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"Please Turn and Talk": Mathematical Discussions in Elementary Classrooms

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by

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Abstract

This research explores the perceptions of elementary math teachers on mathematical communication. The purpose of this research is to better support all students by understanding the benefits, limitations and strategies that are used to utilize mathematical communication to support higher-level thinking. Data were collected for this study over a period of 4 weeks using the transcribed audio recordings of semi-structured interviews with teachers, and through analysis of a reflective teaching journal. Data were coded through constant comparative analysis to find themes that emerged about the perceptions, benefits and limitations that teachers noted when using mathematical communication, or math-talk, in their classroom.

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Introduction

"Please turn and talk with the person next to you." This is something you might hear in many elementary classrooms across New York State. It may now be heard more and more often in math classrooms. I ask my own students to turn and talk regularly in my 4th grade math class. Recently, when teaching a lesson, I posed a question to my class, a question I thought would promote higher level thinking in my students. I asked them to turn to the person next to them and discuss the idea. I quickly realized to my dismay that only a few of my students were talking, and of those that were, very few were talking about math. I began to question my teaching technique. Was incorporating conversational time beneficial for my students or was it just an opportunity for disengagement? This questioning of my practices has led to my exploration of mathematical discussions.

Topic and Research Problem

In 2009, the Common Core State Standards for Mathematics (CCSSM), started to be developed (Hirsch, Lappan & Reys 2012, p.6). The writers determined that there are eight practices that serve as the "foundation for grades K-12 mathematics instruction" (Hirsch et al, p. 6). The CCSSM states that students are expected to utilize higher thinking mathematical practices and "construct viable arguments and critique the reasoning of others"(National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010, p.6). A student needs to be able to explain why s/he solved the problem the way s/he did as well as analyze the work of others. Not only do the students need to verbalize their reasoning, but the students also need to justify it through writing. Jung and Reifel (2011) state that communication is an important tool and necessary to developing not only students' conceptual understanding and

problem-solving skills, but also their thinking and reasoning in mathematics. It is clear to see that communication is quickly becoming a key aspect of mathematical instruction in elementary classrooms.

Rationale

In my classroom, the rigor of the NYS Common Core Learning Standards has been a barrier for many of my students. As they continue throughout the year, I know that the standards become increasingly more difficult as they master 4th grade skills to prepare them for 5th grade. Also, with the NYS Mathematics Assessment looming in May, I want my students to be prepared and feel confident in their problem solving ability. In order to support my students I want to seek out ways to support their mathematical learning through various methods. One method is through mathematical communication, which is shown to support students' problem solving development. However, I wanted to learn more about how educators are using communication in their classroom to support their students' literacy and mathematical needs.

Purpose

My purpose for this study was to learn more about mathematical communication in order to better support my students and inform my instruction. As an elementary math teacher I want to know and utilize the best practices in order to support my students' learning needs. Through this study I wanted to learn more about the experiences elementary teachers have had when it comes to mathematical communication, and also how they use it in their own classroom. I tracked and recorded my own thoughts on my teaching practices as well. I then compared the data to studies by other researchers to learn more about the current methods that are being used to encourage mathematical communication, or math-talk, and further inform my teaching

practices to support my students’ learning needs.

Research Questions

The CCLS suggest that students should be using communication to explore their reasoning and problem-solving ability in mathematics. However, the question remains, what have students been taught about math-talk? Elementary educators are expected to teach their students how to explore and verbalize their reasoning; however, what are the teachers’ attitudes toward math-talk and what practices do the teachers currently use to encourage math-talk within their classroom? Through this research I pursued the answer to this question in order to inform my instruction and support the mathematical reasoning needs of my students.

Review of the Literature

The literature review that follows examines the history of mathematical communication, its importance, and the key role that the educator plays in the development of a mathematical community. Countless studies over the years have proven the effectiveness of mathematical communication toward student understanding. However, the teaching practices and teachers who utilize communication vary in the execution. I utilize a sociocultural lens to examine mathematical communication. This literature review examines five major themes: the term mathematical communication, the sociocultural connections, aspects of a mathematical learning community, using mathematical communication and the teacher’s role.

Mathematical Communication

First, it is important to describe mathematical communication and its components. The importance of communication in education was first examined by Barnes (1976) (as cited in

Murphy, 2016, p. 29). This examination opened the door for other investigators to begin studying how utilizing communication could influence student understanding (Murphy 2016). As the knowledge of best practices for education developed, so did the expectations for educators and students. The NYS CCLS for mathematics state that students are expected to utilize higher thinking mathematical practices and “construct viable arguments and critique the reasoning of others” (National et al., 2010, p.6). Franke, Turrou, Webb, Ing, Wong, Shin, and Fernandez (2015), examined the implications of the standards and say that “explaining ideas to others encourages students to reflect on and monitor their own thinking” (p.127). As students begin to monitor their own thinking they begin to develop their metacognitive skills. According to Garofalo and Lester (1985), metacognition “has two separate but related aspects: (a) knowledge and beliefs about cognitive phenomena, and (b) the regulation and control of cognitive actions” (p. 163). Garofalo and Lester (1985) continue to explore the idea of the knowledge aspect by saying:

> Metacognitive knowledge about strategies includes having a knowledge of general and specific cognitive strategies along with an awareness of their potential usefulness for approaching and carrying out certain tasks. The metacognitive aspect of such knowledge lies in knowing where it can be used, and in knowing when and how to apply it. (p.164)

This means that metacognitive knowledge refers to the awareness, or understanding, that through using a known strategy it will help you complete a task. Metacognition and mathematics are easily relatable because, “Mathematical strategy knowledge naturally includes knowledge of algorithms and heuristics, but it also includes a person's awareness of strategies to aid in comprehending problem statements, organizing information or data, planning solution attempts, executing plans, and checking results” (Garofalo and Lester, 1985, p.168). Through exploring

their own thought processes, students can become aware of the strategies they are using to solve problems in math. One way that students can do this is through utilizing communication in their mathematical classrooms, to examine their own thought processes and problem solving strategies.

Sociocultural Connections

Another major aspect of mathematical communication is its correlation to the sociocultural theory. According to sociocultural theorist Vygotsky (1987), “speech is a means of social interaction, a means of expression and understanding” (p. 48). As students discuss mathematical process they utilize social interaction to develop their metacognitive understanding. Vygotsky (1987) asserted that previous literature had the “tendency to view thought and word as two independent and isolated elements whose external unification leads to the characteristic features of verbal thinking” (pp. 243-244). However, thought and speech are not independent of one another. They come together on what Vygotsky calls the plane of functioning (Vygotsky, 1987). Brown (2007) restates Vygotsky’s claims by saying “in broader terms what takes place between students, and between the teacher and students within a classroom, may be said to have the potential to initiate students into an ever-expanding conversation-conversation which goes beyond the walls of the classroom to engage the sociocultural practices of a mathematical community of practice” (p. 2). In other words, while students are engaging in mathematical communication, they are beginning to think about their thinking, or use metacognition, and engage in higher-level thinking that will help their problem solving abilities.

Mathematical Learning Community

Brown (2007) was not the only researcher to use the term “mathematical community”. The mathematical learning community is one that has been studied by many researchers including Hufferd-Ackles (2004), Kaya and Aydin (2014), Mueller (2014), Store (2015) to name just a few. A mathematical learning community is defined by Hufferd-Ackles (2004) as a “classroom community in which the teacher and students use discourse to support the mathematical learning of all participants” (p.82). Other researchers like Kaya and Aydin (2014), define mathematical communication as “planned interaction in classroom setting, which includes strategies such as questioning, discussions and group activities. The purpose of mathematical communication is to encourage students to express, share, and reflect on their ideas” (p.1620).

The current research acknowledges the importance of mathematical learning communities. Kaya and Aydin (2014) indicate that there are “a number of benefits related with mathematical communication. Teachers believe that mathematical communication is mostly beneficial for monitoring their students learning process” (p.1627). Educators gain from learning more about the student understandings and misconceptions when students discuss their problem-solving strategies. Mueller (2014) describes other benefits to mathematical communication such as:

> …challenged and active students; observant teachers who attend to the developing ideas of students; appropriate open-ended tasks that invite students to extend their learning as they build and justify solutions; student collaborations that make possible the exchange of ideas, conjectures, and alternative ways of working (p.1).

These benefits listed by Mueller help show that the usage of mathematical communication helps

students develop their mathematical skills more and increases their problem solving abilities.

Other researchers, such as Store (2015), delve into the specific aspects of the benefits such as justification. Store (2015) defines justification as “ways of verifying that a mathematical conjecture is true or false to ascertain for self or persuade others” (p. 529). Store (2015) argues that justifications support students’ sense making, and develop conceptual understanding. Adams, Karunakaran, Klosterman, Knott, and Ely (2016) acknowledges the many benefits of justification through math-talk:

> The practice of teaching and learning via mathematical argument/justification affords a practical context with ongoing opportunities for students to deepen their understanding of mathematics and use mathematical language precisely. In mathematical argumentation, the arguer must support or refute a claim with an argument that links the claim to the underlying mathematical principles and relationships. These ideas must be specified precisely and clearly in order for the argument to be understood and accepted by teacher and peers. The goal of peer acceptance of one’s argument presents a powerful motivator for students to learn precise meanings of mathematical terms and to use them appropriately (p. 1,159).

Students learn not only to problem solve, but to use math content language and vocabulary appropriately. Cooke (1998) continues to support this by saying that through examining their thought processes and talking about mathematics helps students can develop understanding and help to increase their problem-solving confidence. Other authors, like Schoenfeld (2016) stated that through the increased use of mathematical communication students can “learn to present their analyses in clear and coherent arguments reflecting the mathematical style and

sophistication appropriate to their mathematical levels. Students should learn to communicate with us and with each other, using the language of mathematics” (p.12). Students greatly benefit from the usage of mathematical communication. All of the benefits of mathematical communication help support why teachers should implement it, but how should they use it?

Using Mathematical Communication

Although there are many proven benefits to mathematical communication, the researched methods used to employ mathematical communication in classrooms vary. Researchers like Mueller (2014) and Murphy (2016) suggest that small-group instruction is the best practice to develop higher levels of participation in math talk learning communities. Mueller (2014) identifies that teachers need to establish social norms for this type of learning community. Mueller (2014) describes that students should be encouraged to “listen to each other’s explanations, explain their own solutions and ask their partners for assistance” in the small group setting (p. 16). Murphy (2016) builds on this by exploring the technique of microteaching which was intended to increase “primary students’ exploratory talk within small-group work in mathematics” (p. 30). Murphy (2016) defines microteaching as, “a scaled-down instructional opportunity, where the normal complexities of classroom practice are limited” (p.30). Microteaching allows educators to use small-group instruction as a method to support targeted instruction and increase communication.

The Teacher’s Role

The instructors themselves play a key role in the implementation of mathematical communication. Olteanu (2015) argues that communication and the teacher are both interrelated:

…communication is an integral part of classroom and schooling processes, and the

> quality of communication influences the quality of teaching and learning mathematics. The definition of goals, the choice of tasks, and the use of media and resources are critical to the success of communication in the classroom. Designing and implementing effective pedagogical situations or opportunities for effective communication is the subtle and essential job of the teacher (p.252).

The teacher is in control of the situation and provides opportunities for communication to flourish or become stagnant in the classroom. Through learning tasks that encourage communication, the students can begin to utilize math-talk as a tool toward higher level thinking. Hintz and Kazemi (2014) agree with the fact that the teacher’s role is important toward building mathematical communication in the classroom, but they also discuss the importance of goal setting and structure during the conversations:

> teachers play an important role in creating learning opportunities through discussion. As teachers foster productive mathematical discussion, it is important to work toward a mathematical goal while helping students learn how to participate as sharers and listeners. Different discussions can and should be structured differently, but all discussions, whether open strategy sharing to elicit a wide terrain of ideas or targeted strategy sharing to carefully examine a particular idea, are about achieving a goal and deepening student learning (p.40).

Again, the emphasis is placed on the importance of the teacher and his/her role as the director and facilitator of the discussion to deepen and encourage student learning.

Kaya and Aydin (2014) also noticed that the teacher’s role held major importance. Kaya and Aydin (2014) add to the current literature by filling a gap because, “there is a limited number

of studies using qualitative methods to explore teachers’ perceptions of mathematical communication” (p.1620). The teacher’s perceptions are not the only factors that influence student learning. Chang (2015), states that “teacher efficacy has been recognized as a variable accounting for individual differences in teaching effectiveness and has a strong relationship to student learning and achievement” (p.1308). The motivation and attitude of the teachers influences the students’ understanding and mathematical development. Their identity influences the ways in which they teach and the ways their students learn. Compton-Lilly (2006), states that “current conceptions of identity no longer describe identity as a personal and individual essence. Identities are formed within relationships with others and are constantly subject to the influences of other people and institutions” (P. 59). I wanted to learn more about the influences on the elementary teachers in my school, and the ways in which this impacts their teaching. This is the basis for the research herein this study.

Mathematical communication has been proven to support student problem-solving and mathematical understanding. The metacognitive conversations support students’ development as they verbalize and use social interaction to delve into the strategies they or their peers used. However, the question remains what role do the teachers play in mathematical learning communities besides the role of facilitator? How do the teachers’ interests, experiences or perceptions alter the way in which they apply communication in their math classrooms?

Methodology

The purpose of this project is to explore how elementary teachers utilize mathematical discussions in their classrooms to support the needs of their students and the expectations of the NYS CCLS. This study examines the utilization of “math-talk” in elementary classrooms, from

the teaching strategies used to encourage mathematical communication to the educators that teach mathematics. Over the course of four weeks, I used a semi-structured interview method to gather data from elementary teachers across grades K-5. I used transcribed audio-recordings and took extensive notes during the interviews. I also recorded reflections on my teaching practices in a reflective journal to cross-check the data for reliability.

Participants

The adult participants in this study were selected because they are elementary teachers who teach math to students in grades K-5. The educators vary from long-term substitutes, first-year teachers, to veteran teachers. The participants not only have varying teaching experiences, but the teachers also have differing educational experiences. The educators are all Caucasian and female.

Setting

The setting for this study is a suburban elementary school that includes grades K-5. The school is located in New York State. It is a small district and students enrolled in the school live in various nearby towns, while some are bussed into the school from the nearby urban setting. According to the 2015-2016 New York State enrollment data, around 300 students are enrolled in the school. Of those 300 students about 75% are white, while the other 25% are African American, Hispanic, Asian or mixed race. There are nearly equal amounts of male and female students. About 40% of the students are economically disadvantaged and 31% receive a free lunch.

Positionality

As the sole researcher for this study, my identity is important to consider in regard to my research. I am a Caucasian woman, in my mid-twenties. I am soon to be married, with no children. I was raised in a rural town, by my father, a corrections officer and my mother, a nurse. Both of my parents completed their associate’s degrees. I am fluent in English. I graduated from The College at Brockport, SUNY with a Bachelor’s Degree in English Literature and Childhood Inclusive Education. I pursued my teaching certifications in Childhood Education and Special Education for students in grades 1-6. I also am working toward completing my Master’s Degree in Literacy B-12. I have previous teaching experience as a long-term substitute. I am a first-year mathematics intervention teacher, working with students in grades 2-4. I also teach general education mathematics to a 4th grade classroom. As an intervention teacher, I believe that all students can learn with the appropriate supports to meet their learning needs. I believe that the use of literacy skills such as speaking and listening can help better support the mathematical problem solving and reasoning skills in students.

Methods of Data Collection

Through this qualitative study I have explored the following questions: What are elementary teachers’ attitudes toward math-talk and what practices do they currently use to encourage math-talk within their classroom? In order to examine this question in depth I chose to interview various teachers to find out what they know about mathematical communication, if they use it and how. I used a semi-structured interview method so that I had flexibility within the interviews.

Procedures

I interviewed elementary teachers, in grades K-5, who teach mathematics during their day. I audio-recorded the interviews for consistency and accuracy in my data. During the four weeks I also kept a reflective journal of my own teaching, in which I recorded my own thoughts and questions after teaching a math lesson to my students.

Trustworthiness

In order to ensure that my research is trustworthy I used triangulation, and corroborated my evidence through different individuals and data sources (Clark & Creswell, 2015). I transcribed audio-recordings verbatim in order to ensure accuracy in my data collection. I also used a reflection journal of my own teaching to explore what types of mathematical communication and questioning I use in my own classroom. My research partner and advisor have also examined my work critically to make sure that my reports are not skewed by my own bias.

Analysis

After I collected all of the data, I looked for trends and patterns through the use of coding, to see if there were any commonalities. Clark and Creswell (2015) note that coding, “is a procedure where a researcher identifies segments of text (or images), places and bracket around them, or highlights them, and assigns a code that describes the meaning of the text segment.” (p. 359) As I read through all of my data I began noticing commonalities between them. When coding my data, I marked and noted the experiences and teaching practices that the educators had, and marked these as “P” for perceptions. I also identified any moments where the educators and myself discussed the benefits of mathematical communication and indicated these with a

“B”. Finally, I identified any indications of limitations of mathematical communication within the data and marked it with an “L”. Through the use of this coding process, I analyzed my data using a constant comparative analysis to ensure that I explored the themes that arose while analyzing the data (Clark & Creswell, 2015). In order to ensure that my trends were accurate, I crosschecked data points across my verbatim transcriptions from the teacher interviews, my notes and my personal reflective journal of my own teaching. Through my use of coding and pattern formulation I was able to discover four major findings that began to provide answers to my research question: what are the teachers’ attitudes toward math-talk and what practices do the teachers currently use to encourage math-talk within their classroom?

Finding One: Students Need to Feel Comfortable Around Their Peers to Use Math-Talk

The first major trend that I noticed from the data collected was that overall, teachers feel as though in order for students to participate in mathematical communication, they must first be comfortable speaking around their peers. They feel that students need to have a classroom culture that is conducive to risk-taking and encouraging one another instead of being afraid of answering incorrectly. Cooke and Adams (1998) noticed that students are “self-conscious and reluctant to draw attention to themselves. At the same time, they may be particularly insensitive to peers” (p. 35). The authors continue to examine the importance of the classroom environment and say that, “in order to overcome student fears that their answers will be wrong or that other students will not listen respectfully, the teacher must work to build trust” (2015, p. 35). Creating a classroom that helps encourage respectful discourse is key. The following is a section of a similar discussion that took place with a 3rd grade teacher:

Interviewer: What strategy did you use to teach math talk in your classroom?

Mrs. Blue: Sometimes I would have a topic I wanted them to explore and I would use a question that would help lead to that, like a math story or a scenario. I might pretend I don’t know anything about this, and ask, how would you explain that to me?

Interviewer: Did you find that this worked for your students?

Mrs. Blue: Yes, but it has its limits. I think that students need a level of trust among the other kids to encourage that questioning culture.

Mrs. Blue noticed that strategies to use math-talk only work so far, students need to feel safe to be involved and engaged in the discussion. The students that tend to be most engaged in the discussions are what a 4th grade teacher called, “the risk takers”. Cooke and Adams bring up a similar point and state that, “encourage risk-taking and help students recognize that there is more than one way to solve a problem and the “best way” is the one that is most meaningful to the learner” (2015, p. 36). Teachers are responsible for facilitating the discussion and encouraging a safe learning space. Chang (2015) notes that “mathematics teacher educators must devote extensive efforts to establish a positive and collaborative working and in-service learning environment” (p. 1308). From my reflective journal I noted my own fear with trying to create this type of environment and said, “I don’t want to discourage them or embarrass them if they don’t know.” Teachers need to work to encourage a classroom environment that is open and inviting for students to feel free to discuss their thoughts and learning process without fear of ridicule from their peers.

Finding Two: The Teacher Influences the Conversation Through Guiding Questions

The second major trend in the data collected revealed that the teachers felt as though the biggest strategy they used to incorporate math-talk was through guiding questions. They felt as

though they acted as the facilitator in the discussions to help encourage the type of conversation that develops higher-level thinking. Ghousseini, Lord, and Cardon (2016) believe that this can be done at all ages, however, “developing this level of intellectual work by young children requires intentional work on the part of the teacher” (p. 1321). This means that specific learning tasks are necessary to help encourage mathematical communication. Olteanu (2014) also acknowledges this idea and says “the role that tasks play in the teaching and learning process and in creating learning opportunities for students depends on whether teachers select cognitively demanding tasks to create a meaningful interaction” (p. 262). Teachers need to select tasks that involve students in the conversation in a meaningful way, and seek to go beyond the literal. Yagi (2016) states the importance of this by saying that “as students gain facility with explaining their thinking and asking each other questions, their ability to form an argument will develop” (p. 691). Other researchers, like Steinberg, Empson, and Carpenter (2004) found that, through discussions, their participants “learned how to use the information gathered in these interactions” (p. 262). The researchers continued to say that the teacher was able to, “influence the direction of these conversations through specific questions about cognitively, socially, and mathematically appropriate extensions of individual children’s thinking” (2004, p. 263). Through teacher led tasks that encourage conversation, students can improve at using mathematical language to justify and reason their problem solving.

The data collected shows that teachers believe that in order to promote mathematical conversation, the questions they use to guide the lessons are key. From my reflective journal I noted, “During small group, I asked the students, “Why do you think that?”, “What other way could you have solved it?”. I noticed that the specific questions I used help to elicit participation from my students in the discussion. The following is a section of a similar discussion that took

place with a Kindergarten teacher:

Interviewer: Do you utilize questioning in your classroom? If so, what types of questions do you ask?

Mrs. Red: I usually ask, what do you see?, where did your eyes go first?, to encourage seeing patterns. When I want to build number awareness I ask, what attributes does it have? We actually use that vocabulary word and they know it well. I believe in using the math vocabulary so it is meaningful to them.

The teacher, Mrs. Red, used specific questions to elicit different discussions from her students. This shows that the teacher acts as the facilitator of the discussions and leads the students to the target learning they want acquired. Another teacher, from 4th grade, noted that, “They just want to answer the question, unless you push them further into that area where they will justify their answer. You have to guide them.” The teachers help support the students and their conversations through targeted, guiding questions that elicit conversations from the students.

Finding Three: Teachers Believe that Conversing and Writing about Math are Intertwined

The third major trend in the data collected revealed that the teachers believe that if students are able to discuss their problem solving strategies verbally, they will be better able to discuss them through writing. Adams et. al. (2016) brings up this point through the use of vocabulary understanding and says that, “the use of precise language allows for the creation of a viable argument, which subsequently allows students to better understand the appropriate use and importance of precise mathematical language” (p.1163). This precise mathematical language was also discussed by Schoenfeld (2016) who noted that instruction should support both verbal and written expression. The researcher stated:

> Mathematics instruction should help students to develop precision in both written and oral presentation. It should help students learn to present their analyses in clear and coherent arguments reflecting the mathematical style and sophistication appropriate to their mathematical levels. Students should learn to communicate with us and with each other, using the language of mathematics (p. 12).

Schoenfeld discusses the “language of mathematics” which refers to the vocabulary and content specific language that is necessary for mathematics instruction. When students are able to use this language effectively and understand it, they can use it both verbally and in writing. I noted, “I want to give them as many discussion opportunities as possible to help increase their ability to explain how they solved a problem or think about how to solve a problem. I think it will help them with their written explanations.” Through the interviews, a 4th grade teacher believed that, “There needs to be opportunities to talk so it transfers to the writing piece. Time to talk with each other even. That way they will be better able to explain their thoughts.” Another educator stated, “Students should be able to question the math they are completing and doing. Ideally, they could write their own problems.” This shows that the ability to understand and use metacognition to analyze his or her mathematical problem solving, could relate to his or her ability to write and even create problems.

Finding Four: The Need for Professional Development

The fourth, and final trend in the data collected showed that the teachers overall felt that there was a need for professional development in order for them to fully implement mathematical communication in their classroom. Sherin (2002) noticed that teachers were able to get their students talking but, “it was quite another matter to understand, from the teacher’s point of view,

what to do with those ideas- where to go next, when to pursue unexpected digression, and when to head off a potential misconception” (p. 208). Sherin goes on to say that, “because of the critical role that teachers play in the implementation of mathematics reform exploring ways to support teacher learning is of great importance to the mathematics education community” (p. 208). The belief that professional development was needed was found in both sets of data. My reflection journal noted, “I wish I knew how to include all students and make them want to be included.” The interviews found a similar trend. Below is the data collected on this matter (see figure 1):

Table 1

Interview Excerpts on Professional Development

Educator Role	Interview Data
Math Intervention	“I hope to see more opportunities for training in the future.”
Kindergarten	“I think what helps me is that I was able to take some graduate courses more recently and I have also been able to work with teachers at different age groups to help with math. But there are always new trainings we could use.”
2nd Grade	“I haven’t had any training. I experienced a little with student teaching through the modules. The language usage was a little trial and error.”
3rd Grade	“I have looked up a lot of stuff on my own. I think it would be helpful, especially with our mixed groups. It would help us learn how to pull in the kids who are not involved in the conversation.”
4th Grade	“I feel like I learned about it in college, but it is hard to apply.”

Figure 1: Data collected that discusses professional development perceptions.

The above table shows that the teachers felt unprepared for using mathematical communication fully, and have tried their own strategies to help implement it. Especially, because they found many limitations to using math-talk in their classroom, including: time, student confidence,

limited socialization skill or speech barriers, low reading levels that impact comprehension of vocabulary, the same students tend to answer and some students seem to be disengaged during conversations. Overall, teachers found many limitations that they felt impaired their ability to use questioning.

Discussion

Conclusions

My data analysis led me to several conclusions that are key to effective mathematical instruction in elementary classrooms. First, the data showed me that teachers acknowledged that students need supportive environments in order to elicit discourse that focuses on justification and reasoning. Students rely on their teacher for support as they converse and discuss their problem solving strategy for problems. The findings of this study relate to the findings of researchers like Cooke and Adams (1998) and Chang (2015) which found that the classroom culture needs to be one that is positive and encouraging to allow for open discourse amongst the students.

The second finding from this study is that the teacher acts as the facilitator and uses guiding questions to elicit targeted conversations from students. Both the interviews and the reflection journal showed that the types of questions and tasks used by the teacher mattered and influenced the course of the lesson. Ghousseini, Lord, and Cardon (2016), Olteanu (2014), Steinberg, Empson, and Carpenter (2004) and Yagi (2016) noted that the tasks and strategies that teachers used impacted both the quality and the direction of the conversation.

The third finding from this study is that teachers encouraged conversation in mathematics to help improve students’ ability to express their thinking through writing as well. The teachers

found that the more opportunities they gave for the students to talk there was an increase in their understanding of the content specific vocabulary, which was shown through their written expressions as well. Schoenfeld (2016) and Adams et. al. (2016) stated that the acquisition of mathematical language was key toward justifying and reasoning. The ability to understand the language is an important part of verbalizing and writing explanations.

Finally, the last finding was that teachers are unprepared for the usage of effective mathematical communication. The data found that the many limitations and lack of professional development impacted the teachers’ usage of math-talk in their classrooms. Sherin (2008) found that teachers could elicit conversations from their students but had difficulty understanding how to use the conversations for progress monitoring and informing instruction during the lesson and in future lessons.

The findings of this study yielded four conclusions: 1) Students need supportive classroom environments to participate in discourse, 2) The teachers’ tasks and strategies used during lessons are vital toward guiding math-talk, 3) Content specific vocabulary understanding helps impact verbal and written explanations, and 4) Teachers need training to better understand how to guide conversations and use the data collected from mathematical discourse.

Implications

There are three main implications that arose from this study. First, since the tasks and strategies that teachers use are so important to the students’ ability to use discussions in math, teachers should receive professional development on not only how to utilize effective discourse strategies, but also on how to inform instruction based off the data collected.

Second, teachers should begin the school year by discussing what listeners and speakers

should do, in order to set the expectations for a classroom environment that is conducive to discourse. Students need to feel comfortable around their peers in order to fully develop their problem solving abilities.

Finally, speaking and writing in math may have a connection, so educators need to build upon their students’ knowledge of content specific vocabulary to help ensure that they are able to use precise mathematical language to support their claims and fully understand their own thought processes.

Limitations

Overall, there were some limitations to this study that could impact future research. First, due to school scheduling and availability, the population of my study was small: only eight elementary teachers were interviewed in total, across grades K-5. This means that some of my findings may not transfer to a study involving a larger population. Second, the study was done in a suburban district which may not transfer across rural and urban settings. Finally, the participants in the study were all female educators, due to the fact that there are no male educators in the elementary school, which may not transfer to a study that incorporates both female and male perspectives.

Recommendations for Further Research

Based on the data collected in this study and the limitations that I identified, there are some areas that could be researched further. Researchers could explore what happens to writing when mathematical communication is used. Since I only collected data on perspectives and beliefs, focusing on the impact of verbal explanation and written explanation would help clarify the connection. Secondly, researchers could explore the perspectives of male educators on

mathematical communication as well, since there were no male participants in this study and males may have varied perspectives on the usage and effectiveness of mathematical communication. Finally, researchers could explore the difference in mathematical communication across varied school settings such as rural and urban, since my study focused on the findings in a suburban district.

Overall from this study, mathematical communication was found to be beneficial for students’ understanding and problem solving ability. However, there is much more work to be done in order for educators and students alike to be able to effectively use mathematical communication to support their learning. Through further research and development, educators can utilize discourse in their classroom to not only meet the expectations of the NYS CCLS but also to help increase their students ability to justify and reason their own mathematical strategies with that of others.

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Appendices

Appendix A

Teacher Interview Form

1. Please tell me about your teaching experience.
2. Please tell me about your educational experience.
3. Explain to me your thoughts on mathematical communication.
4. The NYS CCLS expect students to “construct viable arguments and critique reasoning of others”. What do you think this means?
5. Do you utilize questioning in your classroom? If so, what types of questions do you ask?
6. Are your questions presented to students in whole-group or small-group? How do you monitor student responses?
7. When you ask students questions do you notice a pattern in which students respond? What is it?
8. What do you think are the benefits of using mathematical communication?
9. What do you think the limitations or problems may be?
10. Do you believe you have had enough training in how to encourage this type of communication?
11. What strategy did you use to teach math talk in your classroom?
12. Do you think your students use math talk to justify their answer or just to say what answer they found?
13. Anything else you want to add?