted specifically, "... that having multiple perspectives can be very good for your brain." In addition, Garret spoke about the benefit of perspectives because it allows opportunities to "compare" ideas. Furthermore, the sharing of perspective that occurred through the use of verbal language in math talks proved to be of benefit for students in relation to the overall perception of math talks as well as in relation to their growing math understanding.

Verbal language also allowed students to reflect out loud on their math processes. This reflection often brought students to places where they could catch mathematical mistakes. Mistakes are common in learning math as they can look like a calculation error or a conceptual error. Furthermore, the opportunity students had in talking to their peers focused students on more than the answer they got but also the process it took them to get the answer. 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 played a role in their deepening 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 through the use of different strategies. The use of a piece of paper and a pencil is one that Gwinn pointed out to me in the first week of the implementation of math talks. During the first week, the concept of focus was multiplication and division facts such as $6 \times 5 = 30$ or $21 \div 3 = 7$. With this focus in mind, I didn't 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 math being visual 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, 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 about comparing two equal fractions.

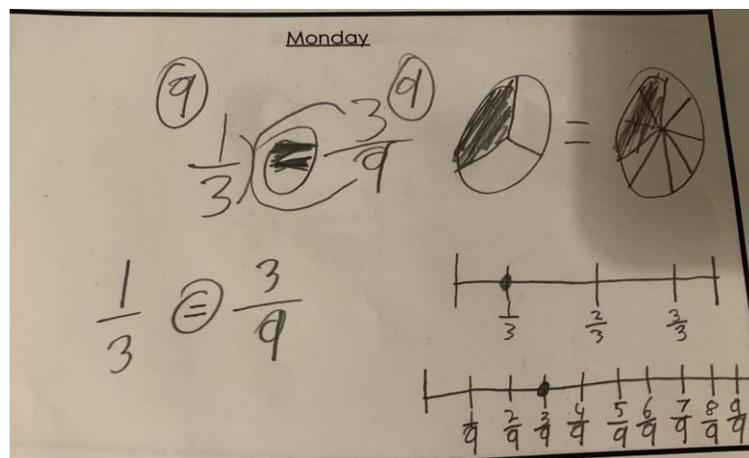


Figure 3. Student’s visual math work about comparing fractions.

The use of the document camera allowed all other twenty-two students in the classroom as well as myself to visually and clearly see the presenting student’s math processes. This increased student engagement and directed the student presenting in what to say as they explained their math work. When students displayed their math 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 recognized as a powerful discovery throughout this study. Specifically, verbal as well as non-verbal language was found to be essential in the implementation of math talks. The use of language was an area that students flourished in overtime 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.” This finding of a growth in students’ math confidence is one that I had not directly seen 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, students were confused and even frustrated 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. At the end of the study, it got to where students were asking each other questions and did not always need the direct scaffold of questions from the teacher.

In addition, the mathematical vocabulary students were using in their explanations during math talks grew. From concept to concept, the vocabulary associated with the topic of focus was reviewed. 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, their confidence in their word choice also grew. Mrs. Ford too 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 things 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]." These students' perceptions point to student rise 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 as she spoke about what she thought about 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, the challenge and depth students were pushed in seemed to also be of benefit. Overtime, the challenge and depth within content during math talks continued to extend. With the challenge and depth, 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. The challenge and depth of math talks also led students to a greater math understanding.

Multiple students compared their experience and perceptions of math talks through the use of 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 work out 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 also made me aware of some misconceptions students had within the 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 their own deepening understanding of math concepts.

The use of language brought perspective to students as they had space to express their math understanding. The expression happened on paper with a pencil as students worked through given math problems and also occurred verbally in their ability to speak about their answers and the math processes that were used to get those 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 grew. Students' growth in their math confidence was another finding in this study. I believe these findings on confidences contributes 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 concepts 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. In addition, I found it to be important to know my students' math knowledge before beginning math talks. I utilized data from a pre-assessment to know where students were in regard to expressing math

concepts and processes before the implementation of 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 engage in math talks.

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 the day to day happenings in our world. With this in mind, I am 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 day to day life outside of school. Though these questions don’t 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 in and out of the school day.

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4. What is $20 \div 5$? 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

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 $5 \times 6 = 30$ 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 relating to math talks	"I felt like they um just their general outlook of when you started math talks was always very positive and they were very engaged."
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	"I like it because I got to hear other people's strategies... And share my own."

		different way	
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."